SCHOOL SAFETY ENGINEERING PROJECT

General Mitigation Measures—Final Report

NEW YORK CITY DEPARTMENT OF TRANSPORTATION
Office of School Safety Engineering
April, 2004

THE RBA GROUP

URBITRAN ASSOCIATES, INC.

EXECUTIVE SUMMARY

This report is a comprehensive 'toolbox' of mitigation measures that can be used to advance the goals of the School Safety Engineering Project. The list includes both traditional and non-traditional measures currently in use by the New York City Department of Transportation (NYCDOT), as well as new or innovative measures that have been developed and that are in use by other jurisdictions.

Inclusion of measures in this report should not be considered as justification for their inclusion at any specific location. Their application, as with any traffic control devices, is dependent upon site-specific conditions and engineering judgment.

The goals of this report are to provide informative and technical descriptions of measures that will enhance pedestrian safety around schools, and to provide technical design guidance and implementation strategies for users of this report—the consultant team and NYCDOT School Safety Engineering staff.

The sixty-six measures are organized in four chapters:

Roadway re-design—the entire right-of-way is considered: sidewalks, parking lanes, bicycle lanes, travel lanes, and crosswalks. Through re-design of the roadway, facilities or enhancements can be provided that improve the safety of pedestrians. New or upgraded traffic control devices, signs, and signals fall within this category, as well as sidewalks, crosswalks, and modifications to the roadway.

Active traffic calming—uses changes to the street geometry to improve conditions for non-motorized street users. These are physical measures that have been proven to be effective in reducing vehicle speeds and volumes. These measures include constrictions, horizontal deflection, vertical deflection, and volume control measures.

Safe routes to school—identifies sign, speed limit, and marking measures that are specific to schools and school zones, and are approved by the Federal Highway Administration in its *Manual on Uniform Traffic Control Devices*. Engineering approaches, such as signs and markings, are companioned with education, enforcement, and encouragement programs and events, that can educate students about walking safely to school, and enforce traffic regulations.

Passive traffic calming—provides visual or other cues that can encourage drivers to travel at slower speeds, such as color and texture, streetscape improvements, and integrated street design.

Each measure comes with a technical description, as well as information specific to its installation or application to New York City. Recommendations for the applicability of measures for a school safety program are given.

The appendix to the report includes specific information on maintenance issues, product information, and measures that are intended to mitigate specific types of pedestrian crashes. A matrix of measures and their effectiveness is included at the end of the report.

In addition to the recommendations provided herein, the following general guidance should be noted:

- Placement of street furniture is by revocable consent permit from the NYCDOT Bureau of Franchises, Concessions and Consents.
- For measures that require maintenance, such as landscaping, the entity providing maintenance must enter into a maintenance agreement with the City.

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INTRODUCTION

This report is a general discussion of traffic safety measures that could be used in the vicinity of schools. The mitigation measures presented in this document offer a range of actions—from simple programs to more costly capital investments—that can be taken to achieve the desired goal of improving a child's safety as he or she travels to and from school.

Suitability of a particular measure to a specific situation must be determined on a case-by-case basis. Engineering judgment must be used, and appropriate guidance, in the form of design manuals and standards, followed. This report is not a design manual; however, decades of experience in building, testing, operating, and maintaining traffic control devices and traffic management measures has created a wealth of reliable source material and design guidance for potential mitigation measures. This report relies upon some national sources on traffic calming and neighborhood traffic management, such as the City of Portland (Oregon) Office of Transportation, *The Pedestrian Facilities Users Guide* (FHWA, 2002), *Traffic Calming: State of the Practice* (ITE, 1998), *The Canadian Guide to Neighbourhood Traffic Calming* (ITE and Transportation Association of Canada, 1998), and *Making Streets that Work* (City of Seattle, 1996). Specific sources from New York City include the New York City Department of Transportation *Traffic Operations Manual for Borough Engineering* (TOMS), the NYCDOT *Traffic Safety Toolbox*, the *Downtown Brooklyn Traffic Calming Project Final Report*, and NYCDOT policy documents on specific measures.

A range of costs is provided for many of the measures included herein. Cost estimates are based on best current information from New York City and from other cities long experienced with traffic calming and other mitigation measures. These cost estimates should be interpreted as a rough guide, keeping in mind that differences in construction materials, practices, and standards may affect overall costs.

The appendix includes a matrix that identifies the most appropriate measure or measures to counteract specific safety concerns—turning vehicle at an intersection, for example.

Placing a physical device in the roadway may, in some cases, impact vehicular capacity and level of traffic service. It may also have an impact on street maintenance, particularly snow removal and street sweeping. Where appropriate, those impacts are described for each measure. A section on general maintenance issues, including snow removal, is included in the appendix to this report.

CHAPTER ONE: ROADWAY RE-DESIGN

The roadway consists of the entire right-of-way: sidewalks, parking lanes, bicycle lanes, travel lanes, and crosswalks. Through re-design of the roadway, facilities or enhancements can be provided that improve the safety of pedestrians. New or upgraded traffic control devices fall within this category, as well as sidewalks, crosswalks, and modifications to the roadway.

CONSTRUCT SIDEWALKS

Most city streets have sidewalks on both sides of the street. Where sidewalks do not exist along school walking routes, they should be installed. Sidewalks should be designed in accordance with NYCDOT standards and ADA requirements, with a minimum clear width of five feet for pedestrians, and pedestrian ramps at intersections, in accordance with NYCDOT, STANDARD DETAILS OF CONSTRUCTION, Standard Drawing No.H-1011-R88 (2). (See also *pedestrian ramps*). Where possible, sidewalks fronting schools or along school walking routes or at bus and subway stops should be wider than the minimum.

Where the curbside lane is a moving travel lane, wider sidewalks and a planting or utility strip of at least four to six feet should be provided between the edge of the sidewalk and the adjacent travel lane to separate pedestrians from passing vehicles, particularly on arterial roadways. The width and type of the buffer zone will vary according to the street type. In commercial districts, a utility strip/tree planting or street furniture program may be appropriate (trees may be planted in pits, but street furniture must be coordinated with an entity that will take on maintenance responsibility). Parked cars and/or bicycle lanes can provide an acceptable buffer zone.

Americans with Disabilities Act (ADA) Sidewalk Design Requirements

Width —a 5-foot minimum width is recommended
—a 4 feet minimum at obstructions (e.g., utility pole)
Cross-slope—2% maximum, for a width of at least 5 feet

Advantages

Sidewalks provide accommodation for pedestrians.

Disadvantages

Could change the 'rural' character of some residential communities in the city where sidewalks do not currently exist..

Cost Considerations

See NYCDOT Item No. 4.13 AA (4" concrete sidewalk, unpigmented) $4.30/S.F.
See NYCDOT Item No. 4.13 AB (7" concrete sidewalk, unpigmented) $5.25/S.F.

Note: Unit prices are from the New York City Department of Design and Construction (DDC) Bidscope Item Price List Report dated July 2002. Prices quoted are those used for capital reconstruction projects; the DDC Bidscope Report should be consulted for other types of construction such as roadway resurfacing or when and where contracts.

REMOVE OBSTRUCTIONS

23rd Street, Manhattan

Street furniture (lighting, signs, benches, planters, newspaper boxes, bicycle racks, information kiosks, bus shelters, telephone booths, etc.), trees and utility poles can become sidewalk obstructions if not placed judiciously and in accordance with current design standards. Additional obstructions in the sidewalk can include awnings, café seating, sandwich board signs, cars parked illegally, and people congregating.

The *Pedestrian Facilities Users Guide* (Federal Highway Administration Research and Development, Publication No. FHWA-ED-01-102, March 2002) lists the following guidelines regarding obstacles along the sidewalk:

> "The distance to the bottom of signs placed in or right next to a sidewalk should be at least 7 feet above the sidewalk surface to avoid injury to pedestrians. Bushes, trees, and other landscaping should be maintained to prevent encroachment onto the sidewalk. Jurisdictions should adopt ordinances requiring local property owners to trim the landscaping they place along their frontage to maintain clear and unobstructed sidewalks. The jurisdictions should provide an inspection procedure or a system of responding to sidewalk encroachment and maintenance complaints."[1]

Another FHWA-sponsored school safety report states that, in school zones, transit stops, news vending boxes, mailboxes or on-street parking should be avoided between the school drop-off zone entrance and exit points along the school frontage.[2]

Keep sidewalk areas clear of unnecessary obstructions, and do not permit streetscaping elements to interfere with walking paths.

Advantages

Removal of sidewalk encroachments and obstructions will result in improved mobility for users of the sidewalk as well as improved visibility between motorists and pedestrians.

Disadvantages

It may be difficult to assign responsibility for each obstruction to the appropriate organization and to orchestrate their removal or relocation. However, street furniture or sidewalk cafés are placed under revocable consent or by permit from NYCDOT. In the case of private aboveground utilities, the cost to bury the utilities is usually prohibitive, and results in some cost to adjacent property owners. Regarding newsracks, a recent

[1] *Pedestrian Facilities Users Guide*, p. 150
[2] *Survey of Traffic Circulation and Safety at School Sites*, ITE for FHWA, 1998, p. 2

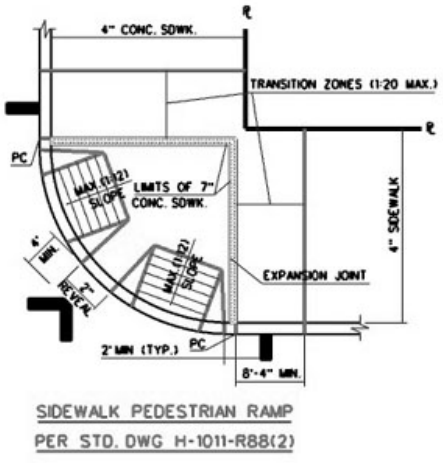
(February 2003) law took effect in New York City regulating the placement, installation, and maintenance of newsracks on city sidewalks. The goal of the law is to ensure that the right of publishers to disseminate information through newsracks is balanced with the safe and orderly use of city sidewalks. It is NYCDOT's responsibility to oversee the placement and maintenance of newsracks on the city's sidewalks.[3]

Recommendation

Ensure that the corner quadrant is clear of all utility poles and street furniture. Where possible, place street furniture to minimize obstruction to pedestrians, and give consideration to the removal of encroachments if the sidewalk width is less than 4 feet along school walking routes.

[3] New York City Department of Transportation website

PEDESTRIAN RAMP



NYCDOT standard drawing for pedestrian ramp.

Pedestrian ramps (wheelchair ramps, curb ramps) provide access to the sidewalk from the roadway for people using wheelchairs, strollers, walkers, crutches, handcarts, and also for pedestrians with mobility impairments who have trouble stepping up and down curbs. Pedestrian ramps must be installed at all intersections and mid-block locations where pedestrian crossings exist, as mandated by federal legislation (1973 Rehabilitation Act). Wheelchair ramps must have a slope of no more than 1:12 (must not exceed 1 in/ft) or a maximum grade of 8.33 percent), with a maximum side slope of 1:10, and must be designed in accordance with the ADA guidelines and NYCDOT Standard Details of Construction ref. H1011.

Provide two pedestrian ramps per corner, located to facilitate pedestrian movement straight through the crosswalk. This allows improved orientation for visually impaired pedestrians and generally facilitates the desired walking path of most pedestrians (where one ramp serves two crosswalks, pedestrians must face the center of the intersection to descend the ramp). Tactile warnings may be placed along the bottom 2'-0" of the ramp to alert visually impaired pedestrians to the sidewalk/street edge. All newly constructed sidewalks must include pedestrian ramps. For more information about curb ramp design, see *Designing Sidewalks and Trails for Access, Part I*, by the Federal Highway Administration, and *Accessible Rights-of-Way: A Design Guide*, by the U.S. Access Board and the Federal Highway Administration.

Advantages

Pedestrian ramps provide access to street crossings.

Disadvantages

Aggressive texture patterns may be problematic for persons with neurological disorders.

Cost Considerations

$2,000 per corner (approx.).

WIDEN SIDEWALKS

A widened sidewalk on The Avenue of the Americas, Manhattan

Widening sidewalks by reapportioning space within a fixed right-of-way (ROW) can only be accomplished by narrowing the width of the roadway (as measured from face of curb to face of curb). Doing so will typically require narrowing or possibly eliminating parking and/or travel lanes. This can adversely affect the capacity and other operational characteristics of the road. It may also, however, lower travel speeds, a benefit to pedestrian safety. Capacity or parking analysis should be performed to assess impacts to motor vehicles (where a lane is being removed). After effects should be monitored to determine if the roadway continues to operate at an acceptable level of service and to ensure that new traffic problems are not created on neighboring residential streets.

Advantages

Wider sidewalks provide increased walkway capacity, and can enhance Pedestrian Level of Service (LOS). (See AASHTO's *Geometric Design of Highways and Streets*, Chapter II, for calculation of Pedestrian LOS). This is especially important at busy intersections where low sidewalk storage capacity resulting from narrow sidewalks can cause pedestrians to spill out into the roadway while waiting for long light cycles. Widened sidewalks can accommodate planting strips where street trees may be planted. They can also accommodate implementation of a coordinated street furniture package.

Disadvantages

Cost: Requires full-depth reconstruction of a portion of the roadway and associated disruption to the community. May require reconstruction of the drainage system and re-routing of underground utilities.

Cost Considerations

Widening a sidewalk can cost $100,000 or more per mile.[4]

Approximate cost of a 5-foot sidewalk widening at the curbside would be upwards of $30,000 for a 400-foot long block in New York City. When sidewalks are widened in conjunction with a planned capital construction project, there is no additional cost incurred.

[4] *Pedestrian Facilities Users Guide*, March 2002.

STREET LIGHTING


An example of roadway lighting and pedestrian lighting, on the same light pole. Route 9A, Manhattan

A good quality, well-designed roadway lighting system can improve pedestrian comfort and safety. Pedestrians often assume that motorists can see them at night; they are deceived by their own ability to see the oncoming headlights. Without sufficient overhead lighting, motorists may not be able to see pedestrians in time to stop. Roadway lighting must be designed in accordance with NYCDOT design standards and illumination requirements. Place poles along both sides of the street for maximum uniformity of illumination.

In autumn and winter months there may be nighttime pedestrian activity in and around schools. Depending on the extent of this activity, consideration may be given to augmenting the street lighting system at schools and school crossings as well as providing supplemental pedestrian level lighting.

Schools in commercial areas may be candidates for specialty pedestrian-level lighting.

Expertly designed lighting systems can also deter crime and alleviate the fear of crime.

Advantages

Lighting enhances the safety of all roadway users, particularly pedestrians. It improves nighttime security, and enhances nighttime aesthetics, particularly in commercial areas.

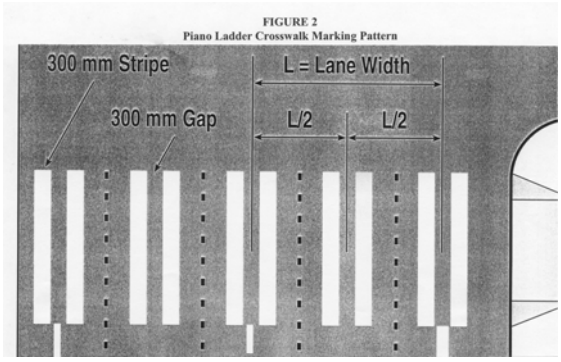
Disadvantages

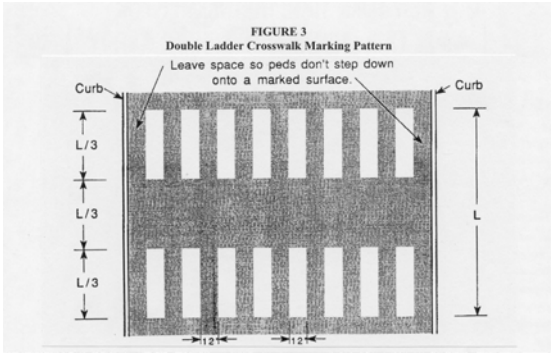
Lighting can be expensive and requires maintenance. Fixture types and maintenance provisions must be coordinated with and approved by the NYCDOT Division of Street Lighting. Lighting can also diminish quality of life in residential neighborhoods if appropriate light levels are exceeded. Lighting is not a substitute for law enforcement in areas where crime is an issue.

Design Considerations

The B-pole is the NYCDOT pedestrian light standard.

CROSSWALK STRIPING AND MATERIALS





GENERAL INFORMATION

Description

High visibility crosswalks should be used to improve safety and to emphasize the recommended path for crossing an intersection. NYCDOT drawing TCW-1 (page 12) shows typical pavement markings for 90-degree and angled intersections. The drawing shows the difference between a regular crosswalk, a school crosswalk, and a high visibility crosswalk, including specified thickness, spacing, and orientation of markings.

The figure above at left shows an alternative 'piano' style marking for high visibility markings, where the bars of the ladder are placed in a pattern that avoids the typical wheel paths of crossing vehicles. The crosswalk should be at least 10 feet wide. Where the crosswalk is to be 15 feet wide or wider, a double ladder or double piano style crosswalk may be installed, as shown in the figure at right, above. This involves eliminating the middle portion of the ladder bars and maintaining only the 5 feet on either side of the crosswalk. Splitting the crosswalk lengthwise into two halves in this fashion is less expensive—it results in the application of less thermoplastic and requires less maintenance. It also provides an unmarked walking surface in the middle of the crosswalk that is not slippery when wet. This can help prevent cars from skidding on the pavement marking material into the intersection as well as reducing the incidence of bicycles slipping on pavement markings while turning corners. Double ladder crosswalks have been proven to be as visible as traditional ladder style crosswalks.

Crosswalk Materials

At least four types of crosswalk marking materials are in use in localities around the United States. Cost effectiveness and durability vary by type of material and location. Traffic paint is the most common and least expensive. Tape is also commonly used, as is thermoplastic. Less commonly used is methylmethacrylate (MMA).

Traffic paint: this is solvent-based, often lead-based paint, that is applied, sometimes in multiple layers, to the roadway for markings. Small glass beads are sometimes placed on top of the paint while it is still wet, causing the beads to adhere to the surface. The difference in the index of refraction between the glass and the paint forms a spherical mirror that acts as a retroreflector, bouncing light back to its source, and increasing the reflectivity of the marking. Markings created with traffic paint are the least durable, and

must be repainted as often as annually. Slick, coarse silica sand is sometimes added to compensate.

Tape: is frequently installed on new and resurfaced streets. It is highly reflective, durable, and slip-resistant, and does not require a high level of maintenance. It can be cold applied, as opposed to thermoplastic (see below). It is more visible and less slippery than paint when wet. Many localities specify inlay tape as the preferred marking material for crosswalks.

Cold-applied plastic pavement marking tapes are supplied in continuous rolls of various lengths and widths, or in sheets from which special shapes, forms, or letters can be customized. These preformed tapes can be supplied in yellow or white.

Pre-formed tapes are most frequently used for crosswalks, stop bars, words and symbols, and other specialized treatments. As with the hot-applied thermoplastic, cold-applied preformed tapes are reported to perform better on bituminous asphalt surfaces than on Portland cement concrete (PCC). Preformed plastic tapes are generally recognized for their durability, especially abrasion resistance.

One of the main reasons that preformed tapes, though highly durable, have not been used more is their high cost and their lack of good retro-reflectivity throughout their service lives. Most tapes are so lacking in adequate night visibility that many state highway agencies specify their use only on well-illuminated roadways. This significantly restricts their use.

Thermoplastic: is a durable material that is a combination of glass beads, binder, pigment and filler materials. It becomes liquid when heated, and bonds with the hot roadway surface to which it is applied. Thermoplastic is being used with greater frequency for roadway markings, including pedestrian crosswalks. It is the typical treatment used by NYCDOT. Though it may cost as much as fifteen times as much as traffic paint, its durability is approximately twenty times as great, making it more cost effective. The roadway surface must be heated to 400 degrees Fahrenheit before thermoplastic can be placed, as the heat of the surface helps to create and seal the bond of the material with the roadway. Thermoplastic is NOT recommended for use on PCC until at least one year after the road surface has been in place. New, lower temperature construction methods have recently been tested (Oregon DOT, June 2002) which may reduce by 20% the installation cost of thermoplastic.

Methylmethacrylate (MMA): is specified by the Washington State Department of Transportation for crosswalk markings. It is more durable than thermoplastic, and is a non-hazardous cold-curing material. It can be installed at a variety of temperatures, and can be sprayed or extruded. It bonds well with PCC. It cannot be applied using standard stripers, but, like thermoplastic, it requires specialized installation equipment. Regarding performance, MMA is designed to be resistant to oils, antifreeze, and other common chemicals found on the roadway. The service life of MMA is from three to ten years, according to tests performed.[5]

[5] *Roadway Delineation Practices Handbook*, Federal Highway Administration, 1994, pp. 123-129.

