Traffic Safety Fundamentals Handbook

Minnesota Department of Transportation
Office of Traffic, Safety and Technology

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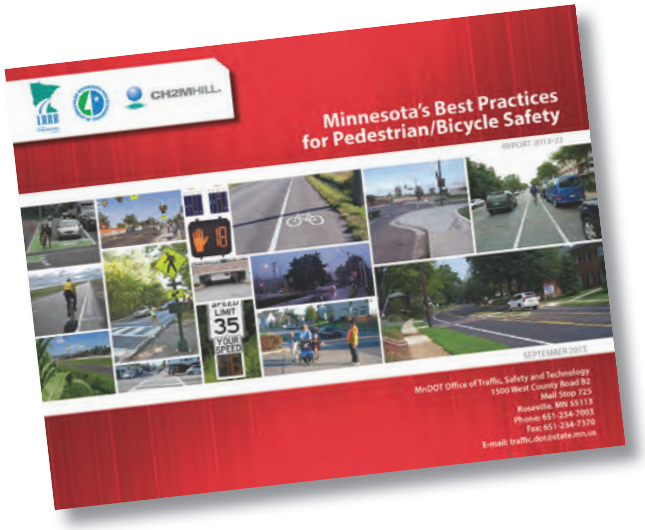
Pedestrian Safety Strategies



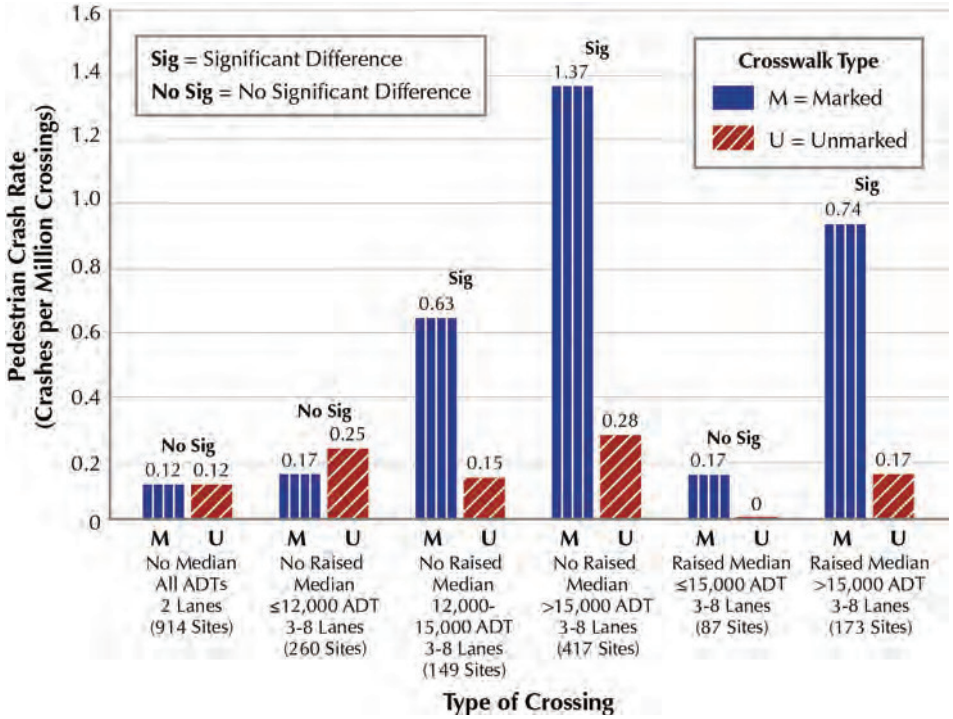
	Strategies	Pages	Crash Reduction/ Crash Features	Proven/Tried/ Experimental	Operational Effects (Mobility)	Candidate Locations	Design Features	Construction Costs
Pedestrian Safety Strategies	Sidewalks	1-2	50 to 90% reduction in "walking in roadway" pedestrian crashes	Proven	N/A	Urban arterials & collectors	Curb ramps, cross slope, buffer zones	$4 to $5 per square foot
	Crosswalks and Crosswalk Enhancements	3-8	Varies	Proven/Tried	N/A	Intersections	Should be part of package including crosswalk enhancements	$200 per crosswalk
	Medians and Crossing Islands	9-10	39 to 46%	Proven	May provide operational benefits	Wide 2-lane roads and multi-lane roadways	4 to 8 feet wide	$15,000 to $30,000 per 100 feet
	Curb Extensions	11-12	39 to 46%	Proven	Potential reduction in speeds	Urban arterials and collectors with curb parking	Roadway with parking or shoulder	$5,000-$10,000 per extension
	Pedestrian Hybrid Beacon System	13-15	60%	Tried	Additional delay for vehicles stopping for pedestrians	Mid-Block Crosswalk locations — Not at intersections	Pedestrian activated	$80,000
	Rectangular Rapid Flashing Beacon	16-17	78 to 100% yield to pedestrian rate	Tried	Additional delay for vehicles stopping for pedestrians	Mid-Block Crosswalk	Passive or active pedestrian activation	$10K to $15K
	Crosswalk Lighting	18-19	33 to 44%	Proven	N/A	Isolated crosswalks not along a continuously lit roadway	Require a power source	$10k to $25K per intersection
	Traffic Signals	20-22	Leading Pedestrian Interval — 60%	Tried	Increases delay and reduces mobility of major roadway	Intersections that meet signal warrants	Short cycle lengths, countdown timers, easy accessibility	New Signal - $175,000 to more than $300,000 per intersection

