technotes

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MARYLAND TRANSPORTATION TECHNOLOGY TRANSFER CENTER

Local Technical Assistance Program (LTAP)
University of Maryland at College Park

www.mdt2center.umd.edu

INSIDE:

Introduction to Crack Sealing

Water is the most destructive element to our pavement. Water entering our roadway through cracks accelerates the deterioration of the roadway. In time, the water will undermine and weaken the roadway base material, creating cracks and potholes. Sealing pavement cracks to prevent water from entering the base and subbase will extend the pavement life from three to five years.

Before the advent of high performance, polymer modified asphalt sealants, many municipalities filled cracks with AC-20, emulsions, J-1 and cutbacks, known as fillers. Fillers did fill the void in the crack but had little flexibility to move with the crack in cold temperatures and not flow or bleed in high temperatures.

Pavements expand and contract with seasonal temperature changes. Consequently, cracks and joints are expanding and contracting when the pavements move. Sealing the cracks with flexible rubberized asphalt that bonds to the crack walls and moves with the pavement will prevent water intrusion. As part of a Pavement Management System, crack sealing can reduce pavement deterioration by restricting water penetration into underlying base and subbase layers. This restriction helps to maintain pavement structural capacity and limits future degradation. Simply stated, sealing cracks and joints in pavements extends the service life of the surface treatment and the pavement.

It should be noted that crack sealing would not improve the initial pavement rideability. The benefits are realized in 3 to 5 years when it becomes obvious that the pavement has not deteriorated. Roads and bridges that are crack sealed last longer than those that are not. Sealing prior to surface treatments and bituminous paving overlays enhances the treatment and further extends the pavement life.

At a time when highway crew sizes are shrinking (along with funds to support road maintenance), crack sealing stands out as an economical maintenance technique. The overall successes of pavement maintenance systems that include crack sealing (combined with the generally low cost) make crack sealing a desired maintenance program. Crack sealing provides the most cost effective use of the dollars over time when compared to other pavement maintenance treatments.

Sealants

Asphalt rubber was the first generation of flexible sealants to move with the pavement and maintain flexibility at warm and cold temperatures. Unlike fillers, asphalt rubber is flexible below 35º F and does not migrate or run when temperatures reach 85º F.

Regional climates encouraged manufacturers to develop sealants that would outperform standard flexible sealants. Extreme high temperatures in the southwest and severe cold temperatures in the northern Midwest prompted the development of sealants that have greater flexibility and better bonding to crack walls. A generation of sealants utilizing polymer technology was introduced.

Polymers, when added to a liquid asphalt base, formulate a sealant that has a greater expansion capability than asphalt rubber sealants. Sealants can now be manufactured with a performance range from 200º F to -30º F.

Equipment

Using the right equipment is an important part of any crack sealing program. There are two major areas of consideration: crack preparation and sealant application. In the same way that a dentist prepares a tooth before filling a cavity, crews must prepare cracks to receive sealants. The better the preparation, the better the chance that the sealant will last and perform.

Cracks must be free of all dirt, dust and debris. The sealant must have a clean, dry bonding surface. Surface preparation can be accomplished with compressed air (100 PSI minimum) and a simple blowpipe. This technique works well when the dirt is dry and not packed hard. If the cracks are filled with wet dirt, the dirt needs to be removed and the crack must be completely dried. An air compressor or a hot-air lance generating temperatures in excess of 2,000º F is the best tool. In simple terms, a heat lance uses hot compressed air that blows cracks clean while drying them out. Field studies and research are finding that heat lances are valuable tools for successful programs.

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Work Zone Safety Toolbox

Work zone safety toolbox was developed by Maryland State Highway Administration (MD SHA) to provide a list of tools that can be used by designers and field personnel to improve safety in work zones. During the development of this toolbox, the MD SHA researched more than 20 strategies, some of which required field tests. Currently, there are 11 tools included in toolbox which include:

- Police Services in Work Zones
- PCMS with Speed Display
- Speed Display Trailers
- Temporary Transverse Rumble Strips in Work Zones
- Determination of Work Zone Speed Limits
- Drone Radar
- CB Wizard Alert System
- Traffic Lookouts
- Reduced Channelization Device Spacing
- Wider Lane Lines
- Intelligent Transportation Systems (ITS) in Work Zones

There is an introduction, objective, literature review, deployment guidelines, and case study section for different tools. In this article, we will briefly discuss one tool.

PCMS with Speed Display:

Objective: Provide drivers an awareness of their speed as they approach a work zone

Deployment Guidelines:

- Place PCMS in advance of work zone location.
- PCMSs should be delineated/protected with traffic control devices.
- When multiple PCMSs are used, all signs should be placed on the same side of the road to avoid conflicting messages.
- If the sign is to be used for more than four (4) weeks, periodic police enforcement should be arranged.
- Due to large size of the signs, install only where shoulder space allows sufficient room for setup outside the traveled way.
- On high-speed facilities (over 50 MPH), the speeds of vehicles traveling 25 MPH over the speed limit should not be displayed.

Various strategies discussed in the toolbox can be used independently or together to try to improve safety in work zones. For example, PCMS with speed display or Speed trailers may be used for speed reduction/awareness, transverse rumble strips for alerting motorists of work area ahead, wider lane lines for discouraging lane-changing behavior and creating perception of narrow lanes to reduce speed, dynamic late lane merge system to improve safety and reduce queues, etc.

This toolbox is envisioned to be a continuously evolving document. It is available online at: http://www.marylandroads.com/Safety/oots/trafficsignalsandlaws/WorkZoneSafetyToolbox.asp.

Technotes is Going Green

Thank you to those who have contacted us about technotes becoming an electronic newsletter, we're glad this decision is being supported!

In an effort to save some trees and money the MD T^2 Center would like to make its technotes newsletter in a digital format only. This new format will be sent to our loyal readers via email and will also be available on our website www.mdt2center.umd.edu

If you would like to recieve Technotes via email, please make sure we have your most up-to-date email address. Our listserv administrator can be contacted at: mdt2@umd.edu.

Thanks for reading!
- Technotes

Results from the Strategic Highway Research Program (SHRP) study show that there is almost a 40% greater chance of sealant success if cracks are routed prior to sealing. Cutting a reservoir also ensures that the proper amount of sealant penetrates the crack. An operator passes the pavement cutter or router over the crack and, through a series of star-shaped steel teeth, cuts a reservoir into the crack. Modern routers can follow even the most random pavement cracks. Once the rout is complete, simply use compressed air (hot or cold) to remove the dust created by the router. Engine-powered steel wire bruses can also be used to clean routed and non-routed cracks. (Note: Older-aged asphalt pavements and thin asphalt pavements may not be suitable for routing.)

The most visible piece of equipment is the melter. In years past the "tar pot" was simply a steel pot with a direct flame burner used to heat the material. Tar pots are still used today for applying AC materials. Also in use today are indirect fire melters, which require a high temperature heat transfer medium such as oil. These kinds of melters are known as "oil jacketed" melters or "double boilers". Special care must be taken to assure that the sealant temperature does not exceed the manufacturer's recommendations; otherwise the polymers may be destroyed therefore reducing the sealant performance.

