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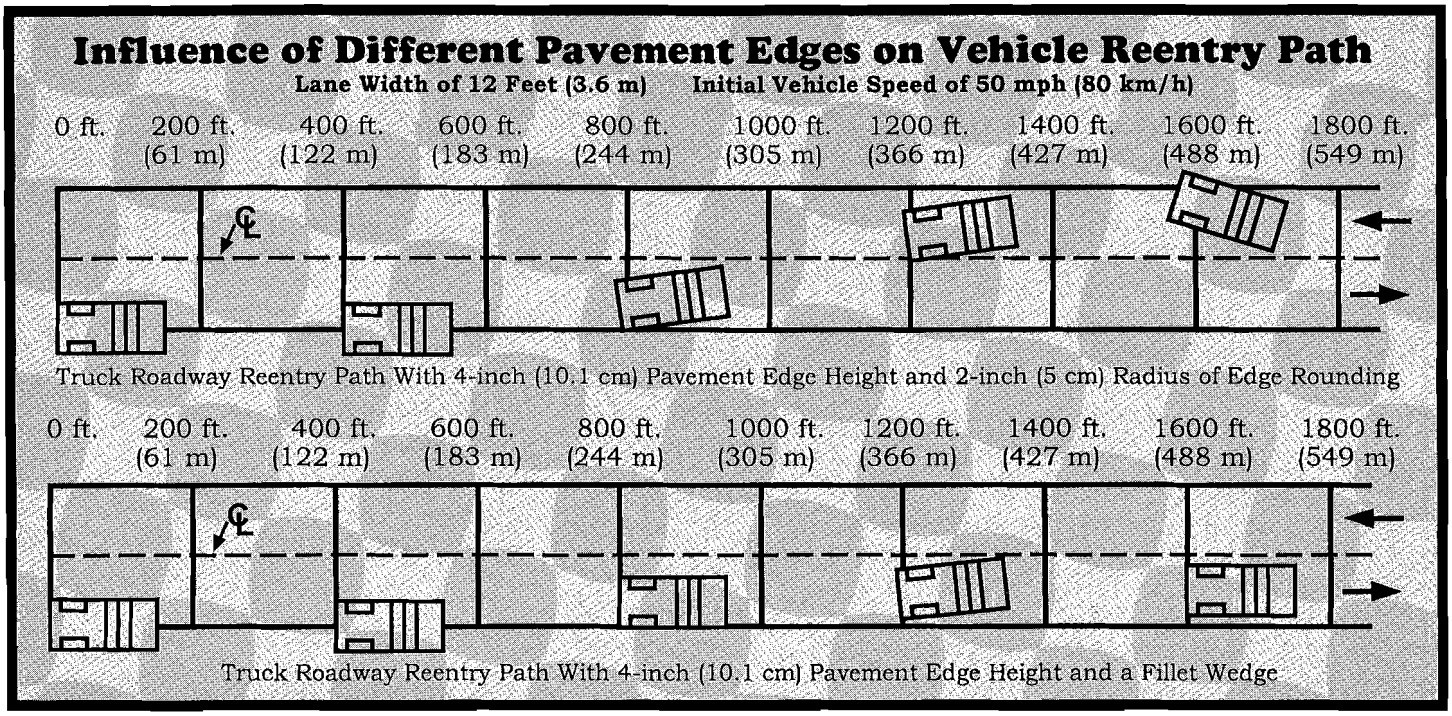

Hazardous Materials:

Exposure Risk for Highway & Public Works Personnel

by Lee Ireland, Ireland & Associates

The road foreman beamed with satisfaction as he plopped the fist-sized ball of lead on the superintendent's desk. "How's that?" he said. "I can make some big sinkers out of that baby." As the superintendent looked the ball over, the foreman explained that he found it in a pile of demolition debris that the highway department was called to remove. Then he saw it. There was no mistaking the black and yellow propeller: the warning symbol for radiation. Luckily, no one was seriously contaminated. The lead container had housed low level, radiated material for use in medicine but was empty.

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Elimination of Pavement Edge Hazards

A Simple, Low-Cost Solution

It's a story we've all heard. A car's passenger-side wheels drop off the edge of a newly resurfaced, two-lane highway. The road's shoulder has not been resurfaced yet, and is 4 to 10 inches (10-25 cm) lower than the roadway. The driver, struggling to return to the road, steers hard to the left. The car jumps back onto the road, its rear wheel catching the steep edge of the road, swinging it further into the opposing traffic lane, where it collides with an oncoming car.