Highlights

- Fatal crashes involving pedestrians are one of AASHTO's Safety Emphasis Areas. In the U.S., there are about 5,000 pedestrians killed each year, which represents about 11% of all traffic fatalities.
- Minnesota averages about 37 pedestrian fatalities annually (about 9% of total traffic fatalities). The involvement rate (0.4 pedestrian fatalities per 100,000 population) ranks 47th – only Rhode Island, New Hampshire, and Idaho have a lower rate.
- Nationally, fatal pedestrian crashes most often occur in urban areas (67%), away from intersections (58%), and during good weather (85%). Over two-thirds of the pedestrians killed are male.
- The most common pedestrian activities associated with fatal crashes are walking/working in the road and crossing the roadway.
- Contributing factors associated with motor vehicle drivers include failure to yield right of way (35%) and driver inattention/distraction (21%).
- To better assist agencies in addressing pedestrian and bicycle safety concerns, MnDOT prepared *Minnesota's Best Practices for Pedestrian/Bicycle Safety*. The document identifies 19 common safety strategies, including crosswalk enhancements, new technologies, road diets, and speed reduction measures. A description is provided for each strategy, along with an overview of safety benefits, typical characteristics of candidate location, implementation costs, and a statement of what constitutes a "best" practice.
- Another resource that can provide assistance in developing pedestrian crossings is MnDOT Report 2014-21: Uncontrolled Pedestrian Crossing Evaluation Incorporating Highway Capacity Manual Unsignalized Pedestrian Crossing Analysis Methodology. This report provides an overview of previous safety research and presents a methodology for estimating the delay that a pedestrian would experience waiting for a safe gap in traffic based on roadway width and traffic volumes. Locations with short wait times would be considered low-priority candidates for crosswalk development and locations with long wait times would be high-priority candidates.

Pedestrian Safety – Crash Rates vs. Crossing Features

Charles V. Zegeer, et al., Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines, 1996-2001 (www.walkinginfo.org/pdf/r&d/crosswalk_021302.pdf)