Hot pour sealants are effectively applied through a delivery hose and wand. These materials are commonly applied at 375º F; however the manufacturer's recommended application temperature must be adhered to. This temperature normally is printed on the cardboard box the sealant comes in. To prevent sealant cooling, setup and clog, the hose is placed under constant pressure and the sealant circulates constantly back into the main tank. Crewmembers must therefore be trained not only in proper safety procedures but also proper operation of the melter. Melters with "on demand" pumping and thermostatically controlled delivery hoses reduce the chances of mistakes and improve productivity.

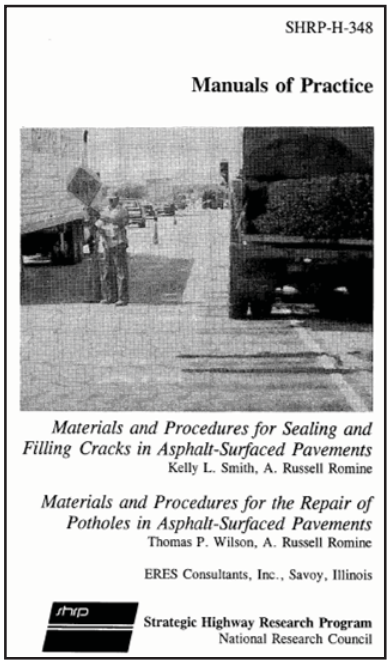
Application

Sealant application can be accomplished in a variety of ways. No less than 12 methods are outlined in the SHRP publication: Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements (SHRP-H-348). This manual was printed as part of the overall study that researched crack sealing methods and programs. Admittedly, the 12 methods did not all perform the same.

The three most widely used material placement configurations are:

1. Simple band-aid (2" to 3" wide band)
2. Recessed band-aid
3. Shallow, recessed band-aid

The success of each method was not only determined by configuration, but also by cleaning technique and sealant selection. Sealant applied in routed cracks performed longer: each of the recessed band-aids had good results. A recessed configuration dispenses material into the confines of a routed crack. The sealant can be placed flushed with the pavement, or slightly below the surface of the pavement, or slightly overfilled on the surface. In an over-band configuration, the sealant is placed onto and over an unrouted crack. The sealant can be shaped into a band over the crack using a rubber blade squeegee or a sealing shoe that flattens the sealant over the crack.



This manual along with other great materials are available online, visit the MD T2 Center's Library.

Seal cracks between ¼" to 1" wide. Cracks smaller than ¼" will not retain sufficient sealer to flex in the cold. Cracks greater than 1" will sag and possibly prematurely fail without the installation of HMA or backer rod.

Contracted crack sealing is typically bid by three methods: Lineal feet of crack, Gallons of sealant applied, or Pounds of sealant applied. Each method has drawbacks.

Lineal Feet: Municipal personnel need to measure cracks during application (preferred) or after the project is completed. This is time-consuming to the municipality and offers no incentive to over-apply sealant.

Gallons: Need to verify melter level and available material (boxes) at the start of the project. Take the total weight of the boxes and divide by the weight/gallon of the material to determine gallons used in each box. Take melter measurement at the end of the project, adjusted for temperature. Subtract the ending kettle level from the start level and add the gallons from the additional boxes to determine the total gallons applied. Some manufacturers only provide weight per pallet of material. In this instance, use an average weight based on the pallet weight divided by the number of boxes on a full pallet.

Pounds of Sealant: Calculate material volume in the melter and convert volume to pounds as above. Count total boxes and add the two figures. Use the method that best suits your requirements.

Conclusion

Pavement selection is often a forgotten element in determining the success or failure of a crack sealing program. If the road has alligator cracking, high density, multiple cracking, poor subbase drainage, or structural damage, crack sealing will not solve the problem. In these cases the damage is too far-gone. If you try to save a pavement that has too much

Tips for Bikeway Designation

As fuel prices rise, awareness increases about healthy lifestyles and being green (as in environmentally conscious) becomes expected by society, traffic engineers and transportation decision-makers will receive more requests to designate bikeways in their communities. Ironically, while promoting bicycling makes sense, it can often prove challenging.

This article is written to familiarize traffic engineers, transportation policy makers and elected officials with a number of issues that often arise in connection with planning and designating a comprehensive bikeway networks. While this article is written from a Maryland perspective, the discussion is, to some extent, applicable elsewhere. However it is important to note that it is not the purpose of this article to provide specific legal advice to those contemplating designating bikeways in their communities, whether in Maryland or elsewhere. Readers are encouraged to seek competent legal advice that is familiar with the laws of the jurisdiction(s) involved. Discussions of legal issues in this article should only be considered as being illustrative and providing a beginning point for the read to initiate discussions with their counsel.

Why Designate Bikeways?

Although the majority of roadways in Maryland are open to bicycle traffic, there are several reasons for designating specific roadways and shared use paths as bikeways. They include:

- Identification of the best or only travel alignment within a transportation corridor as a way for bicyclists.
- Alert motorists to the possible presence of bicyclists and remind the traveling public that bicyclists are legitimate roadway users.
- Encourage bicycle travel, particularly when the bikeway includes destination signing. This can benefit commuters and increase tourism.

In urban or suburban communities, there are often several routes available for bicyclists to choose from. However, sometimes the best choices for bicyclists may not be immediately obvious, even for long time residents considering bicycle commuting for the first time. In rural areas, even if there are not a lot of route choices within a travel corridor, designation of the obvious route choice confirms that bicyclists are legitimate roadway users.

Definitions of Bikeways

There are three basic types of bikeways and confusion often results from the misapplication of descriptive language. The Manual of Uniform Traffic Control Devices (MUTCD) uses the following definitions:

- ***Bikeway*** *– a generic term for any road, street, path, or way that in some manner is specifically designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.*
- ***Designated Bicycle Route*** *– a system of bikeways designated by the jurisdiction having authority with appreciated directional and informational route signs, with or without specific bicycle route numbers. Bicycle routes, which might be a combination of various types of bikeways, should establish a continuous routing.*
- ***Bicycle (or Bike) Lane*** *– a portion of a roadway that has been designated by signs and pavement markings for preferential or exclusive use by bicyclists.*
- ***Shared-Use Path*** *– a bikeway outside the traveled way and physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent alignment. Shared-use paths are also used by pedestrians (including skaters, users of manual and motorized wheelchairs, and joggers) and other authorized motorized and non-motorized users.*

Shared-use paths are often mistakenly called "trails". Shared-use paths are legally considered to be highways in Maryland. The major difference between shared-use paths and other highways is that motor vehicles are generally prohibited from this specific type of highway. For perspective, at the opposite end of the highway spectrum are Interstate highways, which allow most motor vehicles but exclude pedestrians and bicyclists.

Laws, Regulations, Standards and Guideline Documents

There are several publications that are available to guide traffic engineers and others in bikeway design. Chapter Nine in the aforementioned MUTCD covers required and optional traffic control devices for bicycle facilities. In 1999, the American Association of State Highway and Transportation Officials (AASHTO) published the *Guide for the Development of Bicycle Facilities*, the first readily available compendium of guidance and recommendations in areas of bicycle planning, facility design, and facility operation and

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cracking, you will be disappointed with your efforts. The best candidates for crack sealing are newer pavements that are beginning to form cracks.