LOCATION, PLACEMENT, EFFECTIVENESS

Locations

It is New York City DOT policy that at locations where the number of pedestrians average more than fifty per hour for an eight-hour period, marked crosswalks (regular or high visibility) may be installed.

NYCDOT installs marked crosswalks only at intersections where it is lawful and safe for pedestrians to cross. School crosswalks should be placed at all controlled crossings on a school walking route. Outside of school walking routes, regular crosswalks are placed at signalized or stop-controlled intersections; high visibility crosswalks are placed at signalized or stop controlled intersections with substantial vehicular/pedestrian conflict, or to direct pedestrians to the preferred leg of the crosswalk.

In keeping with the *Manual on Uniform Traffic Control Devices*, a stop bar should be placed in advance of the marked crosswalk (see *advanced stop bar*).

Because mid-block pedestrian crossings are generally unexpected by the road user, warning signs should be installed and adequate visibility should be provided by parking prohibitions.

Locations to avoid

Do not use crosswalk lines indiscriminately. Perform an engineering study before crosswalks are installed at uncontrolled locations. Crosswalks at unsignalized or otherwise uncontrolled mid-block locations are not recommended.

BENEFITS

Other

The ladder 'piano' style pattern requires less maintenance if painted to allow the tires of motor vehicles to track between the painted lines.

DISADVANTAGES

Moderate disadvantages

If a 'high visibility' pattern is used at every crosswalk, its impact is diminished and the desired effect will be lost.

MAINTENANCE

More maintenance is required for high visibility and school crosswalks than for the standard parallel bars alone.

COST CONSIDERATIONS

Item 6.44: 4" thermoplastic markings—$0.60 /linear foot.

Cost of a 12' wide school crosswalk on a 30' wide roadway is: $ 350.

Cost for fluorescent thermoplastic (4" wide): $0.65 to $0.78/linear foot (does not include installation).

DESIGN CONSIDERATIONS

General considerations

The following guidance is from the *Manual on Uniform Traffic Control Devices*:

> For added visibility, the area of the crosswalk may be marked with white diagonal lines at a 45-degree angle to the line of the crosswalk or with white longitudinal lines parallel to traffic flow...
> When diagonal or longitudinal lines are used to mark a crosswalk, the transverse crosswalk lines may be omitted. This type of marking may be used at locations where substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired, or at places where a pedestrian crosswalk might not be expected.
> If used, the diagonal or longitudinal lines should be 12 to 24 in (300 to 600 mm) wide and spaced 12 to 24 in (300 to 600 mm) apart. The spacing design should avoid the wheel paths.[6]

Signing and pavement marking requirements

See above.

New York City school crosswalk markings.

NYCDOT Policy

High-visibility crosswalks should be installed at:

- Complex intersections
- Mid-block crossings
- Authorized school crosswalks (ladder design, as shown above.)

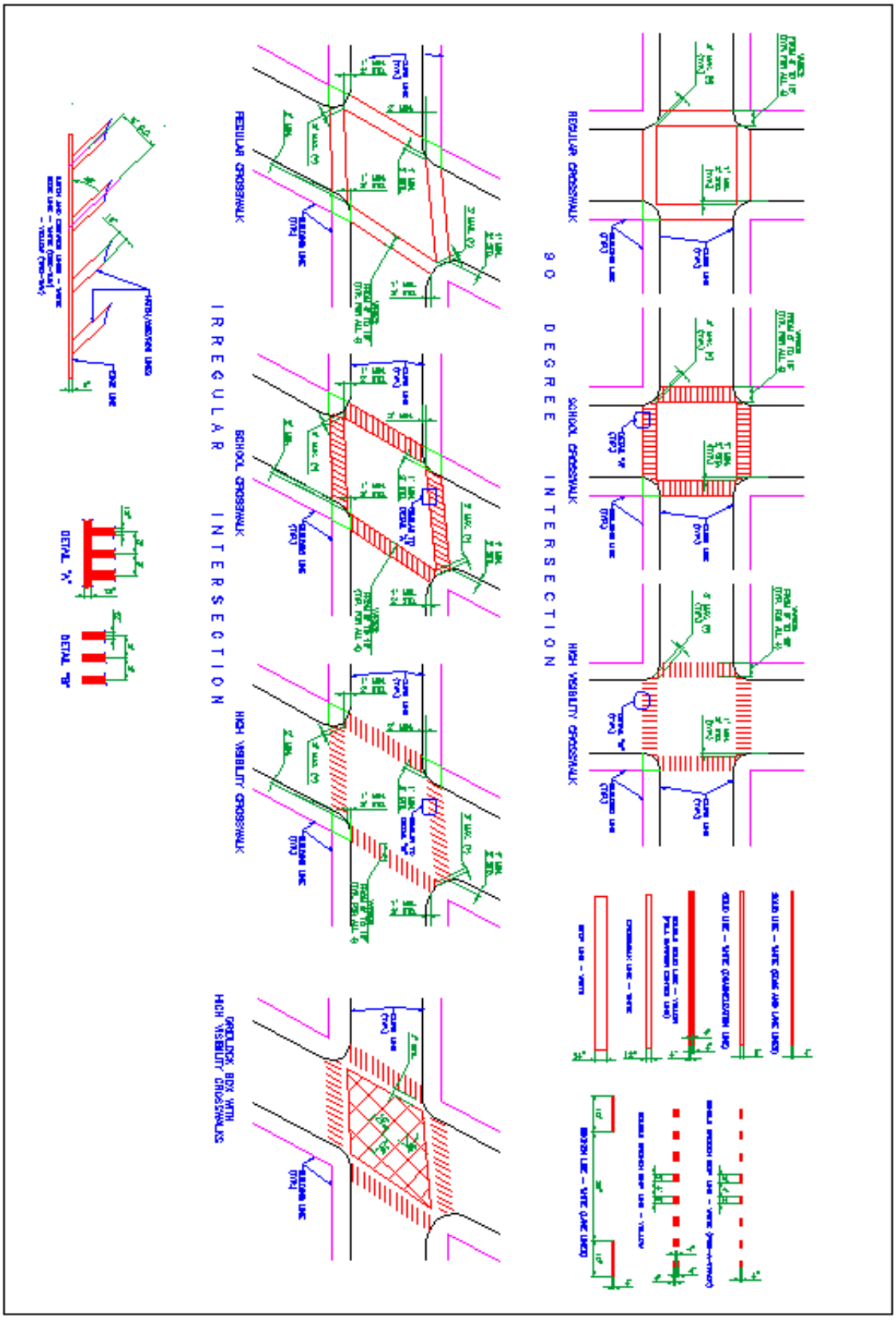
In addition, high-visibility crosswalks should be considered on a case-by-case basis at the following areas:

- Intersections with poor geometric alignment
- High-volume pedestrian crossings
- Shopping districts
- Transportation terminals
- Subway entrances/exits (especially at bus transfer points).

RECOMMENDATION

A school crosswalk—the high-visibility crosswalk accompanied by the parallel lines of the regular crosswalk—is already in use by NYCDOT. Continued use of this measure is recommended for all crosswalks on a school walking route, along with communication or a campaign to notify students and the public of the meaning of this type of crosswalk.

[6] *Manual on Uniform Traffic Control Devices*, page 3B-35, December 2000.



Drawing TCW-1, NYCDOT

ADVANCED STOP BAR

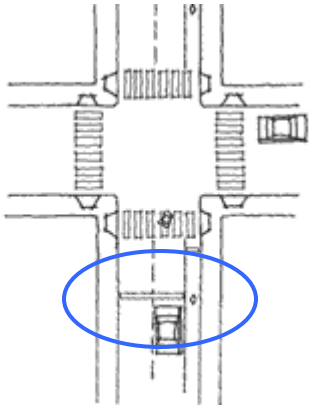


Image: Pedestrian Facilities Users Guide

Description

The MUTCD and NYCDOT standard for placement of a stop bar is 4 feet in advance of a marked crosswalk. At signalized intersections and controlled mid-block crossings, the vehicle stop line can be moved farther back from the pedestrian crosswalk for an improved factor of safety and for improved visibility of pedestrians. In some places, particularly Canada and the United Kingdom, the stop line has been moved back to 10 to 20 ft. from the marked crosswalk, with considerable safety benefits for pedestrians.

The advanced stop bar allows pedestrians and drivers to have a clearer view of each other and more time in which to assess each other's intentions. The effectiveness of this measure depends upon whether motorists are likely to obey the stop line, which varies from locality to locality.

Advanced stop lines are also applicable for non-signalized, controlled crosswalks on multi-lane roads to ensure that drivers in all lanes have a clear view of a crossing pedestrian. In some locations, a wider crosswalk may be an effective alternative.[7]

Effectiveness

A study of three Canadian cities found that use of an advanced stop bar, in combination with the use of a warning sign, 'STOP HERE FOR PEDESTRIANS' (placed at 50 ft. before each side of a crosswalk traversing a multi-lane arterial highway), reduced pedestrian-vehicular conflicts by 90 percent compared to baseline levels.[8]

Advantages

Improves visibility of pedestrians to motorists.

Allows pedestrians to proceed in a crosswalk before motor vehicles turn.

There is no extra cost when the recessed stop line is installed on new paving or during repaving. A 'STOP HERE' sign can be used to supplement the recessed stop line.

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[7] *Pedestrian Facilities Users Guide*, FHWA, March, 2002.

[8] Van Houten, Ron, and J. E. Louis Malenfant, *Canadian Research on Pedestrian Safety*. Federal Highway Administration Publication No. FHWA-RD-99-090. December 1999, pp. 11-12.

Disadvantages

Effectiveness depends on motorist compliance with the marked stop line.

Recommendation

For all crosswalks on school walking routes, the stop bar should be placed ten feet in advance of the crosswalk to maximize the safety benefit for school-aged pedestrians.

MID-BLOCK CROSSWALK

A signalized mid-block crosswalk on 125th Street in Manhattan.

Mid-block crosswalks or crossings are used in areas where the distance between intersections exceeds the distance that a pedestrian can be reasonably expected to walk. Mid-block crosswalks may also be found where two high pedestrian-generating uses are on opposite sides of a street. They may be accompanied by a center median and neckdowns.

Advantages

A mid-block crosswalk shortens the distance that a pedestrian needs to walk in order to find a marked crossing. It works well where the crossing distance is long and pedestrians are looking for a safe crossing area (e.g., Queens Boulevard).

Disadvantages

If not placed well, pedestrians may ignore the crossing and still cross at any spot. Extra illumination is needed for mid-block crosswalks. Mid-block crosswalks must be signalized where a control exists, or meets a warrant for the control.

Cost Considerations

$27,000 per mid-block crossing with neckdowns. The unit cost for a mid-block crossing is the same as the unit cost for necking down two corners of an intersection. Mid-block crossing costs include the cost to reconstruct the sidewalk, relocate the steel-faced curb, and relocate catch basins at sites where drainage is toward the mid-block crossing. Additionally, NYCDOT should confirm that a signal is warranted where a signalized mid-block crossing is proposed.

Recommendation

Consider signalized mid-block crosswalks where the need has been proven, i.e., long blocks with a high mid-block pedestrian generator. Also, do not install mid-block crossings with striping only. Consider extra signs on the approaches, as well as text messages marked on the pavement.

Unsignalized or otherwise uncontrolled mid-block crossings are not recommended.

ILLUMINATED CROSSWALK

Kirkland, Washington. Images courtesy of King County Washington, www.metrokc.gov

Overhead illuminated crosswalk signs may be installed at unsignalized or otherwise uncontrolled marked crosswalks when there is demonstrated use of the crosswalk during low-light times of day and existing overhead roadway lighting and/or roadway geometry does not provide adequate stopping sight distance in advance the crosswalk.

Two of these signs are required for each crosswalk and are positioned over the center of the approach lane(s) with a backlit illuminated 'CROSSWALK' sign (accompanied by flashing beacons) at the center of the roadway. As well as helping to indicate the location of the crosswalk at night, the illuminated sign can also be designed to provide some additional nighttime illumination throughout the crosswalk area.[9]

Illuminated overhead crosswalk signs, typically erected at high-visibility ladder style crosswalk markings and accompanying warning signs, are still experimental in the United States. Supplemental advance warning signs may also be considered for use when vehicular approach speeds are high, when visibility of the crosswalk is limited and/or where there is a history of pedestrian related accidents.

Advantages

These devices have been tested at very dangerous crossings, and have been shown to increase crosswalk usage by pedestrians, as well as increase driver awareness of the crosswalk. They have also been shown to increase driver compliance with yield-to-pedestrian requirements. An increase in daytime driver compliance with yield-to-pedestrian requirements of between 30 and 40 percent has been associated with installation of this type of sign. An 8 percent increase in nighttime driver yielding compliance was observed.

A 35 percent increase in crosswalk usage by pedestrians was noted along with no change in pedestrian overconfidence, running, or conflicts. It was concluded that the high-visibility crosswalk treatments had a positive effect on pedestrian and driver

[9] Municipality of Halifax, Nova Scotia: www.region.halifax.ns.ca/traffic/Reports/OverheadCrosswalk.htm

behavior on the relatively narrow low-speed crossings that were studied. Additional testing is needed to determine if they will also have a desirable effect on wider, higher-speed roadways.[10]

Cost

Approximately $15,000-$25,000 for each installation, including materials and labor.[11]

[10] *An Evaluation of High Visibility Crosswalk Treatment—Clearwater, Florida*, Federal Highway Administration FHWA Report No. RD-00-105, August 2001

[11] City of Kirkland, WA, Department of Public Works, staff memorandum, December 13, 2002.

PEDESTRIAN BRIDGES/UNDERPASSES

Pedestrian underpass below FDR Drive at Glick Park, Manhattan.

Pedestrian overpasses and underpasses are engineered structures that allow for the uninterrupted flow of pedestrians where at-grade crossings are unsafe or technologically infeasible. They tend, however, to be very expensive. Where pedestrian safety due to high vehicular speeds is the issue, it may be more appropriate to try slowing vehicular speeds through the use of traffic-calming measures or install a pedestrian-activated signal that is accessible to all pedestrians. Bridges and tunnels can also be visually intrusive measures subject to rigorous aesthetic design reviews, particularly in areas of historic significance. Attention to aesthetic issues such as amenities, materials and method of construction can dramatically affect the cost of the structure.

Bridges and tunnels must accommodate all persons, as required by the ADA. They typically require construction of ramps and/or elevators adding to both the cost and the aesthetic challenges.

Studies have shown that many pedestrians will not use an overpass or underpass if they can cross at street level in about the same amount of time. Overpasses work best when the topography allows for a structure without ramps. An example of this is an overpass over a sunken highway, such as those over the transverse drives in Central Park.

Underpasses work best when designed to feel open and accessible. The user should be able to see clear through to the exit on the far side well in advance of actually entering the tunnel to feel safe. Artificial lighting should be considered for both overpasses and underpasses. Grade separation is most feasible and appropriate in extreme cases where pedestrians must cross roadways such as highways or high-speed, high-volume arterials. As an example, a pedestrian bridge has been placed over NYS Route 9A (the West Side Highway in Manhattan) at Chambers Street, to provide a safer crossing for students of Stuyvesant High School.

The TriBeCa Bridge crosses the West Side Highway and connects to Stuyvesant High School, Manhattan.

Advantages

Bridges or underpasses provide complete separation of pedestrians from motor vehicle traffic, and provide crossings where no other pedestrian facility is available. Bridges or underpasses can connect sidewalks across major physical barriers.

Disadvantages

Cost. Most appropriate over busy, high-speed highways, railroad tracks, or natural barriers. Pedestrians will not use these facilities if a more direct route is available. Lighting, drainage, graffiti removal, and security are also major concerns with underpasses. Facilities must be wheelchair accessible, which generally results in long ramps on either end of the overpass, or elevators.

Cost Considerations

$500,000 to $4,000,000, depending on site characteristics.[12]

[12] *Pedestrian Facilities Users Guide*, March 2002.

PEDESTRIAN FENCES AND BARRIERS

Pedestrian fences at intersection crossings, West 34th Street and West 23rd Street, Manhattan.

The preferred treatment to a dangerous pedestrian crossing consists of modifying or reconstructing the roadway to make it safer for pedestrians to cross. However, in extreme cases where this is not practical, it may be necessary to prohibit certain pedestrian crossings. Since signs ('DO NOT CROSS HERE') are often ineffective, consider barriers or fences to direct the pedestrian away from hazardous crossings.

Purpose

To protect pedestrians from collisions with motor vehicles by:

- safely directing pedestrians to crosswalks controlled by signals or other traffic control devices and away from intersections or mid-block locations where crosswalks do not exist;
- preventing pedestrians from entering roadways where frequent unlawful crossings occur;
- defining appropriate locations for pedestrians to assemble.

Considerations

Pedestrian fences should be considered when:

- there is a need to better manage pedestrian movements;
- accident analyses demonstrate a pedestrian safety issue;
- alternatives to pedestrian fences have been explored and found unsuitable.

In addition the impact of pedestrian fences on the following factors needs to be considered:

- visibility of pedestrians or motorists, especially at non-signalized intersections;
- loading and unloading of goods;
- passenger loading and unloading;
- pedestrian and vehicular level of service;
- access for fire, ambulance, police or other emergency vehicles;
- sidewalk access for persons parking their vehicles;
- bus stops;

- fire hydrants, utility access and other street furniture.

Design Issues

When a pedestrian fence is installed along a roadway median, a 1 to 3 foot clearance should be maintained on each side of the pedestrian fence so that pedestrians are not physically 'trapped' in the roadway.

The height of a pedestrian fence within forty feet of a non-signalized intersection or slip ramp, where limitations in visibility could adversely affect safety, should not exceed 26 inches.

Near slip openings, pedestrian fences may be considered on the center median or along the block face to lessen the likelihood of pedestrians crossing near a slip.

Pedestrian fences should be installed on both sides of a roadway to promote safe crossing from either direction.

Pedestrian fences should avoid having horizontal members that may act as a ladder for crossing the barrier.

In cases where a pedestrian fence is on a sidewalk adjacent to an active land use, the fences should be designed so that they can be easily removed and replaced in the event of special events.

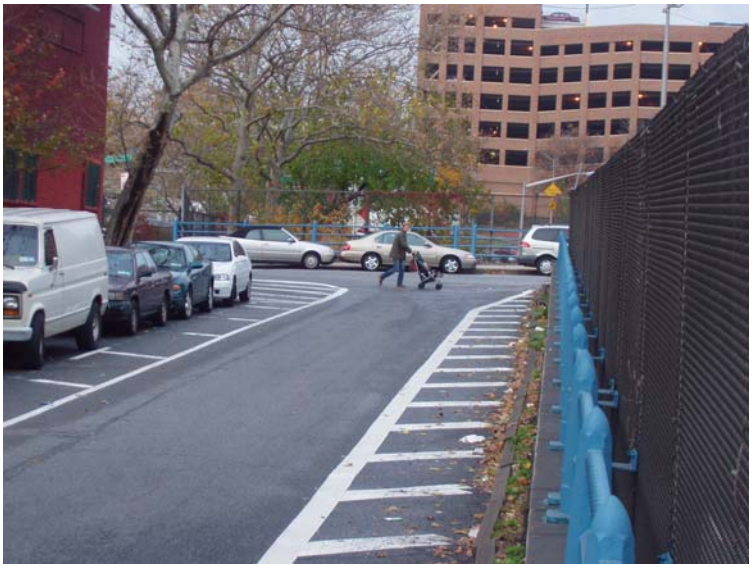
Pedestrian fences may be used in conjunction with raised planters; however, the maintenance of fences on planted malls should be the responsibility of the Department of Parks and Recreation.

Two possible pedestrian barrier treatments are steel railings or decorative concrete planters. The steel railing is the most common treatment used to prohibit mid-block crossings, and is typically three feet high. Concrete planters are less commonly used. The planters are typically two to three feet high, and, when properly landscaped and regularly maintained, are attractive and enhance the beauty of an area. Low planting materials will not impede visibility.

Recommendation

Barriers may be justified at locations with high volumes of right-turning vehicles at high speeds, particularly where school-aged children cross regularly. Barriers are also justifiable at locations where the combination of travel speeds and limited motorist sight distance make pedestrian crossings dangerous.