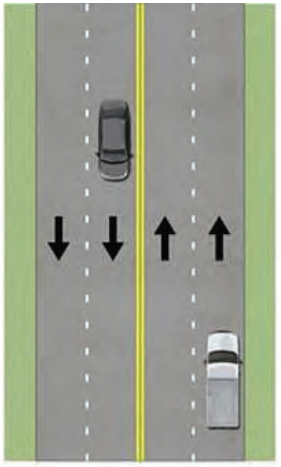
Highlights

- Three of the more common strategies intended to address pedestrian crashes include reducing vehicle speeds, providing a marked crosswalk, and installing a traffic signal.
- The research is abundantly clear – merely changing the posted speed limit has never reduced vehicle speeds, painting crosswalks at unsignalized intersections is actually associated with higher frequencies of pedestrian crashes, and installing a traffic signal has never been proven effective at reducing pedestrian crashes.
- Reducing vehicle speeds is associated with reducing the severity of a pedestrian crash, but actually reducing speeds requires changing driver behavior, which requires changing the roadway environment. Strategies that have demonstrated an effect on driver behavior include vertical elements (speed bumps and speed tables), narrowing the roadway (converting from a rural to an urban section), and extraordinary levels of enforcement.
- A cross-sectional study of 2,000 intersections in 30 cities across the U.S. found that marked crosswalks at unsignalized intersections are NOT safety devices. The pedestrian crash rate was higher at the marked crosswalks and this effect is greatest for multilane arterials with volumes over 15,000 vehicles per day.
- A before/after study at over 500 intersections in San Diego and Los Angeles found a 70% reduction in pedestrian crashes following the removal of marked crosswalks at uncontrolled intersections.
- Traffic signals have not proven to be effective at reducing pedestrian crashes – the highest pedestrian crash frequency locations in most urban areas are signalized intersections.
- Observations of pedestrian behavior at traffic signals suggests that there is a low level of understanding of the meaning of the pedestrian indications and a high level of pedestrian violations – very few push the call button and fewer yet wait for the walk indication.

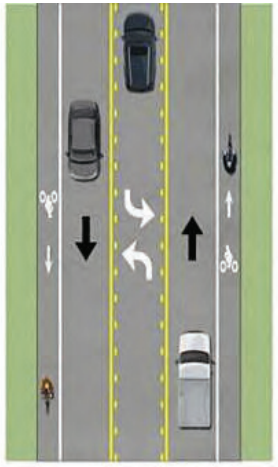
Pedestrian Safety–Curb Extensions and Medians

Median Refuge Near Intersection

Curb Extensions and Sidewalks



4-Lane Road



Road Diet (3 Lanes)

Highlights

- Pedestrian strategies that have proven to be effective include the following:
  - **Overpass** (in order to be effective, crossing the roadway at-grade must be physically prevented)
  - **Street Lighting**
  - **Refuge/Median Islands** – Reduces vehicle speeds at pedestrian crossing locations or intersections.
  - **Curb Extensions** – Reduces potential vehicle conflicts by reducing pedestrian crossing distance and time, and improves lines of sight.
  - **Sidewalks**
  - **Road Diets** (converting four-lane undivided roads to a three-lane cross-section) – Eliminates the multi-vehicle threat that can occur on four-lane roads.

Pedestrian/Bike Strategies

Highlights

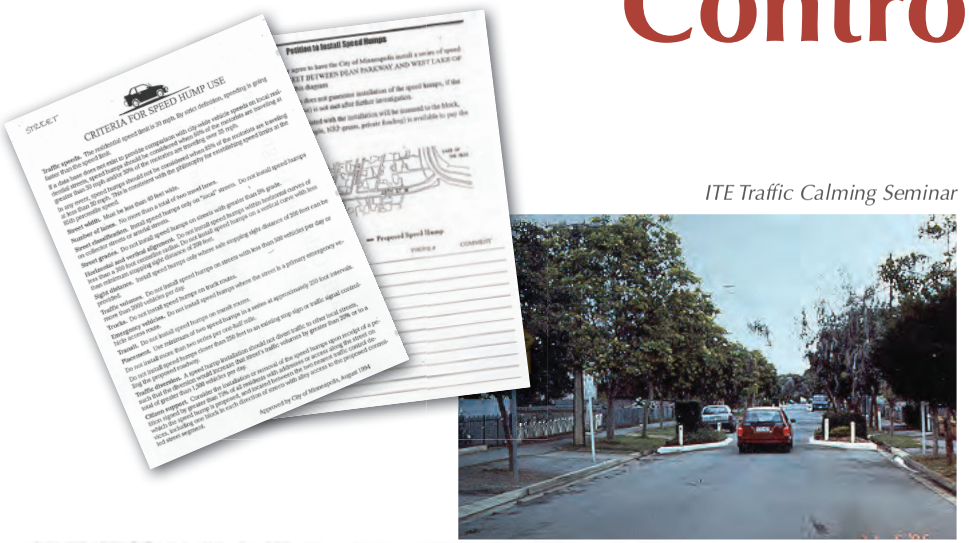
- Some more recent pedestrian and bicycle strategies include:
  - **Countdown Timers** – Countdown timers are flashing timers, usually installed with pedestrian indication lights, which provide the number of seconds remaining during the pedestrian phase.
  - **Leading Pedestrian Interval** – A leading pedestrian interval provides the pedestrian walk 2 or 3 seconds ahead of the vehicle green, allowing pedestrians a head start and the ability to enter the crosswalk before right-turning vehicles can turn into the crosswalk.
  - **HAWK Signals** – Should only be used in conjunction with a marked crosswalk and typically not at an intersection
  - **Bike Boulevards** – still considered experimental – however, one study looking at seven bike boulevards in Berkeley, found a 60% reduction in bicycle-involved crashes.