Always begin your crack sealing program by sealing your best or newest roads first. We can certainly extend the life of these roads. A good rule of thumb is to monitor roadways that have been resurfaced and consider crack sealing within three to five years following the resurfacing.

Keep in mind that more sealant is not always better. Over applying sealant material can lead to problems when paving over with HMA or bleeding up through the seal or paving application. These new sealants are not designed to be "road glue." Yes, thay are very sticky and have tremendous bonding power. However, they were not made to "hold the road together." Crack sealing has one objective: to prevent water from further damaging our roads. Sealing "buys time" and saves money by delaying the expense of major reconstructive pavement work.

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maintenance. In 2007, the Maryland State Highway Administration (SHA) incorporated the AASHTO Guide into its *Bicycle and Pedestrian Design Guidelines* along with more current information. Although written for traffic and design engineers, these guidelines can be of interest to others. SHA's Bicycle and Pedestrian Design Guidelines are available on-line at www.marylandroads.com and clicking on the tab "Business with SHA".

Another document available on-line is the *Reference Guide to Federal and Maryland State Bicycle and Pedestrian Laws and Policies* published by the Maryland Department of Transportation. The Reference Guide ties in US and Maryland laws and policies relating to bicycling and walking as well as access to Maryland's 20-Year Bicycle and Pedestrian Access Master Plan. It provides legal and policy rationales for bikeway designation and can be accessed under "What's New?" at www.mdot.state.md.us/Planning/Bicycle/BikePedPlanIndex.

Bikeway Selection Factors

SHA's *Bicycle and Pedestrian Design Guidelines* provides detailed help with bikeway selection. Many decision makers may not have ridden a bicycle since they obtained a driver's license. This lack of having a recent "handlebar perspective" may complicate decision-making regarding bikeway designation. If a decision maker doesn't personally feel safe riding a bicycle along roadways under consideration for bikeway designation, they may feel uncomfortable encouraging others to ride along those roadways. Furthermore, under such conditions some traffic engineers may feel that bikeway designations may open them and their agencies to liability suits in the event someone gets injured on the designated bikeways.

Additionally, when designing a bikeway network overlaid on an existing roadway network, physical and financial constraints may prevent the creation of an ideal bikeway. Also, political considerations, such as resistance to the removal of on-street parking, or adjacent property owners' opposition may pose challenges to bikeway creation.

The AASHTO Guide offers eight criteria to consider when contemplating the establishment of designated bike routes. They are:

1. The route provides through and direct travel in bicycle-demand corridors.
2. The route connects discontinuos segments of shared use paths, bike lanes and/or other bike routes.
3. An effort has been made to adjust traffic contrl devices (e.g. stop signs, signals) to give greater priority to bicyclists on the route, as opposed to alternative streets. This could include the placement of bicycle-sensitive detectors where bicyclists are expected to stop.
4. Street parking has been removed or restricted in areas of critical width to provide improved safety.
5. A smooth surface has been provided (e.g. adjust utility covers to grade, install bicycle-safe drainage grates, fill potholes, etc).
6. Maintenance of the route will be sufficient to prevent accumulation of debris (e.g. regular street sweeping).
7. Wider curb lanes are provided compared to parallel roads.
8. Shoulder or curb lane widths generally meet or exceed width requirements included under Shared Roadways, page 17.

Sometimes the best choice or only choice for bikeway designation may be a roadway that does not meet all, or even most of these

criteria. However, less than desirable roadway characteristics can sometimes be mitigated. For example, if a narrow curb lane cannot be widened for a short distance, a SHARE THE ROAD assembly could be installed to inform motorists that bicyclists might be operating farther to the left and possibly occupying part of the motor vehicle lane. Drainage grates of the type that can snag bicycle wheels can be improved by welding cross pieces of metal atop the grates if it is impractical to replace the grates. The more of these criteria that are met, the better bicyclists will be served by the facility. Engineering judgment is often needed to determine the best way to accommodate bicyclists in an imperfect world.

Novice and Child Bicyclists Accommodations

Another challenge that many bikeway planners face is determining who their audience is. There is a common assumption that most bicyclists are children and adults lacking in skill to handle complicated traffic situations. This assumption may prevent the selection of certain roadways as designated bikeways on the grounds that this audience doesn't have sufficient judgment or cycling skills to ride safely there. If a community lacks wide, low volume roadways or opportunities to install a network of shared use paths deemed suitable for child riders and novice adults, it can be easy to conclude that a bikeway network is impossible to create. However, bikeway planners need to consider that there are existing competent bicyclists who could benefit from bikeway designation and that inexperienced bicyclists have the potential to become competent road bicyclists with maturity and training.

The engineering features of bikeways shown in publications like the MUTCD, the AASHTO Guide, and the SHA Bicycle and Pedestrian Design Guidelines cannot be expected to accommodate novice and child bicyclists by themselves. These engineering design criteria require a certain level of competence from bicycle riders such as obeying traffic control devices, and being aware of how to avoid dangerous situations (e.g. awareness of potential for collisions at intersections), choosing equipment that is appropriate to their size, skills and conditions of use and being able to safely operate and control that equipment.

Bikeway designation should not be seen as a guarantee against injury. Parents and guardians must judge and set limits to where child bicyclists may and may not ride. Adult bicyclists also need to ensure that they understand how to ride in a competent manner and avoid, to the extent possible, traffic and other conditions with which they feel uncomfortable. The duty of determining whether a bicycle facility is suitable for an individual bicyclist to use rests on the bicyclist not on the traffic engineer.

The Maryland Department of Transportation provides printed, audio, and audio-visual bicycle safety materials for both children and adults to help them become competent bicyclists. Bicycle advocacy and touring clubs also help educate bicyclists through periodic workshops and by matching novice bicyclists with experienced bicyclists on club rides. In short the traffic engineer should not be afraid to provide bike facilities consistent with applicable standards and guidelines simply because they assume some riders may not be competent to use them.

Liability Concerns

As previously mentioned, transportation and elected officials may be reluctant to create designated bikeways due to the fears of getting sued in the event someone is hurt riding a bicycle there. This fear may arise because persons responsible for bikeway designation may not be comfortable cycling themselves and worry how they would fare riding a bicycle on a particular roadway or facility. Or, they may have heard stories of other governmental organizations being sued by injured bicyclists. While it is indeed possible for a government entity to be successfully sued by an injured bicyclist, certain actions can be undertaken in connection with the designation and maintenance of bikeway facilities so as to minimize the possibility of being found liable in the event of a lawsuit. These actions can make bikeway designations and maintenance more of a reasonably manageable risk.

The most important step that transportation officials should take when concerned that bikeway designation would result in increased risk of lawsuit is to consult competent attorneys, usually their own agency lawyers or those on retainer to the jurisdiction. Attorneys can advise them not only on the relative risk of implementing a proposed course of action but can suggest ways of minimizing any confirmed risk. This consultation should occur before plan implementation. However, transportation officials should not hesitate to talk with their legal counsel at any time. The decision whether to implement bikeway projects should only

follow a thorough vetting of all relevant issues, including, by way of example only, issues of risk and liability, with appropriate subject matter experts.