REDUCE NUMBER OF LANES / 'ROAD DIET'



Hicks Street, Brooklyn

Some roads have more travel lanes (capacity) than necessary and are difficult to cross because of their width. Traffic lanes can be transformed into bicycle lanes. Reducing the number of lanes on a multi-lane roadway and converting that space to a sidewalk or median can reduce crossing distances for pedestrians and may slow vehicle speeds. A traffic analysis should be done to determine whether the existing number of lanes on a roadway is appropriate. Level-of-service analysis for intersections should not dictate the design for the entire length of roadway. For example, a four-lane undivided road can be converted to one through lane in each direction, with a raised landscaped median with turning bays and bicycle lanes on both sides of the roadway. Turning bays may be needed only at specific locations.

Depending on conditions, it may also be possible to add on-street parking while allowing for bicycle lanes on both sides of the street, instead of a landscaped median with turning bays. Where width permits, a landscaped buffer will separate pedestrians from the travel lane.

In New York City, a recent road narrowing of Greenwich Street in Manhattan narrowed the roadway from three moving lanes to two, with the additional space converted to a landscaped pedestrian area on the west side of the street. In this instance, the crossing distance for pedestrians accessing P. S. 234 was reduced from 68 feet to 38 feet.

Some jurisdictions have adopted a typical three-lane configuration (two travel lanes and a center turn lane), which also has advantages for motorists. Through traffic can maintain a fairly constant speed, while left-turning drivers can enter the center turn lane to wait. Road diet conversions have been successfully implemented on roads with up to 23,000 average daily traffic (ADT) volumes. They work on the principle that more traffic can pass a given point at slower speeds because of the elimination of 'turbulence' in the traffic stream caused by left turns at intersections and aggressive drivers taking advantage

of the two lanes in each direction. Slower, calmer traffic allows motorists to drive close to one another more confidently and comfortably.

Advantages

Reducing the number of travel lanes can remedy a situation where there is excess capacity, and provide added space for pedestrians, bicyclists, or parked cars. Also, this will reduce pedestrian crossing distance and help optimize signal timing.

Disadvantages

Four-lane roadways with high volumes and numerous right turns may not convert easily to three-lane sections.

Cost Considerations

The cost for re-striping a mile of four-lane street to one lane in each direction plus a two-way left-turn lane and bike lanes is about $5,000 to $20,000 per mile.[13]

[13] *Pedestrian Facilities Users Guide*, March 2002.

NARROWED LANES

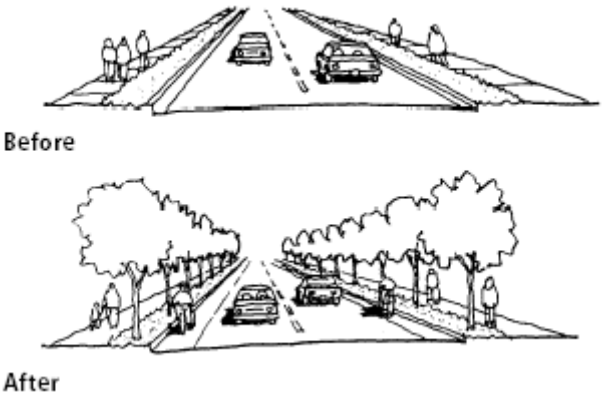


Image: Pedestrian Facilities Users' Guide.

Narrowed lanes and a center striped median Prospect Park Southwest, Brooklyn:

Roadway narrowing can be achieved in several different ways: lane widths can be reduced (to 10 or 11 feet in accordance with AASHTO requirements) and excess pavement striped with a bicycle lane; travel lanes can be removed; or the street can be physically narrowed by extending sidewalks, curbs, and landscaping, or by adding on-street parking.

Advantages

Narrowing lanes has the effect of slowing down operating speeds. It also shortens the distance where pedestrians are crossing, and moving travel lanes can provide opportunity for the installation of bicycle lanes.

Disadvantages

Narrowing lanes has only a slight effect on speeds. It is not the best method for lowering operating speeds. Road/lane narrowing must also consider the presence (per cent by volume) of school buses, emergency and other service vehicles (police, fire, rescue, snow plow, sanitation), and truck volumes. Narrowing may encourage traffic to divert to other local streets in the neighborhood.

Cost Considerations

Striped shoulders or on-street bike lanes can cost as little as $1,000 per mile. The cost for re-striping or reducing the number of lanes to add parking is $5,000 to $10,000 per mile, depending on the number of lane lines to be removed. Widening a sidewalk can cost $100,000 to $1,000,000 or more per mile.[14]

Recommendation

Narrowing lanes through re-striping is recommended on streets near schools where lanes are greater than 12' wide.

[14] *Pedestrian Facilities Users Guide*, March 2002.

ONE-WAY/TWO-WAY STREET CONVERSION

GENERAL INFORMATION

This converts the flow of traffic on a street from two-way to one-way to manage traffic patterns, or from one-way to two-way to reduce speeds. One-way streets operate best in opposing pairs, where the pairs are physically close to one another (separated by no more than one block). Refer any proposed change in direction to NYCDOT's Division of Planning.

NYCDOT policy

The conversion of streets is considered when:

- Street is overloaded and adjacent streets carry little traffic;
- Need for greater capacity of existing streets must be satisfied;
- Reduction of conflict at an intersection to reduce collision is desired;
- Street is unduly burdened by cut-through or other inappropriate traffic.

One-way streets may be necessary if:

- Roadway is less than twenty feet in width and parking is restricted
- Roadway is less than thirty-five feet, and parking is permitted
- Roadway develops circles or squares at focal points

One-way streets can mitigate traffic problems involving:

- Intersection complexity:
  - As an aide to routing
  - To reduce number of entering vehicles
  - To aid signalizing
- Steep grades to reduce danger especially where commercial traffic is heavy
- Control of street use by removing commercial and other inappropriate traffic from residential streets or unimproved streets where traffic uses the residential street to promote a cut-off or to avoid signals
- Routing of through traffic through congested areas
- Handling special events that generate heavy traffic
- A need to create or preserve more on-street parking.

Advantages

The advantages of converting a two-way street to a one-way street include:

- Reduces crashes
- Ideal for progressive signal systems
- Increases vehicle volume
- Increases speed
- Reduces delays
- Transit operations facilitated

- Preferable to stringent parking restrictions
- Reduces confusion at complex intersections
- Can divert traffic from residential areas
- Enforcement is easier
- Emergency vehicle movement is expedited

Disadvantages

- May encourage excessive speed
- May increase traffic volumes
- Additional direction signing may be needed for motorists unfamiliar with area
- Pedestrians may step into traffic lane looking only to the left
- Accidents may temporarily increase
- Some type of businesses may have temporary losses
- Increase travel distance

Conversion of a two-way street to a one-way street includes the following changes in traffic characteristics:

- Intersection conflicts are reduced
- Eliminates head-on and sideswipe conflicts
- Same direction conflicts reduced
- Parking maneuvers made less dangerous
- Headlight glare eliminated
- Speed differentials reduced
- 'Odd' lane of roadway is utilized.

Two-way streets eliminate the need to drive around the block to get to nearby destinations. Converting a one-way to a two-way street decreases the speed of traffic. Conversely, converting a two-way street to one-way operation or changing street direction of a one-way street can be used effectively to prevent cut-through traffic.

Cost Considerations

$20,000 to $200,000 per mile, depending on the length of the treatment and whether the conversion requires modification to signals.[15] Changing street direction of a short section of one-way roadway (one to three block lengths) can be inexpensive, requiring just signage changes.

Other Considerations

Consideration should be given to the following requirements of satisfactory one-way operation:

- An adjacent parallel street preferable, no more that 500 feet and never more than 700 feet away, should be able to handle an equal amount of traffic
- Cross streets should exist 300 to 500 feet apart
- Direction of one-way should be towards normal terminals

[15] *Pedestrian Facilities Users Guide*, March 2002.

- Direction should also divert traffic away from congestion
- Transit routes and bus stops must be carefully studied
- Proper installation of one-way arrows: two signs for the street segment approaching the intersection and one sign for the street segment leaving the intersection. Arrow lenses on green signal faces should be installed where needed.
- Parking meters, bus stops, all regulations and controls must be adjusted for the new one-way direction
- Particular attention should be directed towards use of islands, pavement markings, signals and signs at the extremities of a one-way street
- Mitigation of head-on conditions with opposing one-way streets needed

NYCDOT Investigation Procedure

The Division of Planning conducts investigations. Upon completion of the investigation, Planning prepares appropriate sign orders. NYCDOT Borough Engineering installs the needed signs and makes the appropriate notifications prior to sign installation changes and pavement markings. Groups to be notified of conversions prior to implementation include:

- New York City Police Department
- New York City Fire Department
- New York City Transit (if bus operations are affected)
- New York City Department of Sanitation
- Community board
- Residents of affected blocks
- Motorists that utilize affected blocks
- Institutions in area (e.g., hospitals, schools)
- Local businesses

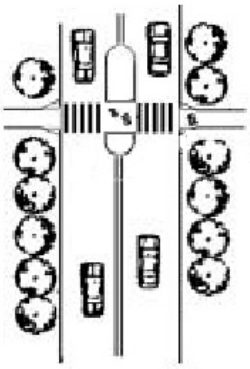
'BLOCKBUSTER'

Beverly Road, Brooklyn

Description

Blockbusters consist of channelization markings to reduce the likelihood of head-on collisions. They are installed at intersections where a one-way street abuts a two-way street. Blockbusters can also be implemented by construction of a raised island instead of striping. This affords additional protection against head-on collisions and provides a protected refuge for pedestrians.

CENTER ISLAND MEDIAN



Drawing: Pedestrian Facilities Users' Guide

Midland Avenue, Staten Island

GENERAL INFORMATION

Description

A center island median is an elevated median constructed on the centerline of a two-way roadway. The median can force a lateral shift in, and/or reduce the overall width of, the adjacent travel lanes.

The purpose of a center island median is to reduce vehicle speeds and reduce pedestrian-vehicle conflicts. Center island medians can serve as a place of refuge for pedestrians crossing the street. Center island medians can also channel pedestrians to safe crossings and discourage dangerous pedestrian movements. They may provide space for trees or other landscaping.

In some environments, medians can be constructed in sections, creating an intermittent rather than continuous median. A center island median may incorporate left turn bays.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Local, collector, and arterial streets.

Effectiveness

Center island medians are effective at providing a refuge for pedestrians who cannot cross the street in one walk cycle. The effectiveness of a center island median can be increased when the median is extended into the crosswalk, with a 'nose' or 'end cap' to protect pedestrians from left-turning vehicles.

Preferred locations

Raised medians are most useful on high-volume, high-speed roads where they may also serve as pedestrian refuge islands.

On wide roads with excess width or capacity, medians may be used to reduce the number or narrow the travel lanes.

BENEFITS

Center island medians have benefits for motorists and for pedestrian safety.

Vehicle speeds

Some designs help decrease vehicle speeds. In Anne Arundel County, MD, a 2 mph reduction in vehicle speeds was observed due to raised median islands, and a 5 mph reduction when used in combination with curb extensions.

Traffic volumes

Center island medians can be used as a volume control measure when placed so as to prohibit cut-through traffic on intersecting cross streets.

Conflicts

Center median islands can function as a pedestrian refuge, and may thus reduce vehicle-pedestrian conflicts.

DISADVANTAGES

Continuous medians may not be the most appropriate treatment in every situation. In some cases, separating opposing traffic flow and eliminating left-turns can increase traffic speeds by decreasing the perceived friction between opposing traffic movements. They may also take up space that can be better used for wider sidewalks, bicycle lanes, landscaping buffer strips, or on-street parking, and may cause problems for emergency vehicles (see design considerations below).

Significant disadvantages

May prevent turns into driveways on opposite sides of the street.

Moderate disadvantages

Speeds may increase if left-turns are eliminated.

MAINTENANCE

No effect on snow plowing, if islands are visible under snow cover due to signs or delineators. May moderately increase snow removal costs. No effect on street sweeping. Generally, the use of planted medians requires a signed agreement between the City and an organization that will ensure maintenance.

COST CONSIDERATIONS

$40,000 per block. The unit cost for a median treatment is a per-block cost, assuming a 4 foot-wide median and a 200 foot-long block at a construction cost of $50/square foot. The unit cost assumes a basic raised concrete median with steel-faced curb at intersections and concrete-faced curb mid-block. It does not include the cost of landscaping or otherwise beautifying the median.[16]

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[16] *Downtown Brooklyn Traffic Calming Project, Final Report*. New York City DOT, May 2003.

DESIGN CONSIDERATIONS

General considerations

The introduction of a center median island on a two-lane street relies on the constraint of a lesser lane width to reduce traffic speeds.

Changes in traffic circulation resulting from the placement of a median need to be carefully studied so that motorists are not forced to travel on inappropriate routes, such as residential streets, or make unsafe U-turns.

Crossing islands should be designed to provide tactile cues for pedestrians with visual impairments to indicate the border between the pedestrian refuge area and the motorized travel lanes.[17]

Geometric requirements

A median should have a minimum width of 5 feet to provide protection for, and from, signs required in the median and to provide a minimal pedestrian refuge area. It should be noted that a 6-foot width will double the storage capacity of the median for crossing pedestrians.

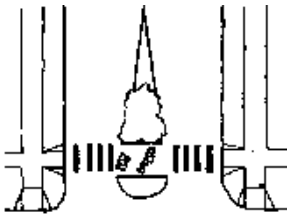
The Fire Department of the City of New York (FDNY) requires a minimum roadway width of 22 feet on streets without parking, and 25 feet on streets with parking.

Signing and pavement marking requirements

For signing and pavement markings on the approaches to the median islands, follow the requirements indicated in the MUTCD.

[17] *Ibid.*, p. 56.

PEDESTRIAN REFUGE ISLAND



Pedestrian Users' Facilities Guide

GENERAL INFORMATION

Description

Crossing islands, also known as center islands, refuge islands, or pedestrian islands, are raised islands placed in the center of the street at intersections or mid-block crossings to help protect crossing pedestrians from motor vehicles. Center crossing islands allow pedestrians to focus on only one direction of traffic at a time, and they enable them to stop partway across the street and wait for an adequate gap in traffic (or the next walk phase) before crossing the second half of the street.

Islands are used on exceptionally wide roads or at large, irregularly shaped intersections where the combination of high pedestrian and vehicle volumes can make crossing difficult. They protect pedestrians in areas of the intersection where there may be complicated or confusing traffic flow patterns or segregated, high-volume vehicle movements (such as turn lanes).

Though most appropriate at signalized crossings, crossing islands may be considered where mid-block or intersection crosswalks are installed at other controlled locations. Curb extensions may be built in conjunction with center crossing islands where there is on-street parking.

Effectiveness

If there is enough width, center crossing islands and curb extensions can be used together to create a highly improved pedestrian crossing.

Advantages

Crossing islands enhance pedestrian crossings, particularly at un-signalized, controlled crossing points, reduce speeds of approaching vehicles, and highlight pedestrian crossings. This kind of facility has been demonstrated to significantly decrease the percentage of vehicle-pedestrian crashes. The factors contributing to pedestrian safety include reduced conflicts, reduced vehicle speeds approaching the island (the island can create a horizontal shift for the motorist), greater attention called to the existence of a

pedestrian crossing, opportunities for additional signage in the middle of the road, and reduced exposure time for pedestrians.

Disadvantages

Crossing islands at intersections or near driveways may affect left-turn access. Installation may require lane narrowing or roadway widening.

Cost Considerations

$4,000 to $30,000. The cost for an asphalt island or one without landscaping is far less than the cost of installing a raised concrete pedestrian island with landscaping.[18]

Design Considerations

Maintain bicycle access: bicycle lanes (or shoulders) must not be eliminated or squeezed in order to create the curb extensions or islands. Make crossing islands at least 6 feet wide.

[18] *Pedestrian Facilities Users Guide*, March 2002.

DRIVEWAYS

Concrete walkway extending over driveway.

Utica, NY. Photo: James Ercolano.

Driveways can cause safety and access problems for pedestrians, particularly wide and/or sloped driveways, driveways with large turning radii, multiple adjacent driveways, driveways that are not well defined, and driveways where motorist attention is focused on finding a gap in congested traffic.

Examples of driveway improvements include narrowing or closing driveways, tightening turning radii, converting driveways to right-in only or right-out only movements, and providing median dividers on wide driveways.

It is necessary to maintain an ADA-compliant sidewalk across the driveway for a width of at least five feet. It is difficult for people in wheelchairs or those who use walking aides to safely cross a sidewalk with a cross pitch in excess of 2%. Curb cuts are by permit from NYCDOT; businesses should not be permitted to retain curb cuts beyond those that are currently permitted.

Where driveways are constructed of asphalt, consideration should be given to reconstruction extending the concrete sidewalk through the driveway. Maintaining the sidewalk material (usually concrete) across the driveway sends the message to the motorist that pedestrians on the sidewalk have priority.

Cost Considerations

No additional cost if part of original construction.[19] Otherwise standard unit costs for curb and pavement apply.

[19] *Pedestrian Facilities Users Guide*, March 2002.

SCHOOL PARKING AND DROP-OFF ZONES

4th Avenue at E. 10th Street, Manhattan

GENERAL INFORMATION

Description

The block fronting a school entrance is generally posted for no standing directly in front of the school. Drop-off areas must be located away from where children on foot cross streets or access the school. Parent drop-off zones must be separated from bus drop-off zones.

Purpose

Parking is prohibited in the vicinity of school buildings to provide access for school buses and emergency vehicles, and improve safety for students (e.g., reduce risk of 'dart out' incidents).

Roadway

Parking and standing regulatory signs are used to prevent parked or waiting vehicles from blocking pedestrians' views, and drivers' views of pedestrians, and to control vehicles as a part of the school traffic plan. The extent to which the regulation should be installed around the entire building is determined based on the number of entrances/exits and the number of school buses serving the students.

NYCDOT policy

NO STANDING 7 AM- 4 PM SCHOOL DAYS (SP-89B) should be installed along all or part of the perimeter of the school to ensure the safe loading and unloading of students. These regulations should be installed according to the number of school buses and other vehicles the school receives daily. Where a school has a fire exit, a NO STANDING 7 AM- 4 PM SCHOOL DAYS (SP-89B) shall be installed.

DAY-LIGHTING

Queens

GENERAL INFORMATION

A frequently cited contributing factor to crashes at intersections is that the motorist or pedestrian could not see each other because of cars parked on the street. Restricting parking at the approach to crosswalks improves visibility between motorists and pedestrians.

Description

The simplest form of day-lighting is the installation of the appropriate NO STANDING ANYTIME sign 30 feet from the corner.

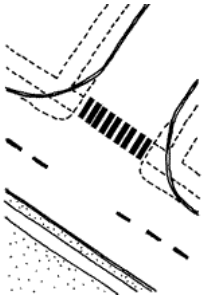
Purpose

To improve visibility of cross traffic and pedestrians for motorists approaching an intersection.

NYCDOT policy

This regulation is recommended when a traffic study concludes that motorists approaching an intersection do not have sufficient visibility of cross traffic. Visibility problems of this nature should be corrected by 'day-lighting' the intersection with a NO STANDING ANYTIME (R7-20R) regulation.

CURB RADIUS REDUCTION



GENERAL INFORMATION

Description

A curb radius reduction is the reconstruction of an intersection corner with a smaller (or 'sharper') radius. The purpose of a curb radius reduction is to slow right-turning vehicles, reduce crossing distance for pedestrians, and improve pedestrian visibility.

Cost considerations

$2,000 to $20,000 per corner, depending on site conditions, such as drainage and utilities,[20] and depending on the construction method chosen, such as:

- Paint and flexible delineators only—$2,000.
- Quick curb and asphalt backfill—$5,000-$10,000.
- Concrete curb and new sidewalk—$10,000-$50,000.

Cost varies depending on radius of the original curb, landscaping, and labor and material costs.

Geometric requirements

NYCDOT design standards specify a standard 12-foot radius for 90-degree turns. This is adequate since most streets also have a parking lane. Where there is a parking and/or bicycle lane on one or both of the intersecting streets, the effective turn radii may be calculated around the outside of these facilities allowing for a tight turn radius on the curb itself.

For turns other than 90 degrees, careful attention must be paid to size turn radii according to the design vehicle. If a very small radius is chosen, long wheel base vehicles such as large trucks or buses may ride over the curb, placing pedestrians in danger.

The corner with an obtuse angle should be designed with the minimum radius required to accommodate the design vehicle in order to minimize high-speed turns. Turning templates or software (AutoTurn) should be used to check turning movements at non-standard corner angles and at neckdowns.

[20] *Pedestrian Facilities Users Guide*, March 2002

BICYCLE LANES

Bike lane with buffer, Hudson Street, Manhattan

Bike lane marking (4 ft. height recommended by MUTCD).