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Is it really cheaper to resurface a road and forget about the bad base?

by Pete Messmer, Technical Assistance Engineer
Cornell Local Roads Program

An interesting way to approach this question is to look at a real road using the "life-cycle" cost analysis method. This road was examined by the Cornell Local Roads Program. It had an aggregate surface that was upgraded with three inches of cold-mix asphalt concrete. The top six inches of the roadbed material consisted of about 50 percent gravel, 21 percent sand, and 29 percent silt and clay. The town decided to place three inches of cold-mix directly on top of this very poor material without reconstructing the base.

Unstabilized base

Table I shows projected life-cycle costs (in present-worth dollars) for the road as constructed over the dirty base material over a ten-year period. The figures for the first five years are actual dollars that have been spent on the road. The remaining five years are projections based on the first five years. The salvage value of the base was set at zero. The base material had no worth because it was never stabilized or replaced. The cold-mix was assumed to have no salvage value at the end of ten years. After ten years of life on a highly frost susceptible base, the cold-mix pavement will be severely deteriorated with extensive cracking, potholes, and patches. The chip seal placed in year 10 is also considered to be worth nothing because it was placed on a failed base and pavement. It makes no sense to seal and waterproof a pavement that has already failed.

Stabilized base

Table 2 shows projected costs of the road if the base had been reclaimed to a depth of six inches. A Portland cement content of 5 or 6 percent by weight would produce a partially hardened soil-cement base. Portland cement was chosen as the stabilizer because of the exceptionally high fines content in the road base material. Asphalt emulsion would likely be much more costly in this case because it would take a lot of emulsion to bind up the 29 percent fines. Alternatively a new, clean aggregate base (less than 10 percent fines) could be constructed. However, the cost of buying and hauling the new aggregate would likely be more than the cost of in-place cement stabilization.

Table 1
Three-inch thick-mix asphalt concrete placed over dirty base

Year	Action Taken	Total Cost*
1	Pave with 3" of cold-mix	$32,000
	Chip seal	6,000
2	Cold patching - 5 tons	200
3	Cold patching - 5 tons	200
4	Cold patching - 15 tons	600
5	Cold patching - 5 tons	200
	Single Chip Seal	6,000
6	Cold patching - 5 tons	200
7	Cold patching - 5 tons	200
8	Cold patching - 15 tons	600
9	Cold patching - 15 tons	600
10	Cold patching - 15 tons	600
	Single Chip Seal	6,000
Salvage Value	Chip seal from year 10	0
	Base course	0
	Cold-mix	0
Total Cost		$53,400

*includes materials, labor, equipment

A double chip seal will be placed over the soil-cement base. The initial capital investment in Table 2 includes $10,000 for installation of sub-surface drainage in wet areas which is necessary when building soil-cement bases. Wet areas must be drained to prevent frost heave of the subgrade which would cause cracking of the semi-rigid soil cement on top. It is assumed that the soil-cement base and double chip seal, together with patching and surface treatments in the years shown, will provide about a fifteen-year pavement life. This is conservative. It will likely last much longer.

The salvage value of the soil-cement includes one-third the total cost of the base ($19,500) because there

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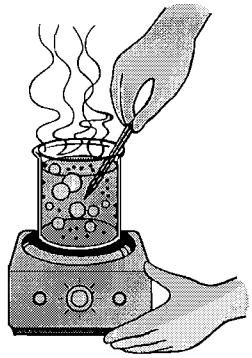
Two members of a sanitation crew were overcome by chlorine fumes while working around the hopper of their vehicle. Even though they were in the open air, they had to be sent to the hospital. Someone included chlorine with their household refuse. Eventually, the chlorine reacted with the moisture in the truck to form the gas which the workers inhaled as they unloaded cans into the hopper.

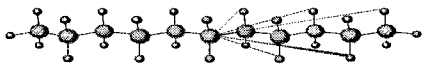
In Atlantic County, members of the Department of Health and Environmental Crimes Unit have investigated incidents such as a five gallon container of carbon tetrachloride left on the side of a road by workers hired to clean out a dry-cleaner's shop. The workers knew that the landfill would not accept the chemical and they simply abandoned it. Also, a doctor, who was moving his practice to another city, left red-bagged medical waste at the curb for regular trash pick-up. Captain Mark Gage says that it is commonplace for 55-gallon drums to be found abandoned with unknown contents. One, whose actual contents have not been exactly identified as yet, contains a strong, caustic material that could have done some serious harm to anyone who handled it. He cautions highway workers to leave these containers alone and to notify authorities.