Historically, it appears that public agencies have been more often successfully sued over maintenance issues rather than design issues. The duty of a public entity to properly maintain those public facilities for which it is responsible by law would likely still exist, regardless of whether such facilities were designated a bikeway. Potholes not filled in a timely manner, downed regulatory and warning signs not replaced within a reasonable time period, or improper work zone procedures that are the proximate cause of an injury to a bicyclist might be fertile ground for a successful lawsuit even if the facility is not a designated bikeway.

In terms of assessing risk in connection with bikeway design and maintenance consider the following:

- Understand the difference between laws, regulations, standards and guidelines. Ensure that applicable laws, regulations and standards are observed.
- Strive to follow applicable guidelines. However if guidelines cannot be followed document reasons why the guidelines were not followed (e.g. *widened curb lanes were not provided between 12th and 17th Streets because historic designation forbade street widening*).
- Ensure that documented reasons for guideline deviation can be retrieved years later by subsequent employees. Seek to provide mitigation measures if possible (e.g. *Bikeway Narrows warning signs*) to warn of any unusual circumstances.

In the event of lawsuit over bikeway designation, it may be helpful if the defendant agency can demonstrate that all applicable laws, regulations and standards in effect when the bikeway designation occurred were followed. Further, it may be helpful to be able to demonstrate that the then current applicable guidelines were followed (or that there was a logical reason for not observing guidelines) and whether any reasonable mitigating action was taken. Being able to demonstrate such points may help the defendant agency show that it was not negligent.

Elements of Tort Law

In order for transportation officials to better discuss tort liability concerns with their legal advisors, the following is a rudimentary overview of tort law and the four elements that must be shown to demonstrate negligence.

Webster's II New College Dictionary defines a tort as, "A wrongful act, damage, or injury done willfully, negligently, or in circumstances involving strict liability, but not involving breach of contract, for which a civil suit can be brought." In order for a defendant to be found guilty of committing a tort, the plaintiff must successfully prove that four elements; duty, breach, proximate causation and damages, were met.

Duty means that the defendant owed the plaintiff a duty of care. *Breach* means the defendant did not honor that duty of care. *Proximate causation* means that the defendant's failure to honor the duty of care owed to the plaintiff directly caused plaintiff's damages. *Damage* means that the plaintiff suffered death or physical injury or some other type of loss, damage or injury as a result the defendant's failure to honor that duty of care. The following example may help illustrate how these elements might directly apply to a common concern that transportation officials have regarding bikeway designation.

Our City designates a roadway by an elementary school as a bikeway and an eight-year old child, Pamela Pedaler, rides her bike there after seeing the BIKE ROUTE signs. Pamela is subsequently struck from behind and seriously injured by David Driver, a motorist, who failed to see young Pamela riding in front of him. Is the City liable to Pamela and her parents for attracting Pamela to ride on this street by installing the BIKE ROUTE signs?

An attorney would likely investigate whether the City owed Pamela a duty of care by installing the BIKE ROUTE signs. For sake of discussion only, we will assume a duty was owed to all bicyclists. Did the City breach that duty? Let's assume that all applicable regulations and guidelines were followed and the bikeway was otherwise well-lighted and well-maintained. However, Pamela's attorney argues that she would not have ridden her bike on this roadway where the driver struck her from behind if not for the placement of the BIKE ROUTE signs.

To determine whether the City was negligent, it would be first necessary to answer a lot of other questions. Among those questions: Was Pamela operating her bicycle in a safe manner? Was her bicycle in safe operating condition and appropriate to her size and experience? Was the driver operating the car that struck her operating his vehicle in an unsafe manner? Was he unable to avoid hitting Pamela because he was speeding or DUI? The answers to these questions (and others) would have a bearing on determining the proximate cause of Pamela's injuries.

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Were the BIKE ROUTE signs the proximate cause? The City would likely be found liable only where it was proven that "but for" the placement of the BIKE ROUTE signs, Pamela would not have been injured.** Based on the answers to the above questions, one might conclude there could be a number of other "proximate causes' of Pamela's injuries. It is also important to know that for some government agencies the doctrine of sovereign immunity might be applicable. Sovereign immunity means that an agency cannot be sued in tort, or that if sued in tort, the amount of damages is limited by law.

Consequently, when asking your attorney about liability risks it may be helpful to formulate your questions in relation to how the elements of tort law might apply. It may also be helpful to ask your attorney whether the agency(ies) or jurisdiction(s) enjoy(s) sovereign immunity, or if sovereign immunity has been waived, to what degree.

***Maryland is in the minority as a "contributory negligence' state. If the plaintiff is contributorily negligent in Maryland, the plaintiff may be barred from any recovery. The majority of other states are "comparatively negligence" states. In those states, a determination is made as to the percentage of liability of each defendant. If a determination is made in such a state that the City's placement of the BIKE ROUTE signs made them 20 % negligent, Pamela might still be able to recover a portion of her claim against the City even though she (or her parents) had been negligent.*

Final Thoughts

It is advisable to seek community input in bikeway designation, particularly from bicyclists whether they are individuals or members of bicycling clubs and advocacy groups. As citizens who stand to benefit from bikeway designation, they have an interest in how their communities' bikeway network is developed. As persons with handlebar perspectives, they can provide useful insight into the needs of bicyclists.

Also, bikeway route designation can provide an opportunity to get on a bicycle and ride the routes under consideration. This is particularly helpful for those decision-makers who haven't ridden a bicycle since acquiring a driver's license because it helps to understand conditions from a bicyclist's perspective. If you are uncertain about your street skills ask experienced bicyclists, particularly local bicycle advocates, to accompany you. This will increase your knowledge and credibility as well as providing enjoyment as well.

Finally, consult with competent counsel who can advise you about managing the risks associated with designating and maintaning bikeways in your area. While the designation and maintenance of bikeways cannot be entirely risk-free, counsel can help assure your bikeway program is planned and implemented with a realistic understanding of what those risks are and how those risks can be mitigated.

- Written by Michael E. Jackson,
Director of Bicycle and Pedestrian Access, Maryland Department of Transportation

Our Currently Scheduled Courses

The following courses are scheduled for 2008-2009, and we are still adding to the list! Sign up now for our currently scheduled courses, hurry, they fill up fast! For more information or to schedule a class contact Janette Prince at 301.403.4623 or register online by visiting us at www.mdt2center.umd.edu.

INTRODUCTION TO TEMPORARY TRAFFIC CONTROL

Juan Morales
October 6, 2008, 8:15am - 4pm
College Park, Maryland
$115 Maryland Local Government Only
$150 State and Federal Government
$195 Private and Out-of-State

An introductory course to temporary traffic control (TTC) in work zones, TCC is a one-day course designed to give participants a complete overview of traffic control in work zones, including applicable standards, devices used, component parts and their requirements, and installation/removal considerations.

WORK ZONE DESIGN

Juan Morales
October 7-8, 2008, 8am-4pm
College Park, Maryland
$225 Maryland Local Government Only
$275 State and Federal Government
$295 Private and Out-of-State
CEU's: 1.2

The course will give participants knowledge of the entire TTC process: planning, design, review, installation, maintenance, and evaluation of proper maintenance of traffic (MOT) controls for work zones. While the functions of planning, design, review, and operation of TTC are covered in detail, issues concerning safety of pedestrians and highway workers, human factors, and legal responsibility are also addressed.