Complete Streets

Highlights

- Complete Streets is a transportation network approach, involving the provision of safe access for all street users, that must be considered during the planning and design phases of all roadway improvement projects. Complete Streets is neither proscriptive nor a mandate for an immediate retrofit; it is however, intended to be reflective of local needs and to serve adjacent land uses.
- MnDOT has a policy that requires the principles of Complete Streets to be considered on trunk highways at all phases of planning and project development in order to establish a comprehensive, integrated, and connected multimodal transportation system.
- A good phrase to summarize the need to determine the right locations to implement pedestrian and bicycle amenities is as follows: "Not all modes on all roads, right mode on right road."
- MnDOT's State Aid bicycle guidelines have been modified to allow designers greater flexibility in order to be able to fit bicycle facilities into constrained cross-sections found along existing roadways.

Neighborhood Traffic Control Measures



ITE Traffic Calming Seminar

Table 8.3. General Warrants. (Sarasota, FL)

Warrant	Major Collectors	Minor Collectors	Local Residential Streets
1. Minimum traffic volume	>8,000 vpd or 800 vph	>4,000 vpd or 400 vph	>1,000 vpd or 100 vph
2. Anticipated cut-through traffic	50%	40%	25%
3. 85th percentile speed	10 mph > speed limit	10 mph > speed limit	> speed limit
4. Pedestrian crossing volume	>100 per hour	>50 per hour	>25 per hour
5. Accidents per year	6	6	3

vpd = vehicles per day; vph = vehicles per hour
Source: Engineering Department, City of Sarasota, FL.

Table 8.4. Speed Hump Warrants. (Montgomery County, MD)

Criterion	Original	Interim	Present
Minimum volume	60 vph	100 vph	100 vph
Minimum 85th percentile speed Secondary street Primary street	 31 mph 34 mph	 31 mph 31 or 36 mph (depending on speed limit)	 32 mph 34 or 39 mph (depending on speed limit)
Minimum length of segment	None	1,000 feet	1,000 feet
Resident concurrence	67%	80% on treated street	80% on treated street 50% on side streets

vph = vehicles per hour; mph = miles per hour
Source: Department of Public Works and Transportation, Montgomery County, MD

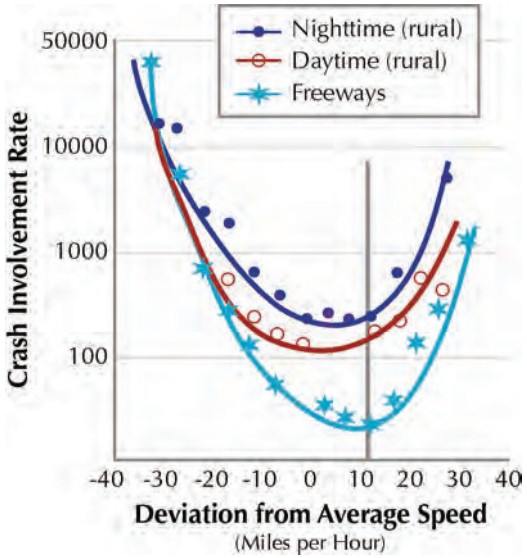
ITE, Traffic Calming - State of the Practice