These are true stories that happened in recent years in New Jersey. They show how hazardous materials are frequently disposed of improperly and how they present an exposure risk to highway/public works personnel. Our highways have become dumping grounds for toxic materials that the public will not dispose of properly, due to cost, inconvenience or sheer ignorance.

The very nature of hazardous materials allows them to harm us in ways that are different from normal workplace hazards. They can burn, poison, blow up and asphyxiate the unwary. They possess the ability to enter the body by physical contact, anywhere, including the eyelids and skin pores. Cuts anywhere on the body and normal breathing and swallowing make for easier pathways to internal organs. Workers should not panic but protect themselves by being educated as to what they are dealing with. The clothes that normally protect us at work are ineffective against hazardous chemicals that can go through zippers, buttonholes, tears in the material and leg or arm cuff openings. Also, chemicals can actually merge with materials that the clothes are made of and work their way through until they come into direct contact with the skin. Any protective coating built into clothes, such as Nomes or Goretex, can be degraded by chemical action. There is no one protective suit that is effective against all known chemicals. Some of the better suits cost over $6,000 each. So, for the average worker the message should be - *do not come into intentional contact with hazardous materials.*



The federal government estimates that each year more than 1,000 new synthetic chemicals are created, chemicals that will be entering our communities. The cheapest and most convenient way to transport these goods is on our nation's highways.



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is still 5 years of assumed life of the pavement structure left at the end of the 10-year analysis period. Assuming a 5-year life for a chip seal, the salvage value also includes $1,200 for the value of one year remaining life for the chip seal placed in year 6. Because the tile is back-filled with clean concrete sand, it should not clog up. Assume a 20-year life for the tile system. At year 10 its salvage value is $5,000 because it has half its life left.

In the final analysis, the total cost per year of the cold-mix alternative for the ten-year period is $5,300. For the base reconstruction alternative, the total cost per year is $5,900. The cost to the highway department is only $600 more per year for the base reconstruction alternative, but how about for the public?

When comparing the two alternatives the public receives an inferior product for the cold-mix road built without base reconstruction. I saw this road when it was four years old. It had ruts several inches deep. Most all the road surface was covered with alligator cracks that had in many places become potholes. Some of the potholes had been patched and some were still unpatched. There were also deep bumps and depressions. By any standard the road was in miserable shape. For most of the ten-year analysis period (except for maybe the first year or two) the public is driving on a very rough pavement. Average speed is likely lower than normal, the risk of accidents is greater, and vehicle maintenance and operating costs are higher. In contrast, for only $600 more per year, the public would have been provided with a smooth, comfortable, and safe road if the base had been reconstructed.

The problem however, for most towns is how to afford the high initial cost of the total reconstruction ($78,000). There are several ideas to consider. For example, tax generated capital improvement funds can be saved from year to year. If your town has a road that would be a candidate for reconstruction, why not save tax generated capital improvement funds for two or three years and then reconstruct the road properly? Do this instead of putting a "band aid" chip seal or cold-mix pavement on top of several roads in the same year.

Investing wisely now will save taxpayers dollars later

Another possibility is a bond issue. If your roads are rapidly deteriorating and the amount of reconstruction is considerably more than your budget can handle you may be a candidate for this strategy. This would provide needed capital to rebuild correctly a number of deteriorated roads. These roads would then only need routine maintenance for a number of years while the bond is being paid off at a rate that is affordable.

In these times when funds are inadequate and roads are in bad shape, it is important to invest wisely. When roads are improperly constructed they will cost the taxpayer sooner or later. Consider investing in proper construction the first time, even if it means changing the ways in which your town saves and uses capital improvement resources. With cooperation between highway officials and board members, and some brainstorming, I'm confident that municipalities can come up with new policies and methods for saving and investing that would allow for proper reconstruction techniques.

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Table 2
Cement base stabilization with double chip seal

Year	Action Taken	Total Cost*
1	Base stabilization	$58,200
	Double chip seal	9,800
2	Sub-surface drainage	10,000
3	Cold patching - 1 ton	40
4	Cold patching - 1 ton	40
5	Cold patching - 1 ton	40
6	Cold patching - 1 ton	40
		6,000
7	Cold patching - 1 ton	40
8	Cold patching - 1 ton	40
9	Cold patching - 1 ton	40
10	Cold patching - 1 ton	40
Salvage Value	Asphalt emulsion base	(19,400)
	Chip seal applied in year 6	(1,200)
	Subsurface drainage	(5,000)
		$58,720

*includes materials, labor, equipment

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After costly court proceedings, the government agency involved is successfully sued for failing to keep its highway shoulder reasonably safe for motorists. Settlement cost --a quarter of a million dollars.