STRATEGIES FOR IMPROVING HIGHWAY SAFETY

Juan Morales
October 9-10, 2008, 8:15am - 4:30pm
College Park, Maryland
$225 Maryland Local Government Only
$275 State and Federal Government
$295 Private and Out-of-State

To acquaint the participants with the options available to reduce traffic congestion and increase mobility. The course will examine the causes behind the growing congestion problem and specific strategies that can be taken to reduce it.

TRENCHING SAFETY

Alan Gesford
October 15, 2008, 8am - 4pm
College Park, Maryland
$125 Maryland Local Governement Only
$165 State and Federal Government
$180 Private and Out-of-State

Anytime anyone excavates a trench, safety should be a number one priority. This course discusses the inherent dangers of trenching operations and outlines the Occupational Safety and Health Administration's (OSHA) rules and regulations on construction excavation. Recognizing the potential cave-in factors, identifying soils, using proper sloping and shoring techniques, and backfilling are all discussed, along with pneumatic and hydraulic shoring systems. A review and work problems using OSHA's timber shoring charts gives the participants knowledge and use of this valuable resource. A review of work zone traffic control and the one-call system (Miss Utility) will also be presented. The session will close with discussions on the importance of a qualified inspector and recordkeeping.

SIGNAL WARRANT & INTERSECTION CONTROL ANALYSIS

Dane Ismart
October 16, 2008, 8:15am - 4:30pm
College Park, Maryland
$115 Maryland Local Government Only
$150 State and Federal Government
$175 Private and Out-of-State
CEU's: 0.6

This one-day course will cover the eight MUTCD signal warrants: Warrant 1: Eight-Hour Vehicle Volume; Warrant 2: Four-Hour Vehicle Volume; Warrant 3: Peak Hour; Warrant 4: Pedestrian Volume; Warrant 5: School Crossing; Warrant 6: Coordinated Signal System; Warrant 7: Crash Experience; and Warrant 8: Roadway Network.The course will also cover warrants for four-way stops as well as alternatives to traffic control signals.

ROADWAY SAFETY FUNDAMENTALS

Mark Hood
October 21, 2008, 8am - 4pm
College Park, Maryland
$125 Maryland Local Goverment Only
$150 State and Federal Government
$175 Private and Out-of-State

This one-day course will cover the following topics: basics of road safety: why; when; and where crashes occur, solving fundamental traffic safety problems, using traffic control devices to improve safety: signs; signals; pavement markings; and maintenance, common roadway safety issues: curves; stopping sight distance; edge drop-offs, etc., and basic intersection safety.

INTRODUCTION TO GEOSYNTHETICS

Ed Stellfox
October 22, 2008, 8:30am - 12:30pm
Gaithersburg, Maryland
$25 All Registrants

This course is an introduction to geosynthetics, beginning with a discussion of geosynthetics, what they are, how they are made and how they can be used in a road maintenance program. The class will cover the following topics: history, materials, geotextile fabrics, geogrids, geocells and geowebs, uses & applications, drainage, inflation, erosion control, reinforcement, separation, and reflective crack control.

STORM SEWER SYSTEMS & PAVEMENT DRAINAGE

Brian Roberts
October 27-28, 2008, 8:15am - 4pm
College Park, Maryland
$225 Maryland Local Government Only
$295 State and Federal Government

$325 Private and Out-of-State
CEU's: 1.2

This course provides students with a thorough knowledge of surface pavement drainage design and hydraulic design of storm sewer systems. The course includes a brief review of hydrology for pavements, detailed information on sizing curb open inlets, grates, and curb and gutter flow. (Please bring a pencil, calculator and a straight edge!)

DRAINAGE MANAGEMENT SYSTEMS

Alan Kercher
October 29, 2008, 8am - 3pm
College Park, Maryland
$95 Maryland Local Government Only
$125 All Other Registrants
CEU's: 0.5

This one-day course will cover the basics of stormwater mangement, the creation of a project map, collection of drainage structure inventory, report generation, and analyzing potential problem areas.

BICYCLE DESIGN & PLANNING

Dane Ismart
November 5, 2008, 8:30am - 4pm
College Park, Maryland
$95 Maryland Local Government Only
$125 All Other registrants

This one-day workshop will introduce plan and design concepts for the development of bicycle facilities.

ROUNDABOUT PLANNING & DESIGN

Dane Ismart
November 6, 2008, 8:15am - 4:30pm
College Park, Maryland
$95 Maryland Local Government Only
$125 All Other Registrants

This course will provide participants with an introduction to the planning and design of the modern roundabout. Topics covered in the roundabout course will include geometric design, signing, striping, safety, and accommodation of pedestrians and bicyclists. An important component of the course will be a discussion of the advantages and disadvantages of roundabouts.

ASPHALT ROADS COMMON MAINTENANCE PROBLEMS

Ed Stellfox
February 11, 2009, 8:30am - 12:30pm
College Park, Maryland
$50 Maryland Local Government Only
$65 State and Federal Government
$75 Private and Out-of-State

Municipal road crews should understand the causes of common maintenance problems on asphalt roads and be familiar with proper repair materials and methods. This course discusses causes and repair procedures for common problems such as cracking, potholes, rutting, corrugations, etc. The procedures cover materials, equipment, and techniques for lasting repairs.

FLAGGER CERTIFICATION

Juan Morales
February 18, 2009, 8am - 12:30pm
College Park, Maryland
$100 All Registrants

The safety of workers, motorists and pedestrians is dependent upon the flaggers' performance. Since the flagger position involves safety, proper training is vital; flaggers are expected to pass a test to prove their proficiency and competence level. A MD SHA-approved American Traffic Safety Services Association (ATSSA) flagger card will be issued upon satisfactory completion of this course. This will be valid for 4 years and is acceptable in several states, including MD, VA and DC. The class s is presented in PowerPoint© and will include a 25-question multiple choice exam and a flagger demonstration (dexterity test). Students will receive their ATSSA Flagger Certification card the day of the course (upon passing the exam).

ASPHALT RESURFACING

Ed Stellfox
March 11, 2009, 8:30am - 12:30pm
College Park, Maryland
$50 Maryland Local Government Only
$65 State and Federal Government
$75 Private and Out-of-State

This course reviews the various asphalt mixes, their components and their uses. Asphalt resurfacing procedures are covered, including preparation, material, equipment, operation and safety. Special emphasis is placed on proper rolling and compaction of the asphalt overlay. Superpave mix design is discussed as well.

ASPHALT RECYCLING

Ed Stellfox
April 8, 2009, 8:30am - 12:30pm
College Park, Maryland
$50 Maryland Local Government Only
$65 State and Federal Government
$75 Private and Out-of-State

This course discusses the advantages of asphalt recycling as part of your road maintenance program. It covers techniques for recycling asphalt pavement, including surface recycling, hot mix recycling, and cold mix recycling. The course emphasizes cold mix recycling, full depth reclamation, reviewing materials, equipment and operations. It also presents recent examples of asphalt recycling projects in several states. The following topics will be discussed: advantages, review of techniques, surface recycling, hot-mix recycling, cold-mix recycling, full depth reclamation, materials, equipment, operations, and examples of projects.