Description

Bicycle lanes have been found to provide more consistent separation between bicyclists and passing motorists than simply providing a wide travel lane. Marking bicycle lanes can also benefit pedestrians: as turning motorists slow and yield more to bicyclists, they will also be doing so for pedestrians. Bicycle lanes also provide a separation between motor vehicle traffic and pedestrians when sidewalks are immediately adjacent to the travel lane, and there is no on-street parking.

It is recommended that bicycle lanes be striped a minimum of 5 feet wide when placed adjacent to parked cars and a minimum of 4 feet wide when adjacent to the curb.

Retrofitting an existing street with new bicycle lanes and the subsequent narrowing of travel lanes usually required by their installation has been linked to an observed reduction in motor vehicle travel speeds of between 3-5 mph on some city streets where they have been installed.

Bicycle lanes are typically designated with pavement markings (4 inch wide white striping and bike and arrow logos placed inside the lane) and signs. Bike lanes are sometimes colored to call attention to them on large busy streets or to distinguish them in an otherwise confusing location such as a large complex intersection. On high-speed, high-volume roads, it may be more appropriate to provide a multi-use path to physically separate both bicyclists and pedestrians from motor vehicle traffic.[21]

Advantages

A bicycle lane provides bicyclists with a path free of obstructions, encourages bicyclists to ride in the correct roadway position, and notifies motorists that cyclists have a right to the road.

[21] *Pedestrian Facilities Users' Guide*, p. 52.

Disadvantages

There is not always the room on an existing street to accommodate a bicycle lane without either widening the road or eliminating a travel or parking lane for motor vehicles. Either scenario could be very costly. Lack of adequate space between the bike lane and parked cars (due to excessive narrowing of the parking lane to make room for the bike lane) may create a hazard for bicyclists ('dooring').

Cost Considerations

$5,000 to $50,000 per mile, depending on the condition of the pavement, the need to remove and repaint lane lines, and the need to adjust signalization. (*Pedestrian Facilities Users Guide,* March 2002).

Other

For more information on the design of bicycle facilities, see:

- *Guide for the Development of Bicycle Facilities* (AASHTO, 1999)
- *Manual on Uniform Traffic Control Devices, Millennium Edition* (FHWA, 2000).

Recommendation

Bike lanes may have application as an accommodation for high school students.

CENTERLINE PEDESTRIAN SAFETY CONE

The New York State Department of Transportation has created a specification for a 'YIELD TO PEDESTRIANS' device which can be placed in the middle of the road at a crosswalk.

The devices, known as supplemental pedestrian crossing channelization devices, are made out of traffic safety cone materials and retroreflective fabric—there are no metallic parts. The sign panel represents a recent New York State vehicle and traffic law, which (as of July 23, 2002) states that motorists shall yield to pedestrians when the pedestrian is in *any portion of the roadway*. The graphic is now included in the New York State MUTCD and can be used in the roadway, or as a separate roadside sign.

Studies have shown that this treatment increases the yielding of vehicles to pedestrians in a crosswalk better than most other treatments; in an FHWA-sponsored study, motorists yielded to 81% of pedestrians where the traffic safety cones had been installed.[22] Overhead signs, in some locations, have shown similar results. The device has also been crash tested by the New Jersey state police, and, as there are no metallic parts, is crash-resistant.[23]

Advantages

The sign has been tested and proven to be effective for safety and motorist compliance. Its placement, in the center of the road at driver eye level, helps focus the driver's attention on the crosswalk and the pedestrian, without unnecessarily moving her eyes or

[22] *The Effects of Innovative Pedestrian Signs at Unsignalized Locations: A Tale of Three Treatments*. FHWA (FHWA-RD-00-098), August, 2000.
[23] *Improving Conditions for Bicycling and Walking: A Best Practices Report.* Rails to Trails Conservancy and the Association of Pedestrian and Bicycle Professionals for the Federal Highway Administration, January 1998, p. 22.

head. Portability and potential for seasonal use are advantages. This sign is relatively inexpensive (approximately $200 per device[24]).

Disadvantages

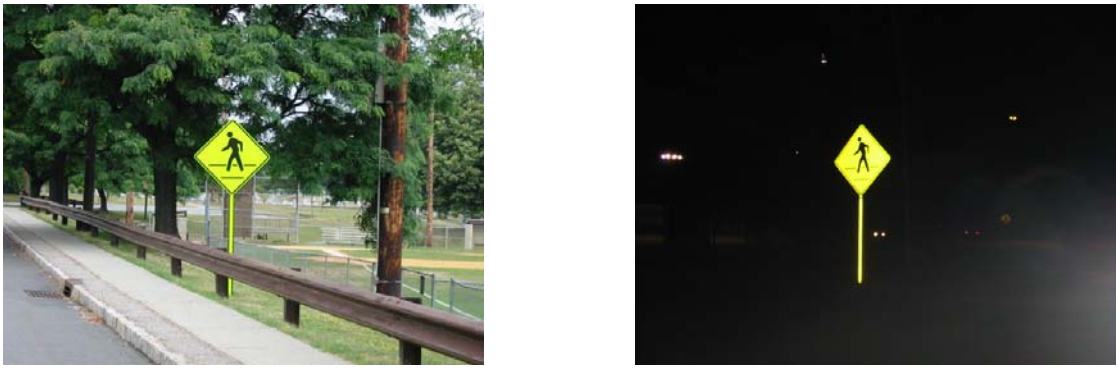
If this sign is used too generously, its effect is diminished. Northern climate communities generally remove these signs during the winter months so as not to impede snow removal. Also, after being hit a number of times by vehicles, the signs must be replaced.

Recommendation

Use these types of signs primarily at uncontrolled crossings, on low-speed (30 mph or less) two- or four-lane roadways, where there is a high frequency of pedestrians.

[24] "Supplemental Pedestrian Crossing Channelization Devices (SPCCD's)," by James M. Ercolano, Pedestrian Specialist, NYSDOT (N. D.)

FLUORESCENT POST REFLECTORS



Post reflector with accompanying pedestrian crosswalk sign, viewed at daytime and nighttime, Denville, New Jersey. Image: courtesy Lordon, Inc.

GENERAL INFORMATION

Description

Recent manufacturing improvements have made possible the inclusion of lasting fluorescence in a microprismatic sign material, and, as a result, a "fluorescent strong yellow-green" color has been developed for roadway sign use. Because of its greater reflectivity and higher luminance, this color is easier to see than the more familiar yellow signs, especially at dusk or in bad weather conditions. The unique color is being used with greater frequency on crossing signs for pedestrians, children, and bicyclists, and most particularly in school zones. In New York City, it is being used exclusively on school crossing signs. It was approved for inclusion in the MUTCD by FHWA in 1998 for use at pedestrian and bicycle crossings.[25]

Non-corrosive PVC plastic post reflector strips are available as attachments to U-channel, round, or square posts. The strips are inexpensive and easy to mount, are available in fluorescent strong yellow-green and other colors, and provide an additional level of increased luminance and conspicuity of school crossing and other signs.

Characteristics

The post reflector strip fits onto the existing delineator post, typically 3.5-inch U-channel galvanized iron, 0.75-inch standard pipe, or 2 in. x 2 in. timber post. The post reflector strip matches the color of the mounted sign: a fluorescent strong yellow-green reflector is used for pedestrian and school crossings, a red reflector for stop signs, and white for speed limit signs.

Effectiveness

The effectiveness of a post reflector can be increased when used in combination with advance warning, school crossing, and other signs.

[25] Federal Highway Administration website: www.fhwa.dot.gov

BENEFITS

Following a high incidence of knockdowns of delineator posts in Houston, tests were performed in 1978 with high-visibility color strips attached to the posts. Research showed a 50% reduction in knockdowns, and colored delineator posts have since become standard in Texas.[26]

Additional research shows that the use of the fluorescent strong yellow-green in signs and other devices increases their conspicuity to motorists, but does not necessarily reduce vehicle-pedestrian conflicts, and only marginally improves pedestrian safety.[27]

Conflicts

There is not extensive research to support any claims of reduced conflicts with use of fluorescent signs or reflector panels. However, two New Jersey communities surveyed—Westfield and Ridgewood—reported that they have installed fluorescent reflector panels at locations that have had high crash occurrences in the past. Both communities reported that these devices have lowered the number of crashes, especially at stop signs.[28]

Environment

There may be some aesthetic objections to the use of bright fluorescent colors.

COST CONSIDERATION

Approximately $28 to $43 per delineator post.[29] The cost does not include installation, and is for one delineator panel, for installation either on a timber post or on a U-channel galvanized iron pipe.

RECOMMENDATION

The use of the fluorescent strong yellow-green color has become increasingly identified with school-related warning signs, and several states have adopted its use exclusively for schools and school zones. Use of this color for signs, post reflectors, and markings is an inexpensive way to identify a school zone, and to notify motorists of the possible presence of school-aged pedestrians.

It is recommended that the fluorescent strong yellow-green post reflector be tested and evaluated for use with school advance warning signs.

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[26] *Roadway Delineation Practices Handbook*, Federal Highway Administration, 1994, p. 140.
[27] Clark, Kenneth and Joseph Hummer, et al. "Field Evaluation of Fluorescent Strong Yellow-Green Pedestrian Warning Signs, *Transportation Research Record* 1538.
[28] Lordon, Inc., Hackettstown, NJ, 888-521-8800. www.britesidepanels.com
[29] Vendor estimate: based on telephone call with Mike McMahon (Lordon, Inc.) on May 29, 2003.

OVERSIZED STREET NAME SIGN

Eastern Parkway at Bedford Avenue, Brooklyn

Oversized street name signs are placed on major arterials where motorists may become confused or lost; they assist in helping them to select the appropriate travel lane and attempt to avoid last-second lane changes. Oversized signs may be placed in advance of the approaching intersection, and at the intersection itself.

PEDESTRIAN DETECTION SIGNALS

Infrared technology can be used to detect the presence of pedestrians in a crosswalk.

Though not currently used in New York City, a traffic signal can incorporate the use of an infrared or microwave-based detection system, mounted on a pole near the crosswalk area, that can be used to either detect the presence of an approaching pedestrian or the continued presence of a pedestrian in the crosswalk. If a pedestrian is detected as still being in the crosswalk, the system is programmed to extend the crossing time. During the extended crossing interval, the steady 'DON'T WALK' display is presented to pedestrians and the green signal for opposing motorists is delayed.

Advantages

Provides intervals in a traffic system where pedestrians can cross streets safely.

Disadvantages

Can interfere with signal offsets at signalized locations up- and downstream. Could create confusion for pedestrians as to whether or not vehicles will be stopping.

Cost Considerations

$30,000 to $140,000.[30]

Recommendation

This measure may have application at certain school crosswalks during school hours.

[30] *Pedestrian Facilities Users Guide*, March 2002.

RIGHT-ON-RED RESTRICTIONS

GENERAL INFORMATION

Description

In New York City, right turns on red are prohibited unless otherwise posted.

A right turn on red promotes traffic flow by permitting vehicles to make right turns on a red signal, after coming to a full stop.

A permissible right turn on red (RTOR) was introduced in the United States in the 1970s as a fuel-saving measure and has sometimes had detrimental effects on pedestrians. While the law requires motorists to come to a full stop and yield to cross-street traffic and pedestrians prior to turning right on red, many motorists do not fully comply with the regulations, especially at intersections with wide turning radii.

NYCDOT Policy

RTOR's are provided only when it can be demonstrated that pedestrian safety will not be jeopardized, and adequate visibility and gaps exist for right turns to be made safely. At selected locations, RTOR is permitted except during school hours.

Benefits

Prohibiting right turns on red increases pedestrian safety and decreases crashes with right-turning vehicles.[31]

Recommendation

The right turn on red restriction in New York City is an effective pedestrian safety measure and should be retained.

[31] *Pedestrian Facilities Users Guide*, p. 95.

ENLARGED SIGNAL LENSES

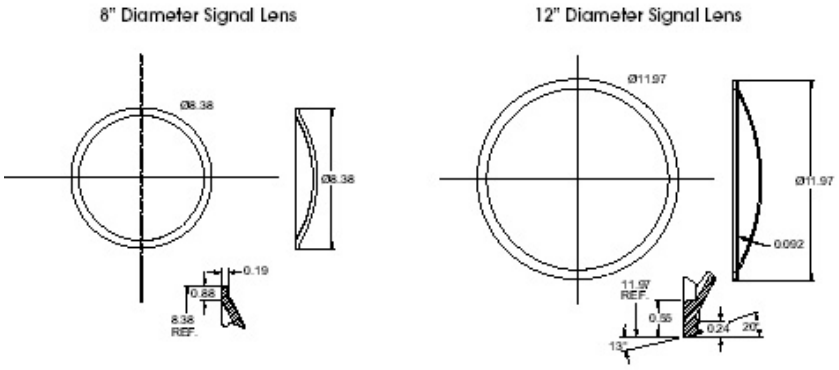


Image: LexaLite, Inc.

A 12" diameter red signal lens atop 8" diameter yellow and green signal lenses.

The standard signal head is 8 inches in diameter. Increasing the size of the signal head from 8 to 12 inches increases its visibility.[32] New York City recognizes the value of an oversized red signal lens display, and this is used where visibility is an issue or to emphasize the control (NYCDOT signal No. RMSZ). The 2000 edition of the MUTCD (Section 4D-15) specifically recommends the larger size signal heads in areas where the percentage of elderly drivers is significant.

A survey of intersections with enlarged signal lenses in Winston-Salem, NC shows that right angle crashes declined by 45%, and total crashes have declined by 8.5%, reductions that is statistically significant at about half of all locations surveyed.[33]

Design Considerations

Factors include roadway geometry, existing signal layout, sight distance and approach speeds. Section 4D-15 of the MUTCD outlines standards for the use of 12-inch lenses.

[32] FHWA website: http://www.fhwa.dot.gov/safety

[33] "Engineering Countermeasures to Reduce Red Light Running," presentation by Edward R. Stollof, Institute of Transportation Engineers, October 22, 2002

PEDESTRIAN SIGNAL HEADS

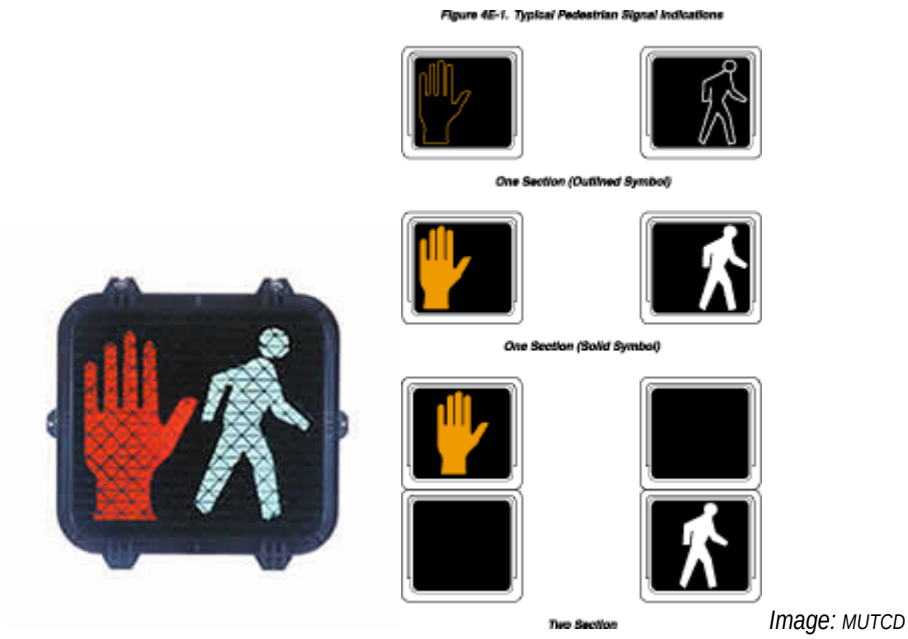


Image: MUTCD

GENERAL INFORMATION

Description

New York City DOT is currently replacing message-type pedestrian signal heads with symbolic signal heads using light-emitting diodes (LEDs), as shown above.

Characteristics

The international symbol pedestrian signal head is preferable and is recommended in the MUTCD; the 'WALK' and 'DON'T WALK' word messages are allowable alternates.

Pedestrian signal heads should be clearly visible to the pedestrian at all times when in the crosswalk or waiting on the far side of the street. Pedestrian signal heads would be beneficial at all school crosswalks. Larger pedestrian signal heads can be beneficial in some circumstances.

Advantages

Symbolic signals are easier to see and understand, and do not require the ability to read English. In addition, use of LEDs permits cost savings for energy and maintenance.

Cost considerations

Pedestrian signal head cost (including unit price and installation): $800.

ACCESSIBLE PEDESTRIAN SIGNALS

Accessible pedestrian signals emit buzzing, whistling, beeping, or chirping sounds that are correlated with the visual 'WALK/DON'T WALK' signals used by sighted individuals. These signals can be either pedestrian activated (connected to the pedestrian call button) or automated (activated by the cycle change at pre-timed intersections). Many of the automatic devices emit different sounds to indicate which direction to cross and how much time is available for crossing.

Variations on this technology include using a digitally recorded verbal message played at the start of the WALK phase. In addition to providing more information to visually impaired pedestrians, the message can be used to prompt sighted pedestrians to look for turning vehicles.

Advantages

The audible signal enables visually impaired pedestrians to safely and independently negotiate intersections. The use of audible messages has been shown to be effective in prompting sighted pedestrians to look for turning vehicles.

Disadvantages

Some traditional audible traffic signals, using 'chirping' noises, are difficult to interpret and do not orient a blind pedestrian or provide other useful information. In urban environments, ambient noise may drown out too quiet a sound. A new system, used in San Francisco, allows only the intended user to hear the recorded voice messages from the traffic signals. The messages, transmitted via infrared light waves, are highly directional pointing the visually impaired traveler very precisely to a desired destination.

Recommendation

With the above disadvantages in mind, consider installation only on an as needed basis, e.g., program schools for visually impaired pedestrians. (N.B. 14 of 1,426 program schools in the NYCDOT school safety engineering project are schools for disabled students.)

LEADING PEDESTRIAN INTERVAL

Leading pedestrian interval on Atlantic Avenue, Brooklyn

GENERAL INFORMATION

Description

A leading pedestrian interval (LPI) is a split signal phasing which gives pedestrians an advance walk signal before the motorists are given a green signal indication.

Characteristics

Pedestrians have several seconds to start in the crosswalk before there is a concurrent green traffic signal for vehicles allowing pedestrians to begin crossing prior to the release of turning vehicles.

LOCATION, PLACEMENT, EFFECTIVENESS

Applicability

Road classification: local and collector streets
Traffic conditions:

- The use of the LPI should be considered where there are a high number of right-turn-on-green conflicts at an intersection where right turn on red is prohibited.
- The advance phase approach is particularly effective where there is a multiple lane turning movement.

Effectiveness

A LPI has the ability to:

- reduce conflicts between pedestrians and turning vehicles,
- reduce the incidence of turning vehicles violating pedestrian right-of-way,
- make crossing the street somewhat easier.

To be useful to pedestrians with vision impairments, an LPI needs to be accompanied by an audible signal to indicate the crossing interval. [34]

Preferred locations

High volume crosswalks with vehicle turning conflicts.

BENEFITS

Conflicts

- LPIs can reduce turning movement pedestrian crashes by up to 50%.
- LPIs work by allowing pedestrians to establish a visible presence in crosswalk, which increases the likelihood of motorists yielding.
- This advance phase approach has been used successfully in New York City for two decades and studies have demonstrated reduced conflicts and increased safety for pedestrians.

DISADVANTAGES

Moderate disadvantages

Motorists can be confused. If they are following the walk signal and pedestrian movement, rather than the traffic signal, they may be prompted to jump the light. However, this tendency disappears during the first months after installation.

COST CONSIDERATIONS

None, this only involves altering signal timing phasing.

RECOMMENDATION

Consider LPIs where turning movements are a crash risk or hinder pedestrian mobility. LPIs are particularly suitable as a school safety mitigation measure, as they give the younger pedestrian the ability to establish presence in the crosswalk.

[34] FHWA, *Safer Journey*, *Interactive Pedestrian Safety Awareness*

'BARNES DANCE' (ALL-WALK PHASE)

Court Street and Remsen Street, Brooklyn

The all-walk phase, also known as the Barnes Dance, is a split signal phase that stops vehicles on all approaches to allow pedestrians to cross at any crosswalk or diagonally. All traffic signals are red, while all pedestrian signals are a steady WALK during the walk interval.