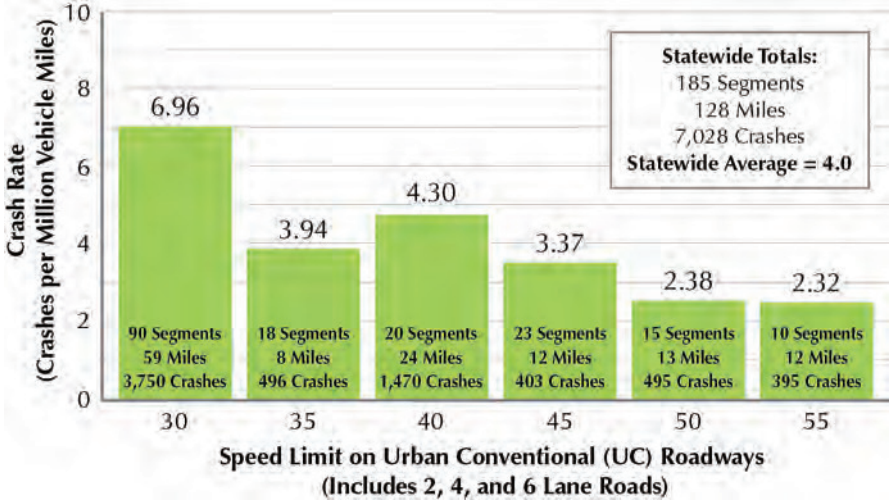
Highlights

- Neighborhood traffic control (traffic calming) usually involves applying design techniques and devices on local streets in order to modify driver behavior and traffic characteristics.
- The application of these devices are usually limited to residential streets, have been infrequently used on residential collectors, and should not be considered on arterials due to the presence of transit vehicles, trucks, and emergency responders.
- Typical techniques involve the use of signs, markings, road narrowing or diverters, vertical elements, and the use of technology to increase the enforcement presence.
- A few studies of the effectiveness of these devices have been conducted – the general conclusions are:
  - Speed humps/bumps are moderately effective at lowering speeds in the range of 3 to 7 mph in the immediate vicinity of the device. However, speeds between the devices have been observed to increase. It should also be noted that these devices are NOT allowed on any state-aided street or highway.
  - Adding STOP signs lowers speeds by about 2 mph, in the vicinity of the STOP sign, but also reduces compliance – a greater number of drivers completely disregard the sign than come to a complete stop. In addition, speeds in the segments between STOP signs have been observed to increase as drivers attempt to make up for lost time. One further point should be considered when evaluating the possibility of adding STOP signs for speed management - research has shown that low volume intersections with STOP control have a higher frequency of crashes than uncontrolled intersections.
  - Changing speed limit signs has never changed driver behavior.
  - Enforcement does change driver behavior - but the halo effect of enforcement may be as small as a few minutes, so a sustained effort is required.

www.ite.org/traffic/tcstate.asp

Speed Zoning





"Statistical relationship between vehicular crashes and highway access" Report: MN/RC–1998–27

Highlights

- There are two basic types of speed zones in Minnesota:
  1. Statutory speed limits established by the legislature – 30 mph on city streets, 55 mph on rural roads, 65 mph on rural expressways, and 70 mph on rural interstates.
  2. Speed zones established based on the results of an engineering study of a particular roadway. The legislature has assigned the responsibility for setting the speed limits in the zones to the Commissioner of Transportation.
- The premise underlying the establishment of speed limits is that most drivers will select a safe and reasonable speed based on their perception of the roadway's condition and environment. This has led to the practice of conducting a statistical analysis of a sample of actual vehicle speeds as part of a comprehensive engineering investigation.
- The two primary performance measures are:
  1. 85th percentile speed – The speed below which 85% of the vehicles are traveling.
  2. 10 mph pace – the 10 mph range that contains the greatest number of vehicles.
- Experience has shown that the most effective speed limits are those that are close to the 85th percentile speed and in the upper part of the 10 mph pace.
- The graph at the top of this page illustrates the relationship between vehicle speeds and crash rates. The data indicates that where vehicle speeds are in the range of 5 to 10 miles per hour above the average speed (which approximates the 85th percentile speed in most speed profiles) crash rates are the lowest.
- The graph at the bottom of this page illustrates the relationship between speed limit and average crash rates for urban highways on the State's system. This data indicates that in Minnesota crash rates go down as speed limits increase along urban highways.
- It should be noted that a similar relationship between speed limits and crashes is documented in the HSM. The same Minnesota research indicates that access density is a better predictor of urban crash rate than is the posted speed limit.