TORT LIABILITY & RISK MANAGEMENT

Ronald Eck
April 21, 2009, 8am - 4pm
College Park, Maryland
$125 Maryland Local Government Only
$150 All Other Registrants

This one-day workshop will provide an overview of the legal duties and responsibilities of roadway personnel. Key legal concepts relating to the liability of roadway agencies are reviewed from a risk management standpoint. Common types of claims/ lawsuits brought against street departments and highway agencies are identified through examples/case studies. Risk management principles and practical risk management activities will be identified.

PEDESTRIAN & BICYCLE ACCOMODATION

Ronald Eck
April 22, 2009, 8:30am - 4:30pm
College Park, Maryland
$125 Maryland Local Government

Only
$150 All Other Registrants

This one-day workshop provides current information on the design, operation and maintenance of successful pedestrian and bicycle facilities. Emphasis is placed on making participants aware of the characteristics and needs of pedestrians and bicyclists and on the importance of an interdisciplinary approach to planning and implementing pedestrian and bicycle programs.

TRAFFIC SIGN RETROREFLECTIVITY

Ronald Eck
April 23, 2009, 8:30am - 12:30pm
College Park, Maryland
$50 Maryland Local Government Only
$75 All Other Registrants

This one-day workshop will help practitioners gain a better understanding of sign retroreflectivity issues in order to improve the overall nighttime visibility of traffic signs. Topics covered will include: sign retroreflectivity importance; basic retroreflectivity science; types of retroreflective materials; measuring retroreflectivity; minimum retroreflectivity levels; and maintenance/ management methods.

INTRODUCTION TO TEMPORARY TRAFFIC CONTROL

Juan Morales
April 28, 2009, 8:15am - 4pm
College Park, Maryland
$125 Maryland Local Government Only
$150 State and Federal Government
$195 Private and Out-of-State

An introductory course to temporary traffic control in work zones, TCC is a one-day course designed to give participants a complete overview of traffic control in work zones, incluing applicable standards, devices used, component parts and their requirements, and installation/removal considerations.

WORK ZONE DESIGN

Juan Morales
April 29-30, 2009, 8am - 4pm
College Park, Maryland
$250 Maryland Local Government Only
$295 State and Federal Government
$325 Private and Out-of-State
CEU's: 1.2

The course will give participants knowledge of the entire temporary traffic control (TTC) process: planning, design, review, installation, maintenance, and evaluation of proper maintenance of traffic (MOT) controls for work zones. While the functions of planning, design, review, and operation of temporary traffic control are covered in detail, issues concerning safety of pedestrians and highway workers, human factors, and legal responsibility are also addressed.

BASIC DRAINAGE

Ed Stellfox
May 13, 2009, 8:30am - 3pm
College Park, Maryland
$75 Maryland Local Government Only
$95 State and Federal Government
$110 Private and Out-of-State

This course emphasizes the importance of good drainage with discussions of water and its effects on roads, problems caused by improper drainage, and ways to handle these problems. It covers types of drainage facilities, ranging from ditches, culverts and subdrains inlets and end structures, their uses, materials, installation and maintenance. It also introduces geosynthetic drainage applications. The following topics will be covered: importance of drainage, characteristics of water, system maintenance, drainage principles, surface and subsurface drainage, ditches, driveways, drainage culverts – materials and placement, headwalls, endwalls and inlets, erosion control, geosynthetics in drainage.

CONSTRUCTION MATHEMATICS

Ed Stellfox
June 10, 2009, 8:30am - 3pm
College Park, Maryland
$95 Maryland Local Government Only
$110 State and Federal Government
$125 Private and Out-of-State
CEU's: 0.5

Construction inspectors may need to brush up on math skills specifically related to construction inspection, especially basic geometry, fractions, area, volume and conversions. The class is a good refresher, and excellent preparation for the construction inspection class. Participants should bring a calculator, a scale, and a straight edge.

FLAGGER CERTIFICATION

Juan Morales
June 16, 2009, 8am - 12:30pm
College Park, Maryland
$100 All Registrants

The safety of workers, motorists and pedestrians is dependent upon the flaggers' performance. Since the flagger position involves safety, proper training is vital; flaggers are expected to pass a test to prove their proficiency and competence level. A MD SHA-approved ATSSA (American Traffic Safety Services Association) flagger card will be issued upon satisfactory completion of this course. This will be valid for 4 years and is acceptable in several states, including MD, VA and DC. The class is presented in PowerPoint© and will include a 25-question multiple choice exam and a flagger demonstration (dexterity test). Students will receive their ATSSA Flagger Certification card the day of the course (upon passing the exam).

INTRODUCTION TO GEOSYNTHETICS

Ed Stellfox
July 15, 2009, 8:30am - 12:30pm
College Park, Maryland
$50 Marylad Local Government Only
$65 State and Federal Government
$75 Private and Out-of-State

This course is an introduction to geosynthetics, beginning with a discussion of geosynthetics, what they are, how they are made and how they can be used in a road maintenance program. The following topics will also be covered: history, materials, geotextile fabrics, geogrids, geocells and geowebs, uses & applications, drainage, inflation, erosion control, reinforcement, separation, and reflective crack control.

PREVENTIVE PAVEMENT MAINTENANCE

Ed Stellfox
August 12, 2009, 8:30am - 3pm
College Park, Maryland
$75 Maryland Local Government Only
$95 State and Federal Government
$110 Private and Out-of-State

Our Currently Scheduled Courses
(concluded from page 11)

This course covers preventive maintenance treatments such as chip seals, slurry seals, and micro-surfacing and discusses when and where each technique could be effective. It presents application methods, including preparation, materials, equipment, operations and safety, along with practical tips on how to avoid trouble.

UNPAVED GRAVEL ROAD MAINTENANCE
Ed Stellfox
September 9, 2009, 8:30am - 12:30pm
College Park, Maryland
$50 Maryland Local Government Only
$65 State and Federal Government
$75 Private and Out-of-State

This course addresses basic maintenance techniques for unpaved and gravel roads. Topics include road maintenance, blading or dragging, reshaping or regrading for proper crown, regraveling, stabilization or full-depth reclamation, and dust control, with an introduction to road management techniques.

WINTER MAINTENANCE
Ed Stellfox
October 14, 2009, 8:30am - 3pm
College Park, Maryland
$75 Maryland Local Government Only
$95 State and Federal Government
$110 Private and Out-of-State

This course covers all aspects of winter operations- planning and organizing, methods of snow and ice control, salt usage, and winter equipment maintenance. This lesson will include usage of snow maps and formal snow plans.

Low-Cost Treatments for Horizontal Curve Safety

Safety Problems at Horizontal Curves

In 1998, the American Association of State Highway and Transportation Officials (AASHTO) approved its Strategic Highway Safety Plan[1], which sets a goal of reducing annual highway fatalities by 5,000 to 7,000. To help implement the plan, the National Cooperative Highway Research Program (NCHRP) developed a series of guides State and local agencies can use to identify ways to reduce injuries and fatalities in targeted areas. One target or emphasis area is the problem of crashes at horizontal curves.