A Barnes Dance usually creates a longer cycle length and a longer wait between crossings. It may eliminate the ability to synchronize timing at adjacent traffic signals. It is most applicable to areas with high pedestrian volumes (i.e., more than 1,200 pedestrian crossings per day). All-walk timing eliminates conflicts with turning vehicles if pedestrians and motorists obey their signals.

Advantages

The all-walk phase eliminates turning conflicts, and allows diagonal crossing movements. Exclusive pedestrian timing has been shown to reduce pedestrian crashes by 50 per cent in some locations with heavy pedestrian volumes and low vehicle speeds and volumes.

Disadvantages

Increases waiting time for pedestrians who must wait through multiple vehicular phases. Unless the vehicular phases are significantly shortened, pedestrians will often have to wait a long time for an exclusive signal. Because of the increased wait time between pedestrian signals, many pedestrians simply choose to ignore the signal and cross if and when there is a gap in traffic.

Recommendation

Consider the all-walk phase only in areas where there are heavy school-age pedestrian volumes and low vehicle speeds and volumes. It may prove confusing for younger children.

PEDESTRIAN SIGNAL TIMING

Queens Boulevard, Queens

GENERAL INFORMATION

Description

One of the first steps in assessing pedestrian accommodations at schools is to study signal timing at signalized intersections. A walking speed of 3.0 feet/second should be used for school-aged children. (Average adult pedestrian walking speed is 4.0 feet/sec., according to the MUTCD.) Where adequate pedestrian crossing time is not provided, consideration should be given to modifying the signal timing.

When considering changes to signal timing, capacity analysis must be performed for all approaches to assess impacts on vehicular LOS. These impacts must be weighed against impacts of improving pedestrian safety. Where intersections are part of an interconnect system, proposed timing changes must be closely coordinated with NYCDOT signals.

Characteristics

Shorter cycle lengths and longer walk intervals generally provide better service to pedestrians and encourage better signal compliance. With concurrent signals, pedestrians usually have more crossing opportunities and less wait time.

Benefits

Changing the length of the pedestrian walk phase is one of the easiest and most cost effective improvements that can be made to improve the pedestrian environment.

Moderate disadvantages

Increasing the length of the pedestrian walk phase may impact vehicular LOS.

Cost considerations

Adjusting signal timing is low cost and requires only a few hours to accomplish.

Recommendation

Evaluate signal timing at all school crosswalks to ensure that children have adequate crossing time.

SIGNAL PROGRESSION CHANGES

Description

In situations where signals are relatively closely spaced, it is necessary to coordinate their green time so that vehicles may move efficiently through the set of signals. Common practice is to coordinate signals on long arterials. The difference between the two green initiation times is referred to as the signal offset. The primary benefit of signal progression is the efficient movement of vehicles and minimizing delay to vehicles traveling through a corridor. Another benefit of signal progression is the maintenance of a preferred speed. The signals can be set so as to encourage certain speeds: vehicles going much faster than this speed will only have to stop frequently.

Therefore, the progression can be set so that motorists will proceed at a speed that is safe for travel in a school zone. Progression speeds can be calibrated at different speeds throughout the day, for example, slowing progression speeds during school arrival and departure times. To keep traffic congestion to a minimum, the progression speeds can be re-set for peak hours and directions, as long as they do not conflict with school travel times.

Applicability

Signalized arterial streets.

Advantages

Slower vehicle travel speeds provide increased safety to pedestrians crossing the affected intersections.

Disadvantages

Changing signal timing to slow vehicle speeds will increase travel time for motorists.

Cost considerations

No cost, where signal progression is already in effect.

CHAPTER TWO: ACTIVE TRAFFIC CALMING

As defined by the Institute of Traffic Engineers, traffic calming is "the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users."[35] Changes to the street geometry, horizontal or vertical, provide physical and visual cues that will induce drivers to travel at lower speeds.

The changes to the street geometry make traffic calming self-enforcing, without relying on traffic control devices. In studies from Europe, North America, and Australia, traffic calming has been proven to be effective: crashes are fewer and are less severe, and noise levels are lower. Use of standard traffic calming devices such as speed tables and speed humps can reduce speeds by 5 to 15% at the 85th percentile speed.[36]

The existing body of knowledge and experience of dozens of cities with traffic calming allows us to conclude that:

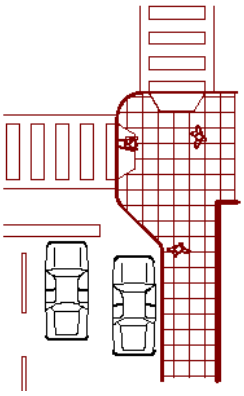
- Speed is more critical than volume in terms of pedestrian safety, and should be addressed first.
- Traffic calming devices that meet more than one goal are generally more acceptable to drivers.
- Measures must accommodate emergency vehicles.
- Treatments must be spaced appropriately to have the desired effect on speed—too far apart and they will have a limited effect; too close and they will be unnecessary nuisances.
- Under-designed facilities will not work.
- Over-designed measures (e.g., speed humps) can be counter-productive.
- Traffic calming measures should not shift a problem from one street to another.
- Trials and temporary measures may be installed to test the design of a device.

Constrictions, horizontal deflection, vertical deflection, and volume control are the categories of active traffic calming measures included on the following pages.

[35] Institute of Traffic Engineers (ITE)
[36] ITE, *Traffic Calming: State of the Practice*, 1998.

CURB EXTENSION / NECKDOWN

Greenwich Avenue at West 11th Street, Manhattan.



Drawing: from the New York State Highway Design Manual

GENERAL INFORMATION

Description

Curb extensions, also known as bulb-outs or neckdowns, extend the sidewalk curb line out into the street (typically into the parking lane) through a horizontal intrusion of the curb into the roadway. The curb is extended into the parking lane on one or both sides of the roadway.

Neckdowns in New York City have been shown to reduce overall crash rates and injury severity. It has been demonstrated that motorists are more inclined to stop behind a crosswalk at a neckdown, and that pedestrians are more inclined to wait on the neckdown rather than in the street.

Characteristics

Installed at corner and at mid-block crossings, neckdowns highlight the pedestrian crosswalk, thereby reducing jaywalking. Neckdowns also permit less signal time to be devoted to the pedestrian phase and reduce the roadway available for illegal or aggressive motorist activities such as failing to yield to pedestrians, making high speed turns, and passing in the parking lane. (Also see *curb radius reduction*).

The New York City DOT policy for neckdowns is included below.

BENEFITS

At intersections

Neckdowns add pedestrian space at the corner where pedestrian volumes are high. At many signalized intersections, a lack of storage space on the corner causes poor levels of service for pedestrians.

Neckdowns shorten the crossing distance for pedestrians. This is particularly helpful in areas with a strong elderly or youth presence, where signal time allocations are crucial.

Neckdowns provide space for pedestrian ramps where underground vaults and hollow sidewalks prevent placement.
Neckdowns reinforce the stop bar and/or crosswalk by making them more apparent to the motorist. This is further assisted by stop signs, planters, and trees, which may be placed outside the sidewalk proper.
Neckdowns force drivers to maintain lane discipline as they pass through the intersection. This also dissuades drivers from jockeying for position and jumping the red signal. The safety issues must be balanced with accommodation of turning vehicles.
Neckdowns slow turning vehicles, emphasizing the legal right of way of crossing pedestrians.
Neckdowns prevent parking in crosswalks and daylight the corner so that vehicles and pedestrians can see each other, especially at the top of a 'T' intersection. (See *day-lighting*.)
Neckdowns define the end of diagonal parking.
Neckdowns can reinforce a 'no truck' regulation, when designed so no vehicle larger than a 30-foot single unit truck may turn the corner.
Neckdowns can restrict entry to a block, for example, where a two-way street becomes a one-way street. (see *blockbuster*.)

At mid-block locations
Neckdowns add sidewalk space for amenities, subway stairs, bicycle parking, outdoor cafes, street furniture, and vendors, without impinging upon space needed for pedestrian traffic.
Neckdowns can accentuate a mid-block crosswalk.

At fire hydrants
Neckdowns guarantee emergency access to fire hydrants when placed in the 'no parking' zones directly adjacent.

DISADVANTAGES

Moderate disadvantages
Some cyclists on shared roadways may feel forced into path of motor vehicles.
May require removal of some on-street parking in location of curb extension. On-street parking can be permitted on either side of extension.
Long trucks, buses, and other large vehicles may need to cross into adjacent (and sometimes oncoming) travel lanes in order to negotiate turns at intersections with curb extensions.

MAINTENANCE
Increased snow removal cost and snow plow damage to grass, trees, and curb extensions.
Curb extensions should have a vertical element so as to be visible to plow operator.

COST CONSIDERATIONS
$27,000 for neckdowns on two corners, $54,000 to neck-down all four corners. The cost assumes that on two corners, sidewalks are extended 7 feet in each direction. The cost

allows for the reconstruction of the concrete corner sidewalk and the removal and reinstallation of steel-face curb with six inches of reveal (unless a raised intersection or crosswalk is proposed). Since neckdowns are typically planned at several intersections in a corridor, the engineer's estimate cost is increased by a factor of 1.5 to allow for the fact that catch basins must be relocated whenever neckdowns are built at corners to which drainage flows.[37]

NEW YORK CITY DOT POLICY FOR NECKDOWNS

Planning

Neckdowns may not be installed on streets where the curb lane is used for moving traffic (either full-or part-time) or where it is predicted that the curb lane will be used for such purposes. Examples include, but are not limited to bus and bicycle lanes, and streets with peak parking restrictions. A curb analysis may be required to assess whether peak period regulations are necessary. Future curb lane use should be justified with a definite, scheduled project.

Where turning movements equal or exceed twenty per cent of the total through movements or three vehicles per cycle, a traffic analysis will be required before installing a neckdown.

An agreement regarding snow and litter removal with a responsible community or private group should be considered for each neckdown.

At fire hydrants, neckdowns may be installed provided they do not interfere with other normal and legal street and parking operations.

Neckdowns should be avoided in industrial zones, as truck movements may be unduly restricted.

NEW YORK CITY DOT DESIGN CONSIDERATIONS FOR NECKDOWNS

Geometric and construction requirements

The standard width of a neckdown shall be the width of the parking lane minus two feet.

The standard length of a neckdown shall be equal to the full width of the crosswalk.

The corner radius of a neckdown will be consistent with the other corners of the intersection, typically twelve feet. The corner radius may be increased to accommodate trucks and buses.

The 30-foot single unit truck will be the standard design vehicle. On designated truck routes or where regularly scheduled buses must turn, the appropriate design vehicle will be used.

A fire truck turning zone with a 50-foot outside radius shall be maintained clear of physical obstructions (signs, planters, non-flexible bollards, and trees).

Bollards, planters, or other street furniture may be included in the neckdown. The design and placement of street furniture shall not impede pedestrian flow, present a trip hazard, or interfere with 'day-lighting' the intersection, emergency operations, or sight lines.

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[37] *Downtown Brooklyn Traffic Calming Project, Final Report.* New York City Department of Transportation, May 2003.

A sign, bollard, or other vertical device shall be placed on the neckdown to alert drivers to the presence of the neckdown. The design and placement of the device shall not obstruct emergency operations or sight lines.

Where drainage conditions, future curb use, or cost of a neckdown are prohibitive, striping and fixed bollards or rails may serve as a substitute (*urban oasis*). In general, the urban oasis is a temporary measure that should be used sparingly.

In new construction, neckdowns shall be built to sidewalk standards, except at hydrants.

At fire hydrants, neckdowns shall adhere to the following requirements:

The length of the neckdown shall be equal to the 'no parking' zone (typically fifteen feet in either direction.)

If the hydrant is not moved onto the neckdown, the neckdowns shall be built to regular street standards to support the weight of the fire truck, with appropriate provisions to allow fire trucks to mount the curb.

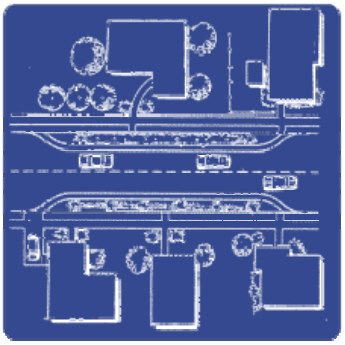
There shall be no physical obstructions (signs, planters, benches, non-flexible bollards, trees) that block access to the hydrant and beyond.

A 22-foot minimum roadway width (from curb to curb or parked vehicle) must be maintained at a fire hydrant, so that a fire truck may pass another parked at the hydrant. This applies if the hydrant is on the neckdown or on the sidewalk proper.

RECOMMENDATION

Curb extensions are an effective measure to enhance child pedestrian safety and visibility that may appropriately be used in school crossing zones.

CHOKER



Drawing: trafficcalming.org

Howard County, MD. Photo: trafficcalming.org

Chokers are curb extensions that narrow a street, effectively creating a pinch point. They can also be used at intersections to create a gateway effect when entering a street.

Chokers can reduce a two-lane street to two narrow lanes at the chokepoint, requiring motorists to slow down. However, they do not typically result in the elimination of a travel lane.

Advantages

Chokers slow vehicles at a mid-point along the street. They create a clear transition between a commercial and a residential area. They narrow overly wide intersections and mid-block areas of streets (e.g., a two-way low volume residential street with under-utilized parking and effective travel lanes greater than 15 feet). Chokers add room along the sidewalk or planting strip for landscaping or street furniture.

Disadvantages

If the travel-lane widths are unchanged (at the location of the choker), it will have a minimal effect on speed. Bicyclist safety and mobility may be diminished. Drainage patterns may be affected unless a channel is preserved along the original curb line.

Cost Considerations

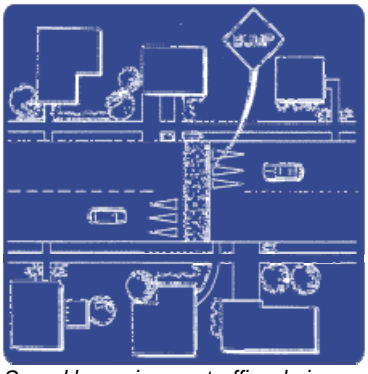
Chokers cost approximately $7,000-$20,000 each.[38]

Recommendation:

Chokers are most appropriate only on low-volume, low-speed streets.

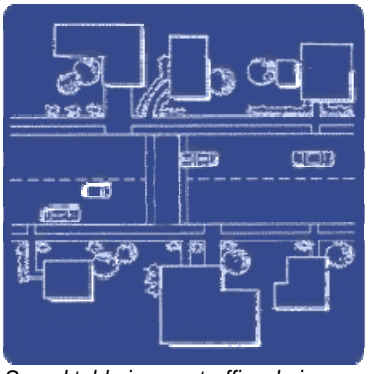
[38] City of Portland Office of Transportation, *Pedestrian Facilities Users Guide*, March 2002.

SPEED REDUCER (HUMP) AND SPEED TABLE



Speed hump image: trafficcalming.org

Speed reducer, Hoover Avenue, Queens



Speed table image: trafficcalming.org

Speed table. Image: City of Cambridge, MA

GENERAL INFORMATION

Description

NYCDOT has successfully implemented speed reducers (speed humps), particularly in the vicinity of schools, since the mid-1990s. A speed reducer is a paved (usually asphalt), raised area of a roadway, approximately 3 to 4 inches high at its center, which deflects both the wheels and frame of a traversing vehicle. The purpose of a speed hump is to reduce vehicle speeds. Speed reducers should be used only when justified by field studies. Speed humps should not be confused with the speed 'bump' that is often found in shopping mall parking lots.

A 'speed table' is a term used to describe a very long and broad speed hump, typically 22 feet. Sometimes a pedestrian crossing is provided on the flat portion of the speed table. The speed table can have either parabolic ramps, making it more like a speed hump, or trapezoidal ramps.

Characteristics

The vertical deflection of vehicle wheels produces an uncomfortable sensation for vehicle occupants traveling at speeds higher than the design speed.

The design speed is determined by the dimensions of the speed reducer, and the spacing between speed reducers.

Typical dimensions are:

Local street speed reducers: 13 feet in length and 3.1 inches high, with a sinusoidal cross-section.

Collector street speed reducers: 30 feet in length and 3.1 inches high, with a flat center section.

The speed reducer extends across the roadway, with gaps for drainage at the curbs.

Bicycles do not require special provisions.

Installation of a speed reducer sign is considered mandatory.

The longer reducers better accommodate longer wheel base vehicles.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Local and collector residential streets.

Traffic conditions

Posted speed limit of $\leq$ 30 mph.

Roadway

Generally two traffic lanes (one in each direction) are required, but a reducer or speed table can be used on one-way streets.

On-street parking can be permitted on speed reducers, unless the measure is used in conjunction with curb extensions.

Preferred locations

According to NYCDOT criteria for the placement of speed reducers, they may be installed:

- On streets classified by AASHTO as 'local' and residential in nature.
- On DOT-maintained streets.
- On one- or two-way streets with no more than two travel lanes, or not more than 40 feet in width.
- On streets over 40 feet wide, if they maintain not more than two travel lanes.
- With sidewalk extensions, planters, medians, diagonal parking, or other types of roadway narrowing devices. Any item placed in the roadway must not reduce sight lines more than that of a parked car.
- On streets adjacent to schools, where 85th percentile speeds are GREATER than 25mph, or where 85th percentile speeds are GREATER than 30mph on all other streets.**
- On streets without curbs, provided roadside delineators prevent driving around the reducer.
- Where the minimum safe stopping sight distance as defined by AASHTO can be provided.
- Where lighting meets minimum city standards. If possible, coordinate the location of the speed hump with existing street lamps.

**NOTE: Speed Reducer policy revised by NYCDOT July 2008

- Where the street pavement and drainage are in good condition; otherwise, the installation will have limited value.
- Where parking is allowed, except as otherwise regulated.
- At least 100 feet from the tangent point of a curve or intersection, and/or crosswalk. On one-way blocks of 200 feet or less, install the hump in the center of the block.
- At least 200 feet from a traffic signal or STOP sign.

In addition, ITE recommends that speed reducers be placed in a series.

Locations to avoid

According to NYCDOT criteria, speed reducers may not be installed:

- On regularly scheduled, local bus routes. Reducers may be installed on regularly scheduled express, long-distance, or tour bus routes.
- On designated local or through truck routes; or where more than five percent of the traffic is long wheel-based vehicles (unless there is a reasonable diversion route).
- On designated snow emergency routes.
- On primary or routine emergency vehicle access routes.
- On streets scheduled to be reconstructed within five years.
- On horizontal curves of more than 300-foot centerline radius.
- On streets with grades of more than eight percent.
- Adjacent to a curb or driveway.
- At a utility cover, fire hydrant, catch basin, or where a utility interacts with the roadbed.

BENEFITS

Vehicle speeds

Speed reducers and speed tables have been shown to be among the most effective of all traffic calming devices at reducing vehicle speeds.

Local street speed reducers—spacing along roadway to achieve desired 85th percentile speeds between speed reducers:

30 mph = every 410 feet

25 mph = every 260 feet

19 mph = in pairs 13 feet to 40 feet apart, every 200 feet.

Speed reductions below 19 mph are difficult to achieve,

Collector street speed humps—spacing along roadway to achieve desired 85th percentile speeds:

30 mph = every 410 feet.

Traffic volumes

Diversion of through traffic to other parallel routes may occur where several speed humps are used in series.

Representative experience in the use and the effect of speed humps on traffic volumes proves their effectiveness in lowering volumes on treated streets.

Conflicts

Reduction from average 0.32 reported collisions per month to 0.19 reported collisions per month, on five streets with a total of twenty-two local street speed humps (Portland, OR). UK experience shows an average 71% reduction in collisions on streets with speed humps.

Environment

Traffic noise may be reduced due to lower speeds. Benefits may be offset by increased noise due to braking and accelerating at speed reducers, and from loose objects in the back of vehicles. Reductions in traffic noise of 3 dBA to 11 dBA after speed humps installed. A 3-dBA change is the minimum difference detectable by the human ear.

DISADVANTAGES

Significant disadvantages

Some traffic may be diverted to parallel streets that do not have speed reduction measures.

Moderate disadvantages

Ambulances: 2.3 to 9.7 seconds typical delay per speed reducer (depending on whether or not carrying patient).

Fire vehicles: 2.8 to 15 seconds delay per speed reducer.

Buses: maximum speed = 19 mph over collector street speed reducer.

Bicycles: no effects at moderate speeds. Some cyclists may experience loss of control at speeds over 25 mph.

Noise: some motorists honk horns when driving over speed reducers.

Some residents report increases in noise due to speed reducers.

Pavement markings and signing could detract from the appearance of a street.