Pavement edge dropoff has been a recognized hazard for nearly forty years. The Transportation Research Board considers shoulder dropoff among the top accident-related pavement disturbances, and a common source of tort claims against highway agencies.

This hazardous condition exists in part because most resurfacing contracts exclude shoulder work. The shoulders are usually completed by agency personnel during slow periods. However, this practice lengthens the period of time motorists are exposed to the hazard and increases the agency's liability.

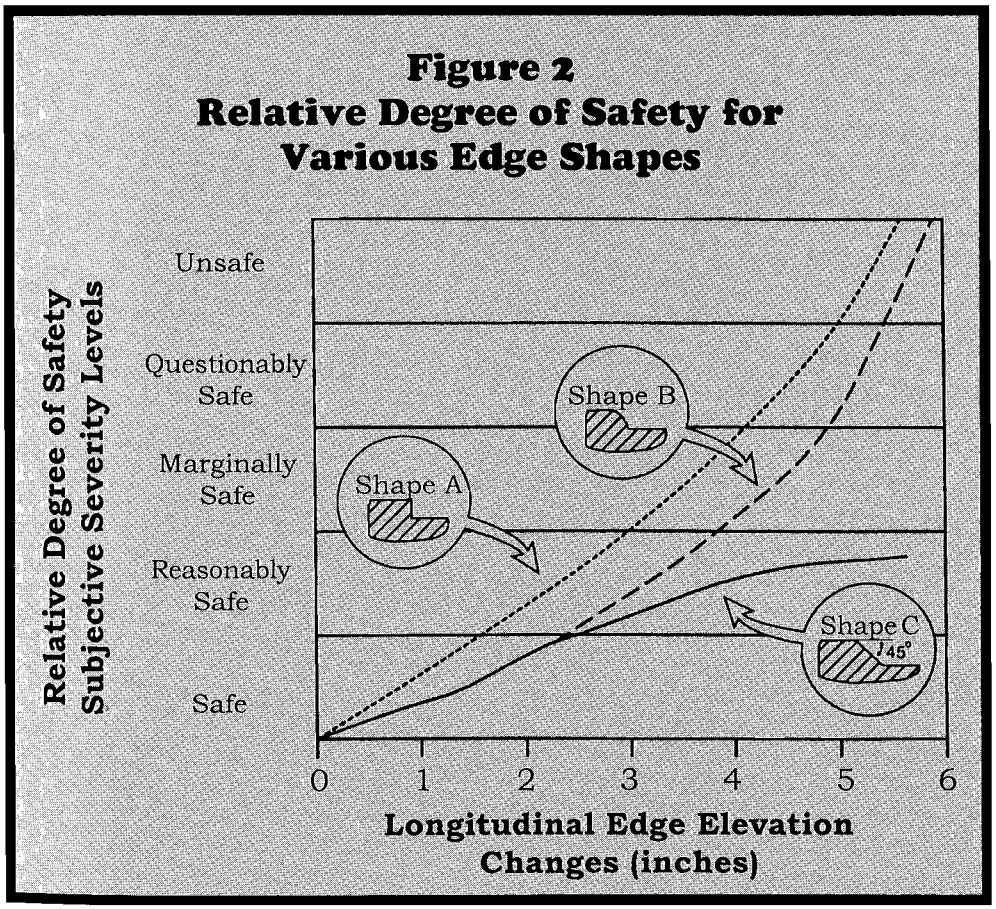
In an effort to eliminate dropoff hazard, the AAA Foundation for Traffic Safety sponsored a study by Jack B. Humphreys and J. Alan Parham at the University of Tennessee Transportation Center. One conclusion of the study is that an inexpensive fillet (wedge), angled at 45°, provides enough continuity between the shoulder and the pavement for drivers to maintain full control of their vehicles when climbing back onto the roadway.

The Dynamics of Pavement Dropoff Hazards

Tires that have dropped off the roadway and are immediately adjacent to the pavement edge create a "scrubbing" condition. When this scrubbing condition exists, a greater steering angle is needed to climb the dropoff than when tires are several inches away from the edge of the pavement.