A Guide for Reducing Collisions on Horizontal Curves, which is referred to throughout this publication as the Guide, illustrates the problem. The Guide reports that nearly 25 percent of people who die each year on the Nation's roadways are killed in vehicle crashes at curves. About 75 percent of all fatal crashes occur in rural areas, and more than 70 percent are on two-lane secondary highways, many of which are local roads. Furthermore, the average crash rate for horizontal curves is about three times that of other highway segments. And, 76 percent of the curve-related fatal crashes involve single vehicles leaving the roadway and striking trees, utility poles, rocks, or other fixed objects or overturning. Another 11 percent are head-on crashes, the result of one vehicle drifting into the opposing lane when a driver tries to cut the curve or redirect the vehicle after having run onto the shoulder.

It is because of these dramatic statistics that the Federal Highway Administration (FHWA) has identified Roadway Departure as one of its three program emphasis areas—the other two are Intersection Safety and Pedestrian Safety. One aspect of the Roadway Departure initiative is to develop a series of practical information publications designed for local road agencies. This publication is a result of, and supports Roadway Departure program goals.

Publication Purpose and Scope

The Guide identified 20 strategies as alternative countermeasures—or treatments—to address the specific safety problem at horizontal curves. These strategies share one of two objectives:

1. Reduce the likelihood of a vehicle leaving its lane and either crossing the roadway centerline or leaving the roadway at a horizontal curve.
2. Minimize the damaging consequences of a vehicle leaving the roadway at a horizontal curve.

Although the Guide provides information about each strategy, transportation professionals felt that a document providing practical

information on where, when, or how to apply a safety treatment or design feature—a resource that includes cost and examples—would be useful to local road agencies. This publication was prepared for this purpose.

There are numerous strategies or treatments agencies can apply to a single horizontal curve or a winding road section to address a safety problem. This publication includes only those engineering treatments that are relatively low cost, as compared to reconstructing the curve or road section to improve the geometric design features, such as degree and length of curve, superelevation, cross section, and shoulders.

The information presented here is concise. To fully cover all the aspects of an individual treatment would require a much larger document that would likely be used less. Rather, this publication provides information specifically relating to local roads and the agencies that manage them. It will help transportation agencies and their crews understand the alternative treatments and how to select and apply them. Where appropriate, and when information was available, this publication provides the following for each treatment:

- Description—what it is.
- Application Guideline—when to install.
- Design—what design elements or materials to use.
- Effectiveness—how a treatment can improve safety.
- Cost—what it will cost.
- Additional sources and contacts.

About the MUTCD

Throughout this publication, you will see references to the MUTCD. Shorthand for the Manual on Uniform Traffic Control Devices, the MUTCD defines the standards for all traffic control devices (signs, signals, and pavement markings) road managers install and maintain to help regulate, warn, and guide drivers safely on the Nation's roadways and streets. The MUTCD is published by the FHWA. All States are required to adopt either the Federal MUTCD or a State MUTCD that is in substantial conformance to the Federal MUTCD. Some States adopt the Federal MUTCD with a State Supplement. State laws regarding traffic control devices should be consulted.

The MUTCD also defines conditions about what, where, and how a device is to be placed or installed. In different chapters of this publication you may see a treatment and the designation that the MUTCD states it shall be used. Shall means something is a standard—a practice or device that is specifically required or mandated—or explicitly prohibited. The MUTCD may designate other treatments as guidance, which tells the road manager that a practice or device is recommended and should be used in typical situations, with modifications allowed for a specific location if an engineering study or engineering judgment indicates the deviation to be appropriate. Finally, the MUTCD provides for options, which are presented as may statements.

To learn more about the MUTCD, visit http://mutcd.fhwa.dot.gov. The site is very easy to use and the Frequently Asked Questions (FAQ) section is very helpful.

Information in this Publication

First, a few comments about the publication's contents:

- The treatments discussed are intended to improve the safety of a single curve or a winding section. It is assumed that the agency has identified the location as an existing or potential safety problem. All transportation agencies should have a program for identifying such locations. If it does not, the Guide can help agencies develop such a program.
- Some traffic control devices or applications described in this publication do not comply with the MUTCD and are considered "experimental." Any road agency wanting to use a noncompliant device on a public road must request and receive FHWA approval for testing. The MUTCD refers to this as experimentation. MUTCD Section 1A.10 outlines the procedure for experimentation.
- Where evaluation information is available, the publication includes estimates of the effectiveness of the treatment in reducing crashes. However, agencies should not expect to obtain these crash reduction values at a specific location, as the actual observed effectiveness of a treatment will vary from site to site.
- Several treatments discussed in this publication are signs or other devices placed on supports or posts, which makes them a hazard. The MUTCD states that roadside sign supports in the clear zone shall be breakaway, yielding, or shielded with a longitudinal barrier or crash cushion. For information on breakaway sign supports and the definition of clear zone at http://safety.fhwa.dot.gov/roadway_dept/road_hardware/signsupports.htm.

Reprinted from FHWA-SA-07-002, to read the full document visit: http://safety.fhwa.dot.gov/roadway_dept/pubs/sa07002/index.htm

The Maryland Transportation Technology Transfer (MD T^2) Center director Phil Tarnoff recently helped publish a manual for the Federal Highway Adminsitration (FHWA). Tarnoff provided his expertise in traffic signal timing to help publish the Traffic Signal Timing Manual. Printed below are excerpts from the manual's introduction and first chapter. To view the full document, visit: http://www.signaltiming.com

This Traffic Signal Timing Manual (TSTM) is intended to be a comprehensive guide to the traffic signal timing engineer and technician on traffic signal control logic principles, practices, and procedures. The TSTM represents a synthesis of traffic signal timing concepts, analytical procedures, and applications based on North American practice into a single publication. The manual also presents a framework for evaluating traffic signal timing applications related to maintenance and operations.

This manual is intended to complement policy documents such as the Manual on Uniform Traffic Control Devices, and is not intended to replicate or replace the Highway Capacity Manual, national or local engineering documents on signal timing, nor is it intended to serve as a standard or policy document. Rather, it provides a summary of practices intended to help practitioners in the timing of traffic signals.

Background

The origin of traffic control signals can be traced back to the manually operated semaphores first used in London as early as 1868. The first traffic signal in the United States was developed with the objective to prevent accidents by alternatively assigning right of way. The traffic signal has changed significantly since its early development.

Today, there are more than 272,000 traffic signals in the United States (1). They play an important role in the transportation network and are a source for significant frustration for the public when not operated efficiently. As the era of freeway building draws to a close, urban arterials are being called upon to carry more users than ever before at a time when the users of these facilities are growing more complex (older drivers, more distractions, larger vehicles, etc) and the demand for such use continues to outpace transportation supply. According to the 2001 Nationwide Personal Transportation Survey, on average, an individual traveled 40 miles per day, up from approximately 35 in 1990 (2). At the same time, the use of traffic signals at a busy intersection in a typical urban area might direct the movement of as many as 100,000 vehicles per day. In fact over ten percent of all intersections in California carry more than 60,000 Average Daily Traffic (ADT) for movements (3). It is estimated that many of these signals could be improved by updating equipment or by simply adjusting and updating the timing plans. Outdated or poor traffic signal timing accounts for a significant portion of traffic delay on urban arterials and traffic signal retiming is one of the most cost effective ways to improve traffic flow and is one of the most basic strategies to help mitigate congestion.