These devices may create drainage problems on some streets.

MAINTENANCE

Snow clearing time may be increased. Plow operators must slow at edge of speed reducer to avoid damaging speed hump surface. Shape of plow may require operator to lift plow at speed reducer. Speed reducer locations are identified by signs.

During street sweeping, a small amount of debris may remain at edges of the speed reducer.

Speed reducers interfere with pavement overlays.

COST CONSIDERATIONS

$1,000 for each speed reducer. $2,000 to $15,000 for a speed table, depending on drainage conditions and materials used. [39]

Installation cost varies, depending on width of roadway, labor, and materials costs.

Plan for maintenance costs, including pavement marking and asphalt repair.

[39] *Pedestrian Facilities Users Guide*, March 2002

DESIGN CONSIDERATIONS

Generalized standards and guidelines

The NYCDOT Planning Division coordinates the review and installation of speed reducers. The following are general standards and guidelines that apply to all NYCDOT speed reducer applications:

Grade—speed reducers may be installed on street sections with a grade equal to, or lower than 5%. The installation of speed reducers on street sections with a grade grater than 5% must be based on an engineering evaluation to assure that the installation will not create inappropriate risks to traffic safety. Speed reducers may not be installed on street sections with grades greater than 8%.

Proximity to Curb—prior to placing speed reducers along horizontal roadway curvature, an engineering evaluation should be conducted to assure that the speed reducer installation will accommodate safe vehicle passage. In addition, speed reducers and/or speed bump warning signs should be placed in such manner as to be clearly visible by approaching motorists.

Street Condition—the NYCDOT Bureau of Street and Arterial Maintenance should inspect all streets prior to any proposed construction of a speed reducer. The Bureau determines if the existing street pavement conditions are adequate to support impact loads caused by the speed reducers and if any pavement maintenance is required. If it is determined that improvements or maintenance is required, that work should be completed before reducers are constructed.

Curbs—speed reducers may be installed on streets without curbs. However, in order to avoid potential circumnavigation around reducers at location without curbs, precautions, such as the installation of roadside delineators, may need to be taken.

Driveways—construction of speed reducers at a driveway location should be avoided where possible to reduce potential vehicle conflict.

Parking—no special parking removal is required on or near speed reducers.

Diversion Potential—adjacent streets, identified by the engineer, as having potential for being impacted by vehicle diversion from the street being treated with speed reducers, should be monitored.

Bus Stops/Zones—where possible, speed reducers should not be installed in street sections where transit vehicles must transition between the travel lane and curb stop. To the extent possible, speed reducers should be located in such way as to ensure that transit vehicles can traverse the reducers perpendicularly.

Spacing—speed reducers installed in series should be spaced according to an engineering evaluation of the physical street section as well as traffic operations data. Typically, speed reducers are spaced between 300 and 600 feet apart.

Utilities—speed reducers should be located in such a way as to avoid conflict with underground utility access to boxes, vaults and sewers.

**

Speeds -- On streets adjacent to schools, the 85th percentile speeds must be GREATER than 25mph, or must be GREATER than 30mph on all other streets.*Policy revised by NYCDOT July 2008

General design considerations

A speed reducer is intended to produce sufficient discomfort to limit travel speeds yet allow the driver to maintain vehicle control. Speed reducers should be designed to reduce the chance of back problems or other physical discomfort experienced by vehicle occupants.[40]

Geometric requirements

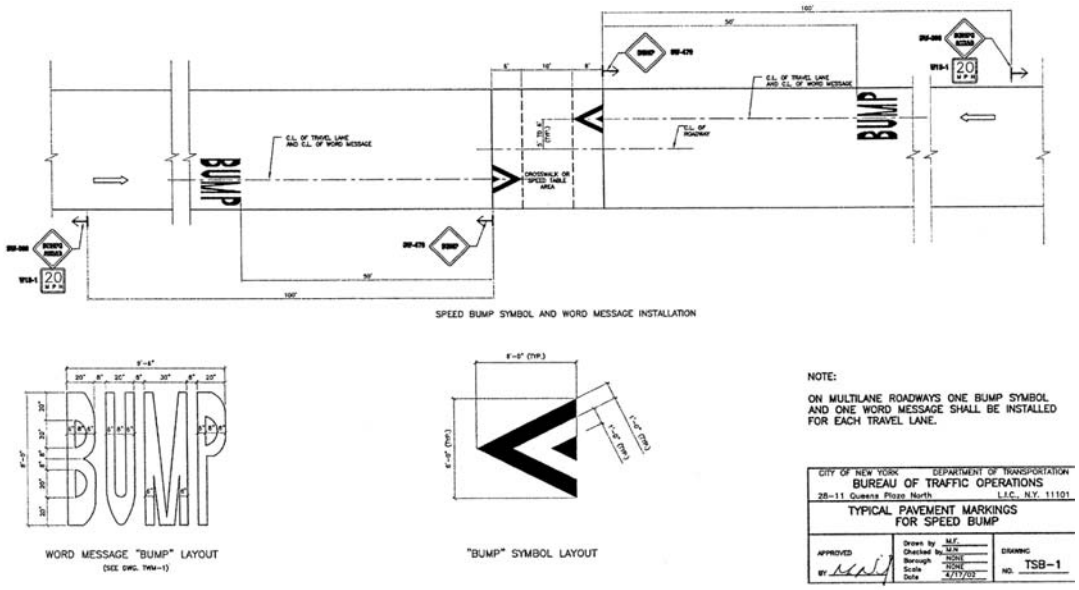
The local and collector street speed reducers have similar configurations except that the latter has a flat top section 10 feet long by 3.15 inches high between the two halves of the local street reducer. This difference recognizes the likelihood of transit and emergency routes being located on the collector streets.

The vertical transition required at each end of a retrofit speed reducer should be keyed into the existing pavement. This will produce a structure which is more securely bonded to the existing pavement than a "feather edged" installation. Such an installation should minimize damage to, and by, snow plowing equipment.

The dimensions and sinusoidal profile of the ramp are the most compatible with roadway maintenance, emergency vehicle travel, and general drivability requirements. It is recognized that while current construction techniques may make achievement of this profile difficult, best attempts should be made.

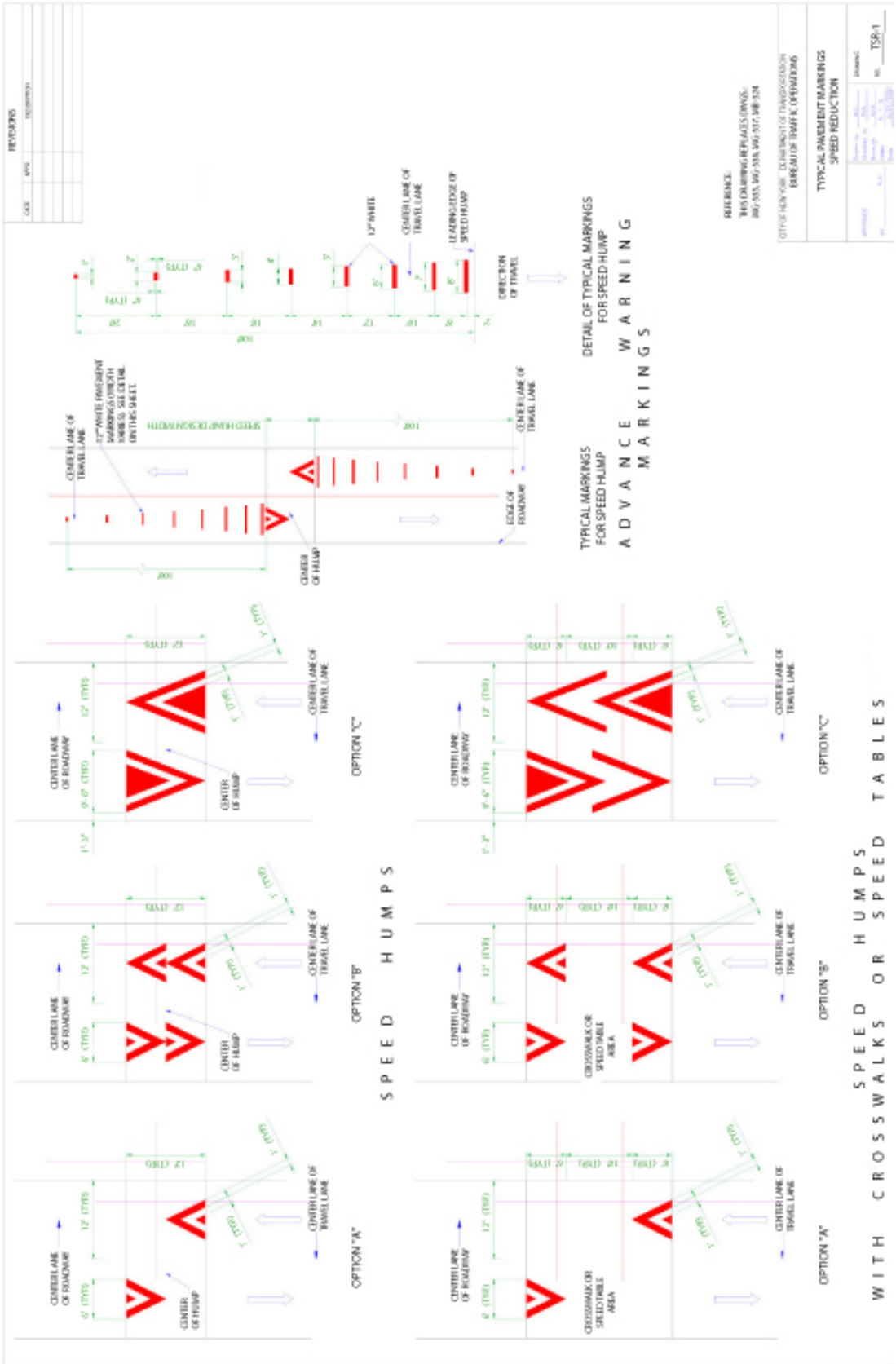
Signing and pavement marking requirements

Install the speed reducer sign facing traffic and immediately adjacent to the speed hump. If a speed reducer is installed on a one-way street, install speed reducer signs on both sides of the street facing traffic. NYCDOT roadway markings for speed reducers are shown below:



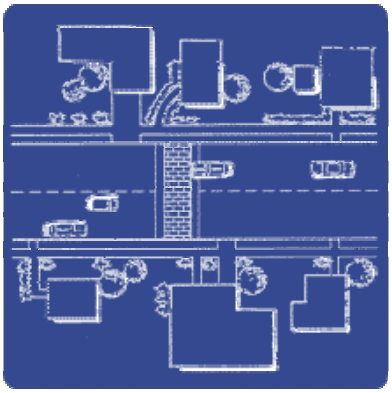
Drawing TSB-1, NYCDOT.

[40] *Pedestrian Facilities Users Guide*, p. 75.



Speed hump markings, NYCDOT.

RAISED CROSSWALK



Raised crosswalk image: trafficcalming.org

Ann Arbor, Michigan

GENERAL INFORMATION

Description

A raised crosswalk is a marked pedestrian crosswalk at an intersection or a controlled mid-block location constructed at a higher elevation than the adjacent roadway. A raised pedestrian crossing is essentially a speed table, with the full width of the crosswalk contained within the flat portion of the table, usually 10 to 15 feet wide. Construction involves providing ramps on each vehicle approach, which elevate the crosswalk approximately 3 inches. The crosswalks on each approach are also elevated as part of the treatment to enable pedestrians to cross the road at nearly the same level as the sidewalk.

The purposes of a raised crosswalk are to: reduce vehicle speeds, improve pedestrian visibility, and reduce pedestrian-vehicle conflicts. Raised crosswalks slow motorists where pedestrian conflicts are most likely to occur.

Characteristics

- The vertical deflection of vehicle wheels produces an uncomfortable sensation for vehicle occupants traveling at excessive speeds;
- The raised surface improves visual identification of crosswalk areas and emphasizes pedestrian priority;
- The roadway approaches to and departures from the crosswalk are appropriately ramped in consideration of vehicle types and desired speed.

LOCATION, PLACEMENT

Road classification

Local and collector residential streets

Traffic conditions

Posted speed limit $\leq$ 30 mph

Preferred locations

Marked, stop-controlled (unsignalized) crosswalks.

Locations to avoid

- Designated emergency access, bus, and truck routes.
- Sharp curves or steep grades.

BENEFITS

Vehicle speeds

Raised crosswalks have proven speed reduction impacts.

Traffic volumes

Reductions on affected streets, likely increases on neighboring streets

Conflicts

See *speed reducers*.

Environment

- Traffic noise may be reduced due to lower speeds.
- Raised crosswalks can be made more conspicuous through the use of special paving materials.

Other

- Pedestrian crossing area better defined.
- Pedestrian safety improved as vehicles are forced to slow through a pedestrian conflict zone.

DISADVANTAGES

Significant disadvantages

Traffic may be diverted to parallel residential streets that do not have traffic calming measures.

Moderate disadvantages

- Impacts and delays to ambulances, fire vehicles, and buses—3.8 seconds per raised crosswalk.
- No effects on cyclists at moderate speeds. Some cyclists may experience loss of control at speeds over 25 mph.
- Visually impaired pedestrians may have difficulty differentiating between the curb and the traveled portion of the street.
- Consistent configuration throughout a community is desirable to facilitate safe use by those with mental impairment.

MAINTENANCE

- Catch basins are required to provide drainage on the uphill side of a raised crosswalk, as crosswalk extends to the curb. If catch basins become blocked, ponding may occur on the uphill edge of the crosswalk.

- Snow clearing time may be increased. Plow operators must slow at edge of raised crosswalk to avoid damaging crosswalk surface. Shape of plow may require operator to lift plow at raised crosswalk.
- Raised crosswalks interfere with pavement overlays.
- Raised crosswalks have no significant effect on street sweeping (small amounts of debris may remain at edges of raised crosswalk).

COST CONSIDERATIONS

Raised crosswalks cost approximately $2,000-$5,000 each.[41] Costs vary depending on drainage requirements, width of roadway, labor, and materials costs.

DESIGN CONSIDERATIONS

A raised crosswalk may be installed at a controlled intersection, or a controlled mid-block location. Its elevation should be raised sufficiently to discourage high speeds yet allow the driver to retain control of the vehicle.

The elevation difference should not adversely affect transit or emergency vehicle operation.

A raised crosswalk is 20 feet wide with a minimum 8-foot crosswalk width, in accordance with the MUTCD.

A raised crosswalk can be built with a variety of materials, including asphalt, concrete, stamped concrete, or pavers.

Geometric requirements

The location of this measure relative to curbs and sidewalks should be identical to that for crosswalks that are not raised, so that visually impaired pedestrians or others who may be affected can clearly understand the relative safety of crossing the street at this location. The reduced curb face shown at these locations will provide a physical indication of the edge of the roadway, yet not present an obstacle.

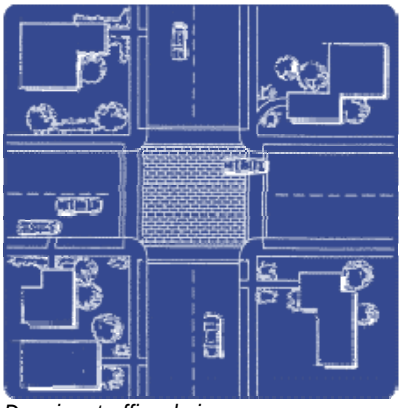
Tactile surface treatment on approaches to such a crosswalk also should be provided. Detectable warning strips at raised crosswalk edges enable pedestrians with vision impairments to detect the crossing location, which might otherwise be difficult to detect for lack of the usual 6-7 inch grade change. These detectable warnings can mark the boundary between sidewalk and the street.

The vertical transition required at each end of a retrofit raised crosswalk should be keyed into the existing pavement. This will produce a structure that is more securely bonded to the existing pavement than a 'feather edged' installation. Such an installation should minimize damage to, and by, snow plowing equipment.

The dimensions and sinusoidal profile of the ramp are most compatible with roadway maintenance, emergency vehicle travel, and general drivability requirements.

[41] City of Portland Office of Transportation estimate.

RAISED INTERSECTION



Drawing: trafficcalming.org

Hicks Street and Pierrepont Street, Brooklyn

Description and purpose

A raised intersection is an intersection—including crosswalks—constructed at a higher elevation than the adjacent roadways. The purpose of a raised intersection is to reduce vehicle speeds, better define crosswalk areas, and reduce pedestrian-vehicle conflicts.

Characteristics

- The vertical deflection of vehicle wheels produces an uncomfortable sensation for vehicle occupants traveling at higher speeds;
- The raised roadway surface emphasizes pedestrian priority at intersections;
- The raised center section includes crosswalks;
- The roadway approaches to and departures from the raised intersection are appropriately ramped in consideration of vehicle types and desired speed.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

local and collector residential streets

Traffic conditions

posted speed limit: ≤ 30 mph;
most effective where there are few large vehicle turns.

Roadway

Maximum two traffic lanes (one each direction) on each approach to the intersection.
Avoid designated emergency access routes, unless acceptable to emergency services.

BENEFITS

Vehicle speeds

Reduction from 29 mph to 22 mph observed.

Other

At a raised intersection, the pedestrian area is better defined.

Vehicles are forced to slow through intersection area.

DISADVANTAGES

Significant disadvantages

High cost.

May divert traffic to parallel residential streets without traffic calming measures.

Moderate disadvantages

Slows emergency vehicles to approximately 15 mph.

Snow clearing time increased slightly. Plow operators must slow at edge of transition section to avoid damaging roadway surface.

No effect on bicycles at moderate speeds. Some cyclists may experience loss of control at speeds over 25 mph.

MAINTENANCE

Small amounts of debris may remain at edges of ramped sections of intersection following street sweeping. A LIFT PLOW sign should be placed to warn snowplow operators in winter.

COST CONSIDERATIONS

$35,000 per raised intersection. The unit cost for a raised intersection assumes that the intersection is raised 4" above the existing roadway crown, and that the raised portion of the intersection is built in concrete, not asphalt. The raised section of the intersection is assumed to reach all four corners of the intersection.[42]

DESIGN CONSIDERATIONS

The elevation of a raised intersection should be sufficiently raised to discourage high speeds yet allow the driver to retain control of the vehicle. The elevation difference should also not adversely affect transit or emergency vehicle operations.

Geometric requirements

Raised intersections should be raised by the same amount as any adjacent raised sidewalks (3 inches recommended). The amount of raising should desirably be consistent throughout a community's street system, including crosswalks, to improve driver and pedestrian comprehension of the intended operation/behavior.

A 0.6" curb face should be retained at all crosswalk locations at the raised intersection to provide a physical indication of the intersection limits. The sloping surfaces connecting adjacent sidewalks to those across the raised intersection should have a tactile finish and a slope of 6% or less.

The vertical transition required at each end of a retrofit raised intersection should be keyed into the existing pavement. This will produce a structure which is more securely

[42] *Downtown Brooklyn Traffic Calming Project, Final Report*. New York City Department of Transportation, May 2003.

bonded to the existing pavement than a “feather edged” installation. Such an installation should minimize damage to, and by, snow plowing equipment.

The dimensions and profile (sinusoidal) of the ramp as shown, are the most compatible with roadway maintenance, emergency vehicle travel and general drivability requirements. It is recognized that while current construction techniques may make achievement of this profile difficult, best attempts should be made.

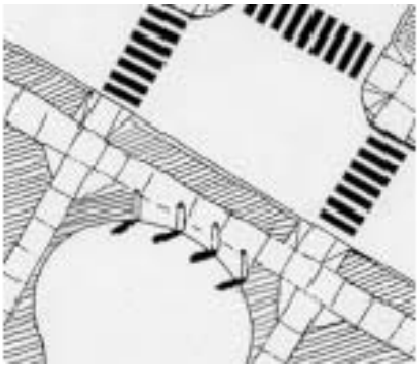
A minimum pavement slope of 1% should be provided within the raised intersection to facilitate surface drainage. Surface drainage implications on the approaches to a raised intersection should also be addressed.

Signs and pavement markings

Install speed hump signs facing traffic and immediately adjacent to the ramp, unless the approach is controlled by a stop sign, in which case no additional signing is required.

Pavement markings to identify the location of the transitions to a raised intersection are the same pavement markings used to identify a speed hump.

FULL STREET CLOSURE



Drawing: Pedestrian Facilities Users' Guide

West Fourth Street and Eighth Avenue, Manhattan

GENERAL INFORMATION

Description

A full street closure is a barrier extending the entire width of a roadway, which obstructs all motor vehicle traffic movements from continuing along the roadway. A closure can change a four-way intersection to a three-way intersection, or a three-way intersection to a non-intersection. Gaps can be provided for cyclists and they are typically passable by emergency vehicles. The purpose of a full closure is to eliminate short-cutting or through traffic.