Previous research by Richard A. Zimmer and Don L. Ivey, of the Texas Transportation Institute, has shown that the inability of the driver to remain in the right lane after over steering, while climbing back on the roadway, is due to the dynamics of the forces acting on the vehicle at the time the scrubbing tire reenters the roadway. In a fraction of a second, the resisting force acting on the tire is overcome. Before the driver can react (in less than one wheel revolution), the cornering forces could double due to increases in the available friction on the pavement and the right front wheel load, as a result of cornering. The vehicle then pivots about the right rear tire, until that wheel can be dragged up on the paved surface. This action results in the vehicle crossing the centerline and into the path of oncoming traffic (see Figure 1).

Figure 2
Relative Degree of Safety for Various Edge Shapes



Pavement Edge Shape as a Hazard Factor

The shape of the pavement edge dropoff effects the tire differently depending upon the "effective edge height." Effective edge height is defined as the point at which the tire rubs on the edge of the pavement to generate an edge mounting force system. Research results show that a 45° beveled edge has acceptable safety characteristics, whereas rounded edges and sharp edges generally have unacceptable safety characteristics (see Figure 2).

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Six Clues to Detect the Presence of Hazardous Materials

There are six clues to the presence of hazardous materials that awareness training teaches workers to be on the lookout for as they go about their work day.

1. Location/Occupancy

The first clue, location/occupancy, means that workers should be aware of the chances of coming into contact with hazardous materials. The type of activity that is conducted in that part of their county, municipality, or township could be a sign to beware. If the area contains a major truck route, an interstate highway, an industrial park, or a commercial zone, the chances of encountering hazardous materials are greatly increased. Workers also should connect with the nature of the work they were sent to do in these areas. If it is to assist with a spill from a motor vehicle accident, to do roadwork in the vicinity of a manufacturing plant, or to work in an area where underground paths could carry liquid chemicals, then increased caution is required.

2. Markings & Colors

The second clue is the markings and colors of containers. Often, hazardous materials are clearly identified with their name written on the container. Warnings such as "DANGER," "CAUTION," and "POISON" are frequently included. It is amazing how many people have ignored these warnings and proceeded to handle and even open properly marked containers just to see what was inside.

3. Shape & Sizes

The shapes and sizes of containers can provide clues as to the class of hazardous materials they may contain. The next time you spot a gasoline tanker on the road, note that the tank as seen from behind, is an oval lying on its side. This is a sign of liquid contents which are not under pressure. Tankers that hold liquid propane gas (LPG) and liquid natural gas (LNG) are made with rounded ends so they can better resist the strength of the forces pushing outward. Therefore, rounded ends mean compressed gases. On a smaller scale, most of us would easily recognize the bullet shape of tanks of oxygen and acetylene that are carried on stake body trucks.

4. Placards/Labels

The placards/labels clue refers to the diamond-shaped signs we see on the rear and sides of over-the-road vehicles and also refers to the small stickers on boxes, barrels, packages. There are eleven classes of hazardous materials that must be placarded according to federal regulations. A simple system using coded numbers covers all hazardous materials governed by the US Department of Transportation (DOT). Its use is mandated and regulated, and requires identification of individual containers. Contact your local or county emergency management official and request copies of the US DOT "Emergency Response Guidebook." It easily explains a wealth of valuable information related to hazardous materials and highways.

5. Shipping Papers

Shipping papers are probably the least available of the six clues, but one of the best. That is because they spell out exactly what is supposed to be on board. The regulations require shipping papers to be with the driver or in the tractor cab.

6. Senses

The use of the senses is intentionally left for last. Using the senses of smell, taste, and touch may provide a route for hazardous materials to enter the body. We certainly don't want to taste the chemical product or even try to smell it intentionally since that means inhaling it. Touching it means intentional, direct contact that is against a defensive approach to dealing with hazardous materials. It is said that if you are close enough to hear the high-pitched sound that a pressurized tank makes when on fire, it probably will be the last thing you hear in this world.

A tongue-in-cheek guide for serious emergencies involving hazardous materials is to use the "binoculars and sneakers approach" - that is, get far enough away to need binoculars and wear sneakers to get even further away.

Typical Locations of Hazardous Materials Along Highways

Note that in Table 1, lumber that highway/public works personnel often use in outdoor construction, chromated copper arsenate (CCA), is listed. This wood, tinted green, has been treated with arsenic acid. For this reason, it should not be burned or used where it will come into direct contact with food.

Arson investigators in New Jersey have been hospitalized, the day after the fire was out, after handling the ashes from a patio deck made out of wood treated with CCA. Workers should wash thoroughly with soap and water after contact with CCA.