Speed Zoning

Speed Zoning Studies					
Study Location	Before	After	Sign Change +/- MPH	85% Before After	Change MPH
TH 65	SPEED LIMIT 40	SPEED LIMIT 30	-10	34 34	0
TH 65	SPEED LIMIT 50	SPEED LIMIT 40	-10	44 45	+1
Anoka CSAH 1	SPEED LIMIT 45	SPEED LIMIT 40	-5	48 50	+2
Anoka CSAH 24	SPEED LIMIT 30	SPEED LIMIT 45	+15	49 50	+1
Anoka CSAH 51	SPEED LIMIT 40	SPEED LIMIT 45	+5	45 46	+1
Hennepin CSAH 4	SPEED LIMIT 50	SPEED LIMIT 40	-10	52 51	-1
Noble Ave	SPEED LIMIT 30	SPEED LIMIT 35	+5	37 40	+3
62nd Ave N	SPEED LIMIT 35	SPEED LIMIT 30	-5	37 37	0
Miss. St	SPEED LIMIT 30	SPEED LIMIT 35	+5	39 40	+1

Minnesota Department of Transportation (MnDOT)

Highlights

- In Minnesota, state statutes assign the establishment of sped zones to the Commissioner of Transportation in order to achieve a consistency across all roads in Minnesota.
- Speed zones are established based on an analysis of existing vehicle speeds along a segment of roadway and a variety of other information including road cross-section, density of access, land use and other characteristics of the road environment.
- In a number of cases, local authorities have questioned the outcomes of the technical analysis and requested the posting of a lower speed limit. The table to the left illustrates the outcome of experiments that were conducted – the posted limits were changed and local agencies were invited to apply as much enforcement as staff levels would allow. The outcome was identical in all cases, driver behavior did not change.
- These experiments support the notion that a majority of divers pick a safe and comfortable speed based on their perception of the road environment and only changing the posted speed did not change their behavior.

Speed Reduction Efforts

Designing Roads That Guide Drivers to Choose Safety Speeds, Iran, J. & Garrick, N., Connecticut Transportation Institute, 2009

Summary of Impacts and Costs of Rural Traffic Calming Treatments

Treatment	Change in 85th Percentile Speed (mph)	Cost	Maintenance	Application
Transverse pavement markings [1]	-2 to 0	$	Regular painting	Community entrance
Transverse pavement markings [1] with speed feedback signs	-7 to -3	$$$	Regular painting	Community entrance
Lane narrowing using painted center island and edge marking	-3 to +4	$	Regular painting	Entrance or within community
Converging chevrons [1] and "25 MPH" pavement markings	-4 to 0	$	Regular painting	Community entrance
Lane narrowing using shoulder markings and "25 MPH" pavement legend	-2 to 4	$	Regular painting	Entrance or within community
Speed table	-5 to -4	$$	Regular painting	Within community
Lane narrowing with center island using tubular markers	-3 to 0	$$$	Tubes often struck needing replacement	Within community
Speed feedback sign (3 months after only)	-7	$$$	Troubleshooting electronics	Entrance or within community
"SLOW" pavement legend	-2 to 3	$	Regular painting	Entrance or within community
"35 MPH" pavement legend with red background (1)	-9 to 0	$	Background faded quickly; accelerated repainting cycle	Entrance or within community

[1] Experimental approval required per Section 1A.10 of MUTCD.

$ = under $2,500
$$ =$2,500 to $5,000
$$$ = $5,000 to $12,000

Traffic Calming on Main Roads Through Rural Communities, FHWA-HRT-08-067, Krammes, R., 2009

Highlights

- Beyond merely changing the posted speed limit, efforts to change driver behavior have focused on two approaches – added enforcement (remember – electronic enforcement is not allowed in Minnesota) and making changes to the road environment in order to adjust driver perception.
- The use of added enforcement (be sure to check with your local police/sheriff to determine if they have the resources to provide a higher level of enforcement) produces a high level of consistency with the posted limit BUT only when the officers are present. The spillover ("Halo") effect of enforcement has been observed to be as little as a few minutes and rarely as long as a week.
- One approach to changing driver perception of speed involves adding pavement markings (to provide an illusion of speed), reinforcing pavement messages, vertical elements and dynamic signing. The results of these attempts (see table) have proven, in most cases, to be very limited.
- A second approach to changing driver perception involves reconstructing the roadway to add design elements that reinforce the notion of an urban environment and lower speeds that are typical in these areas. A typical operating speed on a two-lane suburban road is in the 40 to 45 mph range but on a similar two-lane urban road with curb, gutter, and sidewalk, the typical operating speed drops to around 30 mph.