Temporary street closures (during specified school hours) have long been in use at some New York City schools (see *play streets*).

LOCATION AND PLACEMENT

Road classification

Local streets, where streets are more than 100 feet long.

Preferred locations

At an intersection.
Mid-block (closure can be used to separate different land uses, such as separating residential and commercial).

Locations to avoid

Designated emergency access routes, unless design permits passage by emergency vehicles.
Not appropriate for collector streets.
Not recommended for school bus routes.

BENEFITS

Traffic volumes

Eliminates all short-cutting or through traffic.

Environment

Traffic noise may be reduced locally due to a reduction in traffic volume.
Air quality may be improved locally due to a reduction in traffic volume.

Other

This is the ultimate limitation of motor vehicle traffic to certain streets. Full street closures also provide a turnaround area for motor vehicles, including service vehicles, and provide for surface drainage.

DISADVANTAGES

Significant disadvantages

Restricts resident access.

May divert significant volume of traffic to parallel streets without traffic volume reduction measures.

May prevent emergency access, unless closure is designed to be passable by emergency vehicles.

Moderate disadvantages

Some motorists may deliberately circumvent barrier, driving across adjacent properties.

A turn-around area is required on dead-end streets, which may require property acquisition.

May require on-street parking prohibitions in vicinity of closure.

MAINTENANCE

No significant implications for snow removal provided that sufficient space is available for the plow to reverse and turn around.

May complicate street sweeping, snow removal, and garbage collection routes.

COST CONSIDERATIONS

The cost for a full, landscaped street closure varies from $30,000 to $100,000, depending on conditions.[43]

Cost varies, depending on width of roadway, configuration of turnaround area, extent of landscaping, labor and material costs.

DESIGN CONSIDERATIONS

General considerations

This treatment provides complete severance of vehicle access (including emergency access) between two roadways, just as a permanent street closure and de-mapping would do. Pedestrians (including wheelchair users) and bicycles, however, should be accommodated.

[43] *Pedestrian Facilities Users Guide*, March 2002.

Geometric requirements

The provision of some form of cul-de-sac at the end of the closed roadway must be included.

Bollards or trees should be strategically placed across the closed roadway alignment to discourage continued off-road travel to and from the severed street.

Rolled or mountable curbs are recommended adjacent to the confined bicycle lanes to reduce potential conflicts with bicycle pedals.

Signing and pavement marking requirements

At the entrance to the full closure block, a NO OUTLET sign is required. NO PARKING signs may also be required.

There are no pavement markings specific to this measure.

RECOMMENDATION

Full street closures should be used only in the most rare of circumstances. Neighborhoods with cul-de-sac streets require extensive out-of-the-way travel, which is not a mere convenience issue, but has serious implications for impacts on other streets. All traffic is forced to travel on feeder streets, which has negative consequences for the people who live on those streets and forces higher levels of control at critical intersections.

Precede the installation of all volume control measures by a traffic study to project the effects of diversion of traffic onto neighboring streets. Temporary closures can be accomplished with removable elements like bollards.

PARTIAL STREET CLOSURE

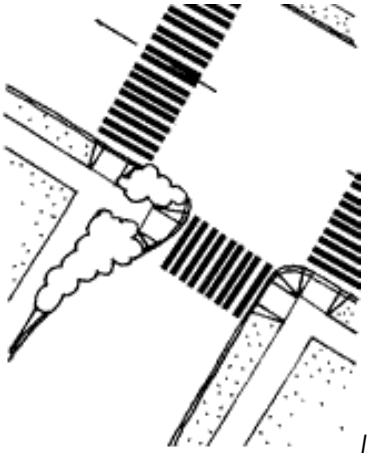


Image: Pedestrian Facilities Users Guide

GENERAL INFORMATION

Description

A partial closure (also called a directional closure) uses a semi-diverter, curb extension or vertical barrier extending to approximately the centerline of a roadway, effectively obstructing (prohibiting) one direction of traffic. The purpose of a partial closure is to obstruct short-cutting or through traffic.

Bicycles may be permitted to travel through a partial closure in both directions, including the direction in which motor vehicle traffic is obstructed. In some cases, gaps or a contra-flow bicycle lane are used to provide bicycle access.

If the partial closure only eliminates an entrance to a street, a turnaround is not needed; closing an exit will generally require a turnaround.

Characteristics

When combined with other measures elsewhere in the neighborhood, partial closures obstruct short-cutting or through traffic routes. The design of this measure should allow for easy access by bicyclists and all pedestrians, and not block drainage.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Local streets at intersections with collector or arterial streets.

Roadway

On-street parking can be permitted on both sides of a roadway on which there is a partial closure.

Preferred locations

The preferred orientation is to prevent ingress to a street, rather than to prevent egress from a street.

Locations to avoid

Local street intersections with other local streets.

BENEFITS

Vehicle speeds

Reduction in 85th percentile speeds from 35 mph to 29 mph (Gainesville, FL).

Traffic volumes

Reduction in volume by approximately 60-65% (Gainesville, FL and Montgomery County, MD).

Conflicts

Reduced pedestrian crossing distances may reduce vehicle-pedestrian conflicts.

Environment

Traffic noise may be reduced locally due to a reduction in traffic volume.
Air quality may be improved locally due to a reduction in traffic volume.

Other

Partial street closures prevent turns from an arterial street onto a residential street, reduce cut-through traffic, and restrict access to a street without creating one-way streets.

DISADVANTAGES

Significant disadvantages

Resident access is restricted.

May divert a significant volume of traffic to parallel streets without volume control measures.

Moderate disadvantages

Partial closures may impact school bus routes.

Partial closures may not address speeding issues.

Some motorists may deliberately circumvent partial closures, particularly during off-peak times when traffic volumes are lower, or if closure is located on a lower-volume street (such as at a local street intersection with another local street). Police enforcement may be required.

MAINTENANCE

May complicate street sweeping, snow removal and garbage collection routes. There are no significant implications for snow removal, provided the edges of the partial closure are identified for the plow operator with signs, posts, or other features which protrude above the snow.

COST CONSIDERATIONS

A well-designed, landscaped partial street closure at an intersection typically costs approximately $10,000 to $25,000. They can be installed for less if there are no major drainage issues and landscaping is minimal. [44]

Cost varies depending on the width of the roadway, length of the partial closure, drainage requirements, extent of landscaping, labor and material costs.

DESIGN CONSIDERATIONS

General considerations

This measure requires the physical obstruction of one or more lanes at an intersection. If the roadway entrance beyond the intersection has a partial closure, then all motorized vehicular traffic approaching such a closure is forced to turn onto the cross street. If the partial closure is on the near side of the intersection, the side street can be entered by all traffic, but motorized traffic cannot enter the intersection from the side street.

Geometric requirements

The width of exit-only partial closures islands must be sufficient in order that traffic proceeding straight through the intersection would conflict with opposing traffic. Partial closures are commonly introduced on two-lane roadways, thus the single unclosed lane would satisfy this requirement. Application on four-lane roadways would provide a lesser deterrent to through travel.

Openings can also be provided to accommodate bicycle traffic through the intersection. These gaps should be bordered by rolled curbs to define the bicycle path and channel any drainage runoff from the closure. The width of these openings should be 5 feet to 6.5 feet to provide sufficient maneuvering space for cyclists, yet not enough space for motorists. With this restricted width, the rolled curbs reduce the potential of pedals striking the curbs.

Signing and pavement marking requirements

For the exit-only closure, 'RIGHT TURN ONLY' or 'LEFT TURN ONLY' and 'ENTRY PROHIBITED' signs are required to advise approaching traffic of the closure. Exceptions can be made for bicycles, in which case the 'EXCEPT BICYCLES' supplementary tab sign is required. 'ONE-WAY' signs must also advise traffic on the cross street that no turns into the closed street are permitted. Delineation markers or bollards with reflective striping may be an acceptable alternative to object markers.

For the entrance-only closure, a NO OUTLET sign, advising that exiting is not possible, is required.

RECOMMENDATION

Model the effects on neighborhood traffic circulation before installing this measure.

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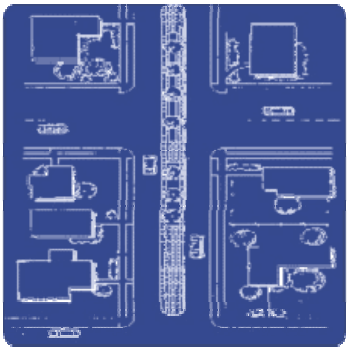
[44] *Pedestrian Facilities Users Guide*, March 2002.

MEDIAN BARRIER



Drawing: trafficcalming.org

Loveland, Colorado. Photo: pedbikeinfo.org

GENERAL INFORMATION

Description

A median barrier through an intersection is a raised median located on the centerline of a two-way roadway through an intersection, which prevents left turns and through movements to and from the intersecting roadways. It can create a refuge for pedestrians and cyclists, enabling them to cross one direction of travel at a time, thereby reducing waiting time for gaps when crossing the roadway. The purpose of a median barrier is to obstruct short-cutting or through traffic, and to reduce crossing distance for pedestrians.

LOCATION AND PLACEMENT

Road classification

Collector or arterial streets at intersections with local streets or residential collector streets.

Locations to avoid

Avoid local street intersections with other local streets, as motorists are likely to deliberately circumvent median barriers in low-volume locations.

Avoid primary emergency access routes.

BENEFITS

Traffic volumes

Reductions of approximately 35% have been observed (Victoria, BC, Canada).

Environment

Traffic noise may be reduced locally due to a reduction in traffic volume.

Air quality may be improved locally due to a reduction in traffic volume.

DISADVANTAGES

Significant disadvantages

Restricts resident access.

May divert a significant volume of traffic to parallel streets without traffic calming measures.

Moderate disadvantages

Some motorists may attempt to circumvent the median barriers, particularly during off-peak low volume periods and locations.

May require removal of some on street parking in the vicinity of the median barrier.

May obstruct emergency vehicles in locations where median cannot be easily circumvented. (see design considerations below.)

MAINTENANCE

Maintenance costs and procedures are the same as for raised medians.

COST CONSIDERATIONS

Median barriers cost approximately $10,000-20,000.[45] Cost varies depending on length and width of median, landscaping, labor, and material costs.

DESIGN CONSIDERATIONS

General considerations

By incorporating a short section of median through an intersection, left turns to and from a local street and straight through movements on the local street are obstructed.

A median barrier through an intersection should extend a minimum of 16 feet beyond perpendicular extensions of intersecting streets, to discourage attempts to drive to the left of the median to complete a left turn.

The median barrier should be sufficiently wide to offer a minimal pedestrian refuge area. The sidewalk crossings of the median barrier should include a depressed section. This depressed section should be narrow enough to discourage general usage but not preclude emergency access. Separate openings may also be required for cyclists.

Geometric requirements

The median should have a minimum 5-foot raised portion and provide a minimum 12-foot single lane width on each side beyond the intersection. Turning vehicle requirements will dictate the actual lane width adjacent to the median. The median should extend 16 to 23 feet beyond the outer edge of the crosswalk, depending on driveway locations, to discourage shortcutting.

The Fire Department of the City of New York (FDNY) requires a minimum roadway width of 22 feet on streets without parking, and 25 feet on streets with parking.

[45] City of Portland Office of Transportation estimate. *Pedestrian Facilities Users Guide*, March 2002

Signing and pavement marking requirements

The two ends of the median should have 'KEEP RIGHT' signs and object markers. At the center of the protected cross street, 'ONE WAY' signs should be erected on the median facing both approaches. 'NO STOPPING' signs may also be required, depending on the remaining lane widths.

RECOMMENDATION

Model the effects on neighborhood traffic circulation before installing this measure.

FORCED TURN ISLAND

Drawing: trafficcalming.org

Orlando, FL. Photo: trafficcalming.org

GENERAL INFORMATION

Description

A forced turn island is a raised triangular island at an intersection approach which obstructs left turns and through movements from the intersecting street or driveway. The purpose of a forced turn island is to obstruct shortcutting or through traffic.

Bicycles are typically permitted to make left turns and through movements from the side street, either through gaps or depressions in the turn island, or by traveling around the island.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Local and collector residential streets.

BENEFITS

Traffic volumes

Reductions in volume by approximately 35% were observed in Victoria, BC (Canada).

Environment

Traffic noise may be reduced locally due to a reduction in traffic volume.

Air quality may be improved locally due to a reduction in traffic volume.

When landscaped (respecting sight lines), forced turn islands may enhance the appearance of a street.

DISADVANTAGES

Significant disadvantages

Restricts resident access.

May divert significant volume of traffic to parallel streets without traffic calming measures.

MAINTENANCE

May complicate street sweeping, snow removal, and garbage collection routes.

COST CONSIDERATIONS

Similar to a diverter, a forced-turn island can cost $15,000 - $35,000.[46] Cost varies depending on width of roadway, labor and material costs.

DESIGN CONSIDERATIONS

General considerations

This treatment is intended to discourage straight-through movements and left turns to and from a street segment. All volume control measures should be designed so as to allow the continued safe and unimpeded movement of pedestrians and bicyclists.

Geometric requirements

The intersection radii should be chosen to produce a divisional island large enough to effectively discourage straight-through and left-turn movements. A minimum island size of 64 sq. ft. to 108 sq. ft. is required for pedestrian refuge.

Careful selection of the curb radius between the two street edges will maximize the island length along the unobstructed street thereby further discouraging through traffic on the obstructed street. Larger, infrequent vehicles should be accommodated by judicious location of depressed curbs and signs.

Signing and pavement marking requirements

On the protected intersection approach, a RIGHT TURN ONLY sign is required in advance of the intersection and on the divisional island. On the end of the divisional island facing this approach, a KEEP RIGHT sign and an object marker are also required. On the end of the divisional island facing traffic turning right onto the protected street, an object marker is required.

On the divisional island, facing the prohibited straight through movement, a NO ENTRY sign is required.

A LEFT TURN PROHIBITED sign should be placed on the cross street on the far side of the intersection and also at the end of the divisional island. Both signs should be facing the traffic which is to be prohibited from turning left.

On the intersection approach facing the divisional island, a RIGHT TURN ONLY or LEFT TURN ONLY sign will be required to advise drivers that they must turn onto the cross street.

RECOMMENDATION

Since this treatment eliminates certain movements, it can lead to new unforeseen diversions elsewhere in the system and should, therefore, be used judiciously. As with all volume control measures, conduct a network simulation to model anticipated traffic impacts on surrounding streets, and install a temporary test installation prior to permanent construction.

[46] City of Portland Office of Transportation estimate.

CHAPTER THREE: SAFE ROUTES TO SCHOOL

There are sign, speed limit, and striping measures that are specific to schools and school zones, and are approved by the Federal Highway Administration in its *Manual on Uniform Traffic Control Devices*. These include engineering approaches, such as:

- School advance warning
- Reduced speed limit
- Entering/leaving school zone sign

School-specific measures also include education, enforcement, and encouragement programs, events, and enforcements that can increase walking for a single day or as part of an ongoing program, that can enforce traffic regulations or speed limits, and that can educate students about walking safely to school.

SCHOOL ADVANCE WARNING

Image: FHWA

GENERAL INFORMATION

Description

School advance warning signs are typically placed between 150 and 700 feet prior to a designated school crosswalk or school grounds, as indicated in the MUTCD. School advance warning signs may be placed in advance of established school crossings not adjacent to a school ground.

School advance warning signs may be the standard yellow color, or fluorescent strong yellow-green. NYCDOT is currently installing the fluorescent strong yellow-green warning sign citywide.

Characteristics

These signs are intended to warn motorists that a school is nearby and to drive appropriately. Appropriate driving includes slowing, being prepared to stop for pedestrians, stopping as directed by crossing guards, and yielding to pedestrians in crosswalks.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Arterial, collector, or residential streets where there is a school crosswalk.

Effectiveness

The effectiveness of a school advance warning sign can be increased when used in combination with crosswalk markings and a school crossing guard.

BENEFITS

Other

If used uniformly, the advance warning sign can help to make drivers aware of areas where they should be more alert.

COST CONSIDERATIONS

Signs cost approximately $200 per sign, plus installation.

School advance warning signs are typically used in combination with an entire assembly of school zone markings and signs, and may also include a school crossing guard program. Costs for these additional items are separate.

DESIGN CONSIDERATIONS

General considerations

Signs should be used uniformly and consistently prior to all school crossings. The overall effect is minor but is critical because of the longevity of the sign itself and the public acceptance of the message.

Signing and pavement marking requirements

See MUTCD for guidance on size, color, and placement.

NYCDOT Policy

The advance school crossing sign (W9-1) shall be used in advance of any installation of the school crossing sign. The advance sign shall be installed not less than 150 feet nor more than 700 feet in advance of the school crossing. The advance sign shall be supplemented with a supplemental plaque with the legend 'AHEAD' to provide notice to motorists of crossing activity.

The school crossing sign (W9-2) shall be installed at school crosswalks at intersections controlled by traffic signals and at the uncontrolled leg of an intersection controlled by a stop sign. The school crossing sign shall be supplemented with a supplemental plaque with the diagonal arrow. N°. W9-2 should be installed on the stop-controlled leg of an intersection. The high visibility fluorescent yellow-green signs shall be used exclusively for all school crossing signs.

RECOMMENDATION

Use of the school advance warning sign and marked school crosswalks is recommended for continued and consistent application for all program schools. Placement of the assembly should be uniform and consistent for all schools.

The use of the fluorescent strong yellow-green color has become increasingly identified with school-related warning signs, and several states have adopted its use exclusively for schools and school zones. Use of the fluorescent strong yellow-green color for signs and markings is an inexpensive way to identify a school zone, and to notify motorists of the possible presence of school-aged pedestrians.

If the fluorescent strong yellow-green is selected as the color for school advance warning signs, its use should be consistent with other measures (school crosswalk signs, school speed zone signs, post reflectors, and crosswalk markings). The MUTCD recommends consistent use of sign colors for school zones.

REDUCED SPEED LIMIT

Reduced speed limit in a school zone.

GENERAL INFORMATION

Description

Reduced speed limit signs are used by some jurisdictions in and around schools or other high pedestrian areas. Reduced speed limit signs may also accompany SCHOOL ZONE signs or PLAYGROUND signs, and are typically placed on the right side of the roadway.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Local and collector residential streets.

Effectiveness

Used in conjunction with advance warning signs, these signs may help to alert drivers to the presence of school-aged children in the vicinity.

Used in combination with traffic calming measures, reduced speed limit signs may be more effective in reducing vehicle speeds.

Raised crosswalks and speed humps would be more effective in reducing vehicle speeds.

Preferred Locations

Physical features (undesirable geometrics, poor sight distance, or surface conditions) and environmental factors (schools, residential areas, and large numbers of pedestrians and/or bicyclists) may influence posted speed limits.[47]

BENEFITS

Vehicle speeds

Typically, reductions in maximum-posted legal speeds on individual streets or sections of a street do not result in significant reductions in vehicle speeds unless accompanied by

[47] Iowa State University, Center for Transportation Research and Education (www.ctre.iastate.edu)

regular police enforcement. The lower the posted maximum posted legal speed, the lower the rate of compliance: 17% for a 25 mph posted limit; 24% for a 30 mph posted limit; 29% for a 35 mph posted limit (based on studies in 23 states). According to research conducted by FHWA in 1997, raising and lowering speed limits as much as 20 mph has little or no effect on prevailing speeds.[48]

Other

In some communities, speeding fines are doubled in school zones. Increased enforcement has shown an increase in the number of citations for speeding in these areas, but no significant reduction in vehicular speeds.[49]

DISADVANTAGES

Significant disadvantages

These signs are sometimes used without any other physical measure to lower vehicle speed, creating an enforcement problem. The signs could create conditions of vehicles traveling at substantially different speeds (those complying with the school speed limit and those not).

Moderate disadvantages

Collisions may increase with use of inappropriate maximum-posted legal vehicle speeds and as the differential increases between the posted and operating speeds.

COST CONSIDERATIONS

Signs are a small part of the overall cost: $200 per sign plus installation costs. Regular enforcement is often required when speed zones are lowered, and enforcement costs can be high.

RECOMMENDATION

Do not use a reduced speed limit sign unless coupled with physical traffic calming measures and with regular enforcement.

[48] "Managing Speed" by Elizabeth Alicandri and Davey L. Warren, in *Public Roads*, Jan.-Feb. 2003.
[49] Based on a National Highway and Traffic Safety Administration study in Yakima, WA, 1997.