Not all highway locations are prone to hazardous materials incidents because of what goes over them, but because of what is in and under them. Trenches, catch basins, equipment vaults, manholes, and pump stations are just a few areas that are known as "confined spaces." Often hazardous materials make these areas into death traps for workers and for emergency respondents. They provide a natural opening and pathway for hazardous materials to enter and travel through. Nationwide, over sixty percent (60%) of victims were would-be rescuers of people who had fallen prey to the conditions of these areas.

Like all other dangers that we face as we go about our lives, we need to manage the risks so that we may enjoy the benefits these chemicals bring to us.

Table 1

Location	Danger
• Trucks with Hazardous Materials Stopped Along Highways	• May be hit while parked • Convenient place to dump "problem" cargo • Prior damage to cargo may show • May go off road, spilling cargo
• Motor Vehicle Accidents	• Exceeding training capability • Exceeding equipment capability • Contact with hazardous materials • Contaminated clothing and equipment
• Facilities Visited by Highway Workers	• Haz. materials dumped in transfer station • Haz. materials dumped in recycling bins (e.g., needles in beverage cans) • Asphalt, petrochemical vapors • Lumber yards (e.g., CCA)
• Hazardous Materials Left on the Road by the Public	• Failing to recognize danger • Salvagers • Children • Contaminated Soil
• Highways and Public Works Facilities	• Haz. materials "over the fence" by public • Would-Be Rescuers • Hazardous materials used on the job
• Bulk Transport, Storage Plants	• Asphalt plant, petrochemical vapors • Pesticides, fertilizers for ball fields, parks, • Confined space of salt domes
• Swimming Pools, Water and Sewage Plants	• Leaks in chlorine cylinders being delivered * Chlorine delivered to city pool • Transport of hazardous waste

Table I outlines highway areas where hazardous materials are typically encountered and the dangers that can exist at these locations.

Awareness Through Training

Dealing with the hazardous materials situations should not terrorize highway/public works personnel or cause them to feel powerless to prevent harm. Like all other dangers that we face as we go about our lives, we need to manage risks so that we may enjoy the benefits these chemicals bring to us. The main way to do that is by being aware of the special nature of hazardous materials and being trained to respect their power. Remember, you cannot guarantee safety, but you can guarantee awareness through training.

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A Simple, Low-Cost Solution

The research-and common sense clearly shows that a fillet with a bevel angle of 45° can greatly reduce the control problems attributable to edge drops. The installation of an asphalt fillet can be accomplished by attaching a device known as a "moulding shoe" to the paving machine. The moulding shoe not only forms the shape of the asphalt fillet, but also reduces the amount of hand work required to finish the pavement edge. The fillet can be compacted using a hydraulic powered wheel, attached to the compaction rollers, that pinches the edge of the mat towards the drum.

Lay-down and material costs are usually insignificant. For example, when resurfacing a typical 24 foot wide (7.3 m), 2-lane rural roadway with 12 foot (6.3 m) lanes, with 2.5 inch (6.3 cm) overlay, 978 cubic yards (748 m^3) of asphalt is used. The volume of asphalt required to place a 45°, fillet along each side of the same road surface is only 9 cubic yards (6.8 m^3)-less than 1 percent of the total asphalt required for the project.

The cost of an asphalt fillet is minimal when compared to the total amount of the resurfacing contract. In addition, the fillet could save countless dollars in lawsuits and property damage, not to mention human lives.

For a complete copy of this report call the Michigan LTAP office at (906) 487-2102.

Adapted from *The Elimination or Mitigation of Hazards Associated with Pavement Edge Dropoff During Roadway Resurfacing,* AAA Foundation for Traffic Safety and reprinted with permission from Michigan LTAP Center Newsletter, Vol. 9, No. 1.

The Baystate Roads Program, which publishes *Mass Interchange* each quarter, is a Technology Transfer (T2) Center created under the Federal Highway Administration's (FHWA) Local Technical Assistance Program (LTAP). FHWA is joined by the Massachusetts Highway Department, the Department of Civil and Environmental Engineering at the University of Massachusetts/Amherst, and local public works departments in an effort to share and apply the best in transportation technologies.

In addition to publishing *Mass Interchange*, the Baystate Roads Program facilitates information exchange by conducting workshops, providing reports and publications and videotapes on request, and offering one-to-one technical assistance on specific roadway issues. Because the program relies on input from many sources, inquiries, articles, and ideas are encouraged.

Local Technical Assistance/Technology Transfer Center

To contact the Baystate Roads Program, call (800) 374-ROAD (in state) or (413) 545-2604.

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