Despite their important role in traffic management, traffic signals, once installed, are often not proactively managed. Maintenance activities are frequently delayed or canceled, in reaction to shrinking budgets and staffs. More than half of the signals in North America are in need of repair, replacement, or upgrading. In 2007, the National Traffic Signal Report Card was released by the National Transportation Operations Coalition and consisted of the composite national scores from an agency self-assessment related to traffic signal control and operations, the responses in five sub areas indicate an overall national "grade" of D up from a D- in 2005. (4).

FHWA has recognized the critical role that traffic signal timing plays within the overall transportation network. Signal timing offers the opportunity to improve the mobility and safety of the street system and contribute environmental benefits. This document is intended to further increase the awareness of the need for resources devoted to operation of the transportation system.

Purpose of Traffic Signals

The Manual on Uniform Traffic Control Devices (MUTCD) defines a traffic control signal as any highway traffic signal by which traffic is alternatively directed to stop and permitted to proceed. Traffic is defined as pedestrians, bicyclists, ridden or herded animals, vehicles, streetcars, and other conveyances either singularly or together while using any highway for purposes of travel. (5)

It is with this need to assign the right of way at locations that we consider the dual purpose of traffic signals —efficiency and safety— which in some cases seem to be conflicting. Safety may be seen as an element needed to be sacrificed in order to achieve improvements in efficiency and meet ever-increasing demands. The reality is that traffic signals can, and in fact must, serve both operational efficiency and safety based on the conditions. The MUTCD goes on to describe that traffic control signals can be ill designed, ineffectively placed, improperly operated, or poorly maintained, with resulting outcomes of excessive delay, disobedience of the indication, avoidance, and increases in the frequency of collisions.

A traffic signal that is properly designed and timed can be expected to provide one or more of the following benefits:
1. Provide for the orderly and efficient movement of people.

2. Effectively maximize the volume movements served at the intersection.
3. Reduce the frequency and severity of certain types of crashes.
4. Provide appropriate levels of accessibility for pedestrians and side street traffic.

The degree to which these benefits are realized is based partly on the design and partly on the need for a signal. A poorly designed signal timing plan or an unneeded signal may make the intersection less efficient, less safe, or both.

Intersection Design and its Relationship to Signal Timing
The design of the intersection has a direct influence on its safety and operation from a design and user-ability perspective. Design elements that are particularly relevant include the number of lanes provided on each approach and for each movement, whether there are shared thru-and-turn lanes, the length of turn bays, the turning radii (especially important for pedestrians), the presence of additional through lanes in the vicinity of the intersection, the size and location of detectors, and presence or absence of left-turn phasing. Other geometric features, like additional through or turn lanes, can also have a significant positive impact on intersection capacity, provided that they are sufficiently long. The other aspect of intersection design is the perception and reaction of the end users. Various decisions need to be made as a user approaches the intersection, which makes it important to simplify the decision making process.

Another aspect of the design is detection. Detectors provide the ability to sense vehicle and pedestrian demands at an intersection; enabling modes of operation that may be more efficient than fixed or pre-timed control. It is critical that functional and properly designed detectors communicate with the controller to ensure continued functional signal control at the intersection. Detectors that are improperly located or are an inappropriate length can unnecessarily extend the green indication and increase the frequency of phase termination to the maximum limit (i.e., max out). Conversely, a poorly located detector could cause premature gap-out. A protected left-turn phase provides a time separation for left-turning and opposing traffic streams and may reduce leftturn delays or related crashes. However, the additional phase increases the minimum cycle length and may increase intersection delays and, in the case of a protected-only left-turn, may even increase left-turn delay.

The topics discussed in this section are intended to serve as a reminder of the close relationship between signal timing, intersection design, and traffic control device layout. The quality of the signal timing plan is directly tied to the adequacy of the intersection design and the traffic control device layout. In some situations, achieving safe and efficient intersection operation may require changes to the intersection design or the traffic control device layout. The subsequent chapters of this manual provide more detailed information about the role of these factors in signal timing plan development.

Objectives of Basic Signal Timing Parameters and Settings
A primary objective of signal timing settings is to move people through an intersection safely and efficiently. Achieving this objective requires a plan that allocates right-of-way to the various users. This plan should accommodate fluctuations in demand over the course of each day, week, and year.

Because travel demand patterns change over time, the signal timing plan should be periodically updated to maintain intersection safety and efficiency.

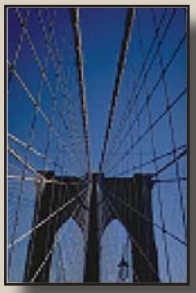
There are many signal timing parameters that affect intersection efficiency including the cycle length, movement green time, and clearance intervals. Increasing a traffic movement's green time may reduce its delay and the number of vehicles that stop. However, an increase in one movement's green time generally comes at the expense of increased delay and stops to another movement. Thus, a good signal timing plan is one that allocates time appropriately based on the demand at the intersection and keeps cycle lengths to a minimum.

The relationship between signal timing and safety is also addressed with specific timing parameters and the design of the intersection. For instance, the intent of the yellow change interval is to facilitate safe transfer or right-of-way from one movement to another. The safety benefit of this interval is most likely to be realized when its duration is consistent with the needs of drivers approaching the intersection at the onset of the yellow indication. This need relates to the driver's ability to perceive the yellow indication and gauge their ability to stop before the stop line, or to travel through the intersection safely. Their decision to stop, or continue, is influenced by several factors, most notably speed. Appropriately timed yellow change intervals have been shown to reduce intersection crashes (6). Signal timing plans that reduce the number of stops and minimize delays may also provide some additional safety benefits.

The traffic signal controller at an intersection implements timing settings designed for that specific location. The settings are designed to respond to users at the intersection and meet objectives defined by the policies of the responsible agency.

The policies may include standards defined by the agency with potential guidance from regional or state standards and must consider pedestrians, vehicular traffic conditions, change and clearance intervals, and if actuated, detection layout. These settings may be influenced by adjacent intersections (the concept of coordination is more fully explored in Chapter 6), but are applicable for each intersection considered as an isolated unit.

To view the full manual FHWA-HOP-08-024, visit: http://www.signaltiming.com




MD T² Center Staff

Philip Tarnoff, Director
301.403.4619
Tarnoff@umd.edu

Ed Stellfox, Co-Director
301.403.4696
Stellfox@umd.edu

Janette Prince
Assistant Program Manager
301.403.4623
Janette@umd.edu

Ellen Neal
Administrative Assistant
301.403.4239
Ellen@umd.edu

Carly Keane
Communications & Marketing
301.403.4601
ckeane@umd.edu

Address Change?

The MDT² Center is continously updating its mailing list, please let us know if you have a new address. Email us your new address at mdt2@umd.edu or call Ellen Neal at 301.403.4239 and we'll be glad to update your information.

Maryland Transportation Technology Transfer (T²) Center
University of Maryland, College Park
Building 806, Suite 3102
College Park, Maryland 20742-6602

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