ENTERING AND LEAVING SCHOOL ZONE

Residential model safety zone, Carlton Avenue, Brooklyn. *Image: MUTCD*

GENERAL INFORMATION

Description

There is no standard sign for entering a school zone. Reduced speed zone signs, advance warning signs, school bus stop signs, and other signs can be used to signal the entrance to a school zone. However, the *Manual on Uniform Traffic Control Devices* (MUTCD) has a standard 'END SCHOOL ZONE' sign, as shown above. The MUTCD states:

> "The end of an authorized and posted school speed zone shall be marked with a standard SPEED LIMIT sign showing the speed limit for the section of highway that follows or with an 'END SCHOOL ZONE' sign."[50]

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Arterial, collector, or residential streets in the vicinity of a school.

Effectiveness

The effectiveness of school zone signs and markings can be increased when used in combination with crossing guards, proper enforcement, and traffic calming measures.

BENEFITS

A clear advantage of signs and markings is their relative low cost.

DISADVANTAGES

Moderate disadvantages

Repeated exposure to any sign reduces its effectiveness. Some drivers disregard such warnings and exceed the regular posted speed when traveling through a school zone.

[50] *Manual on Uniform Traffic Control Devices*, December 2000, Section 7B-13.

COST CONSIDERATIONS

Signs cost $200 per sign, plus installation.

For each school, consider the costs of all signs and delineator posts at necessary locations within the school zone. Ensuring uniform use of sign colors may add to the costs of purchasing new signs or replacing non-conforming signs.

DESIGN CONSIDERATIONS

Signing and pavement marking requirements

The MUTCD recommends a standard size of 24" x 30" for the 'END SCHOOL ZONE' sign.

RECOMMENDATION

The 'END SCHOOL ZONE' sign can inform motorists of the outer boundary of a school zone. The use of the advance warning sign, school crosswalk sign, and school speed limit assembly, along with the 'END SCHOOL ZONE' sign, adds to the conspicuity of the signs, but is not a substitute for more aggressive measures.

SCHOOL SAFETY PATROL

Calgary. Photo: Alberta Motor Association

School safety patrols are made up of student volunteers from upper elementary grades and middle schools. School safety patrols aid school pedestrians at crossings near elementary schools. The job of a safety patrol is to regulate the safe movement of school children, in the immediate vicinity of a school. Student volunteers also teach other students about traffic safety and are expected to act as role models for younger children. School safety patrols should not direct vehicular traffic. They stop children back of the curb or edge of the roadway and allow them to cross only where is an adequate gap in traffic.

Advantages

This low-cost volunteer project is intended to instill leadership and responsibility in student safety patrol members. A peer-to-peer safety message is often better received by students than a message delivered by grown ups. School safety patrols may be used to direct and control children at signalized intersections where turning movements are not a problem and to assist adult crossing guards in the control of children at crossing locations used by large numbers of children.

Disadvantages

The program may be too much responsibly for students. Being a school safety patrol member can be hard work for a young person who has a full class schedule and often has after school activities.

SCHOOL CROSSING GUARDS

E. 19th Street, Manhattan

Crossing guards are adult uniformed part-time civilian employees who are responsible for crossing children at designated school crossings to assist elementary school pedestrians at specified hours when going to or from school. The crossing guard's primary duty is to see that children cross the street in marked crosswalks and in a manner that provides for their maximum safety. In New York City, candidates train for six days at the Police Academy and undergo a medical exam and background investigation.

Advantages

Crossing guards help guide children across the street and negotiate potential pedestrian vehicle conflicts.

Disadvantages

Crossing guards are only effective at intersections where they are posted and present. Even when crossing guard posts are funded, New York Police Department precincts report that it is difficult to attract qualified candidates to the low-paying post.

Recommendation

Use crossing guards to help children cross in conjunction with other measures that manage speeds and regulate traffic.

WALKING SCHOOL BUS

UK. Photo: saferoutestoschools.org.uk

A 'walking school bus' is a group of students who are accompanied by one or more adults on their walks to and from school. In a walking school bus program, walking bus 'drivers' walk a set route and pick up children along the way and walk with them safely to/from school. This type of program promotes and encourages walking to school. Typically, the students live near one another and may already walk to school, with or without adult supervision. The walking school bus is unique in that it is intended to be a consistent, supervised system in which children walk together with an adult. Often walking school buses are staged as one day events to raise awareness about pedestrian safety or to promote walking to school for health reasons.

Advantages

Adult supervision helps to control children's behavior around traffic, and introduces opportunities to model safe walking behavior. By providing a safe supervised walking trip between home and school, the walking school bus saves parents the need to drive their children to/from school individually.

Disadvantages

The program is difficult to administer and sustain on a volunteer basis.

WALK TO SCHOOL DAY

E. 19th Street, Manhattan

Walk to School Day is an international event in early October promoting pedestrian safety and walking to school. Participating schools and municipalities often sponsor pedestrian safety poster contests, stage walking school buses and hold assemblies. Schools reach out to drivers and parents through the media with traffic safety messages reminding them to drive carefully near schools.

International Walk to School Day gives children, parents, school teachers and community leaders an opportunity to be part of a global event as they celebrate the many benefits of walking. In 2001, nearly 3 million walkers from 21 countries walked to school together for various reasons—all hoping to create communities that are safe places to walk. The goal of the walk varies from community to community. Some walks rally for safer and improved streets, some to promote healthier habits and some to conserve the environment. Whatever the reason, Walk to School Day events can promote walkability.

A few of its goals include:

- Encourage physical fitness.
- Raise awareness of how walkable a community is and where improvements can be made.
- Raise concern for the environment.
- Reduce crime and take back neighborhoods for people on foot.
- Reduce traffic congestion, pollution, and speed near schools.
- Share valuable time with local community leaders, parents, and children.[51]

Advantages

Raises public awareness of child pedestrian safety issues. Introduces or reminds school and children of traffic safety basics.

Disadvantages

No data on efficacy of one-day safety event.

[51] Pedestrian and Bicycle Information Center

WALKABILITY AUDIT

Image: Pedestrian and Bicycle Information Center

A walkability audit is a checklist that communities, schools or municipalities can use to assess how safe and easy it is to walk in a particular location, and identify areas for improvement. Areas of evaluation include sidewalks, crossings, safety, security and traffic and driver behavior.

A walkability audit involves a parent or caregiver taking a walk with her or his child and using the checklist (shown above) to determine if the neighborhood is a friendly place to walk. The next step involves reviewing the checklist, and while on the walk, noting the locations of things that require change. At the end of the walk, a rating is assigned to each question. An overall score rates the walk. Following the rating and identification of problem areas, the next step is to figure out what can be done to improve the community's score through both immediate and long-term solutions.

A rating is assigned to each of these questions, and the neighborhood can be evaluated based upon its ratings.[52]

Advantages

Can be used to create public awareness and ownership of potential changes.

Disadvantages

May foster unrealistic expectations about project.

[52] Pedestrian and Bicycle Information Center

PROGRAM IDENTIFICATION

In the United Kingdom, different types of pedestrian crossings have been developed, and given names from the animal kingdom as unique ways to identify them. Both the 'zebra' and the 'pelican' are similar or identical to types now used in the United States, but the addition of the 'toucan' and 'puffin' to the crossing types increases their unique identification and association with pedestrian safety and particularly children's safety, as the original pelican crossing, when instituted in 1969, was promoted on children's television programs. In keeping with the theme, the 'hawk' crossing has recently been instituted.

'Zebra' crossing:

The 'zebra' is the standard ladder-type or high-visibility crosswalk, so named for its striping. It is usually accompanied by flashing lights on either side of the crosswalk.

S. Oxford Street, Brooklyn

'Pelican' crossing:

The Pelican (**Pe**destrian **Li**ght **Con**trolled) crossing uses pedestrian-operated push button control. There are signals for drivers and pedestrians, instructing each when to stop and go. In the UK is there is a 'flashing green' (do not start) phase for pedestrians and a flashing amber for motorists warning of an imminent signal change.

'Puffin' crossing:

Puffin crossing: source: UK Department for Transport

The Puffin crossing (**P**edestrian **U**ser **F**riendly **In**telligent Crossing) is a development of the Pelican crossing. It has automatic detection of pedestrians to extend or reduce the all-red period as required to suit the crossing speed of the pedestrian. Curbside detectors can cancel a pedestrian demand if the pedestrian walks away from the crossing point.

'Toucan' crossing:

Image: Nottinghamshire Township, UK

The Toucan ("**two can** cross") crossing is designed to be a shared crossing for pedestrians and cyclists, with the same form of pedestrian-or cyclist-on crossing detector as the Puffin crossing. Toucan crossings have a complex set of push buttons and detectors for pedestrians, as well as different signal phases for pedestrians and bicyclists. Curbside detectors can also be employed but only when nearside signaling is used.

'Hawk' crossing:

HAWK crossing, Tucson, AZ

The Hawk (**H**igh intensity **A**ctivated cross**W**al**K**) crossing also uses pedestrian-operated push button control. When operated, a traffic signal flashes yellow and then turns red, stopping traffic completely before the pedestrian crosses.

The crossing intersection must be equipped with electrical wiring; for installation, it is recommended that the crossing intersection be 600 feet from the nearest stoplight, and have 120 to 150 pedestrians crossing the intersection each hour.[53]

Average costs for installation

Zebra: $1,150
Pelican: $10,000
Puffin: $14,000
Toucan: $70,000[54]
Hawk: between $75,000 and $100,000

[53] University of Arizona *Daily News*, August 30, 2001.
[54] Based on installation costs for the Borough of Gosport, County of Hampshire, UK: thisishampshire.net

SPEED BOARD

Queens Boulevard, Queens

Queens Boulevard, Queens

GENERAL INFORMATION

Description

Speed boards—signboards on mast arms or trailers that display the speed of passing vehicles—are used by police departments and transportation agencies as educational tools to enhance speed enforcement.

Characteristics

Speed boards can help raise residents' awareness of how they themselves are often those speeding, not just 'outsiders.' Speed boards enhance enforcement efforts through public education and awareness.

Effectiveness

The effectiveness of a speed board can be increased when used in combination with Neighborhood Speed Watch or other neighborhood safety education programs.

BENEFITS

Vehicle speeds

Reductions of 3 to 5 mph were noted in a study by the Texas Transportation Institute.

DISADVANTAGES

Moderate disadvantages

Speed boards are not a substitute for engineering measures.[55]

COST CONSIDERATIONS

$10,000 to purchase the speed board, plus the cost to move the trailer to different locations and to monitor.[56]

[55] *Pedestrian Facilities Users Guide*, p. 103.

RECOMMENDATION

Speed boards can be used at several locations and should be accompanied by police monitoring and enforcement to maintain driver respect.

However, speed boards are not substitutes for permanent actions, such as traffic-calming treatments, that may need to be taken to address neighborhood speeding issues.

[56] *ibid.*

PHOTO ENFORCEMENT (RED LIGHT CAMERA)

Queens Boulevard, Queens

Photo enforcement systems detect traffic law violators, photograph their cars, and issue tickets for their respective violations. The most common applications are red light cameras and speed cameras. Red light cameras catch red light violators, while speed cameras use radar or laser to target speeders.

Advantages

Photo enforcement strategies are proven to reduce both violations and crashes. In New York City, red light running has decreased by 40 percent at intersections with red light cameras. Speed cameras are used outside of New York City to similar effect. According to the *British Medical Journal*, the number of deaths in a test corridor in London was reduced threefold and the number of serious injuries fell by more than 25 percent after speed cameras were installed.

Disadvantages

The public is wary of improper use of photo enforcement technology for surveillance and revenue generation. Past legislation to increase New York City's red light camera inventory and add speed cameras to their enforcement capabilities has met with opposition from state lawmakers. Until legislation permits an increase in real red light cameras, New York City augments their existing 50 red light cameras with non-ticketing decoy cameras.

CHAPTER FOUR: PASSIVE TRAFFIC CALMING

These elements do not force a change in driver behavior, but provide visual or other cues that can encourage drivers to travel at slower speeds. Passive traffic calming measures include the categories of:

- color and texture
- streetscape improvements
- integrated street design.

ADVANCE WARNING ROADWAY MARKINGS

Carlton Ave., Brooklyn

Pavement markings should be one lane in width (MUTCD).

This type of marking is used in the road pavement itself. Word and symbol markings on the pavement are used for the purpose of guiding, warning, or regulating traffic. Word and symbol markings are white; the markings, no more than three lines of information, are not used for regulatory, but rather support standard signs. Large letters and numerals should be 6 feet or more in height. All letters, numerals, and symbols should be in accordance with NYCDOT standard details and the *Standard Alphabets for Highway Signs and Pavement Markings*.[57]

Advantages

Advance warning stenciling is becoming more common. The stenciling is a constant reminder to drivers because it is within their normal line of sight and helps to convey a message without the necessity of having the driver avert his eyes from the road.

Disadvantages

Any striping will not last as long as signs. Also, during winter storm events the striping will not be visible. Some materials used for pavement markings, particularly thermoplastic, can be slippery when wet and so should not be placed directly adjacent to crosswalks. As with all sign and marking measures, used too frequently they lose their effectiveness, particularly if pedestrians are not regularly present.

Recommendation

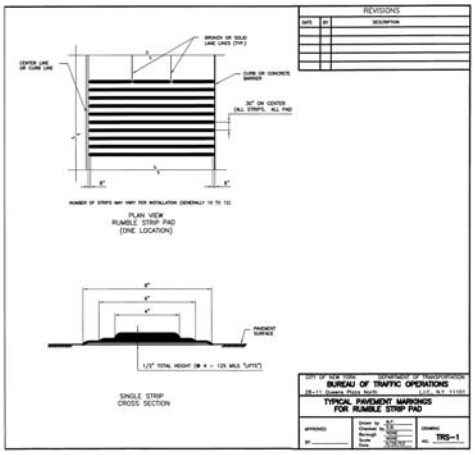
Place a thermoplastic 'STOP' message in the pavement at all stop-controlled intersections within the school zone.

Place a thermoplastic 'SCHOOL X-ING AHEAD' message in the pavement in advance of every school crosswalk.

[57] *Manual on Uniform Traffic Control Devices*, Section 7C.06, December 2000.

RUMBLE STRIPS

Jackie Robinson Parkway at Jamaica Avenue, Brooklyn



NYCDOT drawing TRS-1, rumble strip.

Description

Rumble strips are made of raised thermoplastic strips—a 6" strip topped by two 4" strips—placed transversely across the pavement and spaced at regular intervals along the roadway to create both noise and vibration in a moving vehicle. They are used primarily to slow vehicles down or to warn them of a traffic-calming feature ahead. Advance warning signs are often installed upstream of rumble strips.

Advantages

Rumble strips are easy and inexpensive to install. They make drivers aware that something is coming up, and that they should be ready to slow or stop.

Disadvantages

Rumble strips require regular maintenance, especially on high volume roadways. They also add noise to a street, which residents may find objectionable. Snowplows may pick them up, and they may be slippery in wet weather, particularly on an incline.

Recommendation

Because the thermoplastic may cause skidding when wet, do not use rumble strips in advance of a crosswalk. Use rumble strips on a case-by-case basis because of the noise issue. Also, use them in conjunction with signage and other types of measures.

COLORED PAVEMENT

Colored pavement marks a bicycle lane on Henry Street in Brooklyn, during a recent pilot test project.

Description

Colored paving can often enhance the function of portions of the roadway, such as a colored bicycle lane. This can create a perception of street narrowing, in addition to enhancing the travel facility for bicyclists.[58]

New York City has experimented with test colored bike lanes, and is also investigating the use of Imprint©, a proprietary hot applied, synthetic bitumen compound used for overlay on existing pavement. Since the year 2000, the City of Portland, Oregon has been researching techniques that could help improve safety in bicycle-vehicle conflict areas. Thus far, they have found that the most promising, cost-effective technique is to use durable thermoplastic pavement markings to delineate the conflict area. Portland has named these the 'blue' bike lanes, but the use of the color blue, which, in the MUTCD, is reserved for delineating handicapped access, is controversial. A similar technique is used in many European cities and has been found to greatly reduce conflicts (European cities thus far seem to prefer red or green for bike lanes and use other materials besides thermoplastic which tends to be expensive, difficult to apply, and slippery when wet). Despite Portland (and Cambridge, MA), this technique is not in extensive use by American cities, and is not included in the MUTCD.[59]

Colored pavement may also be used to delineate pedestrian space or walking routes.

[58] *Pedestrian Facilities Users Guide—Providing Safety and Mobility* (FHWA, March, 2002). p. 79
[59] www.trans.ci.portland.or.us

Advantages

Colored pavement sends a visual cue about the function of a street and delineates a separate space for pedestrians or bicyclists. Colored pavement can visually narrow the roadway.

Disadvantages

Slippery surfaces, such as smooth paint, should not be used in the primary pedestrian or bicycle travel paths. Colored pavement may be inappropriate in historic areas because of aesthetic concerns. Some transportation engineers have voiced concern over the possibility of confusing motorists through the use of certain colors on the roadway, such as red, yellow, and blue, all of which have specific significance when used on traffic signs.

Cost Considerations

$7,500 per block (based on a 200-foot long block). The unit cost for a high-visibility bike lane is a per-block cost, assuming a 5-foot wide lane and a 200-foot long block. The unit cost includes the costs of power sweeping and the lane, installing ColorSet® or a comparable color-texturing product, and laying all lane striping and symbols.[60]

Additional Information

Information on ColorSet®, a proprietary technique for color-coating asphalt, is contained in the Appendix.

[60] *Downtown Brooklyn Traffic Calming Project, Final Report*. New York City DOT, May 2003.

SIDEWALK STENCILING, WAYFINDERS, UNIQUE MARKINGS, WORD MESSAGES

Student project for wayfinding using sidewalk stenciling


Pratt Institute, Brooklyn

Sidewalk stenciling

Sidewalk stenciling is used to provide information to pedestrians. This type of treatment can be used for a variety of reasons (advance warning, advertising, wayfinding, trail blazing). There are also a number of materials that can be used depending on the type of impact desired: thermoplastic, UV-stable base film, and a slip-resistant over-laminate walking surface which can be imaged using both screen and digital printing technologies, light projections, and laser projections.

Advantages

Can be used to provide safety and directional information to pedestrians.

Disadvantages

Slippery surfaces, such as smooth paint, should not be used in the primary pedestrian or bicycle travel paths. Sidewalk stenciling may be perceived as visual 'clutter.'

Recommendation

Consideration may be given to the implementation of sidewalk stenciling to identify school walking routes. (Color and design may be coordinated with the fluorescent strong yellow-green school safety markings.)

Wayfinders

The Freedom Trail, Boston

In Boston, the Freedom Trail links sites closely identified with the Revolutionary War. In the early days (1960s), it was first marked with a red stripe down the center of the street, and later, with a double-brick pattern in the designated streets that make up the trail around central and north Boston. Significant sites along the trail feature a bronze plaque inset into the sidewalk, as shown above.

Advantages

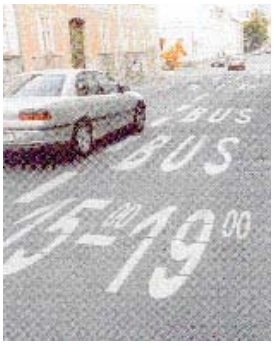
Can be used to provide a clear walking route and identity.

Disadvantages

A large number of schools participating in such a program may contribute to a confusion of marked walking routes and sidewalk 'clutter.'

Word messages and symbols

London



UK

Germany

USA

USA

Queens Boulevard, Queens, NY

A variety of methods can be used to attract the attention of motorists, pedestrians, and other users of the roadway. The use of colored pavement has already been discussed above, particularly with reference to bicycle paths. Above, a bus stop in North London is shown with both colored pavement and an in-pavement word message. Other in-pavement markings can remind pedestrians to look before they cross, or to watch for turning vehicles, as the message shown above does. A unique in-pavement stencil in Germany shows two pedestrians crossing the road, a reminder to motorists, or perhaps an indication of a safe crossing area for pedestrians. A bolder version, with the appearance of an MUTCD yellow pedestrian crossing sign painted on the asphalt, is also shown.

Regarding color, the MUTCD specifies the use of particular colors for particular uses, and has reserved some colors for future use. Selection of any color for a pathway or walking route must conform to MUTCD approved standards.

GROOVED, TEXTURED AND PATTERNED PAVEMENT

Patterned crosswalk in Greenwich Village, Manhattan

Textured pavement in Long Island City, Queens

GENERAL INFORMATION

Description

At a crosswalk, a textured or patterned surface may be emplaced which contrasts with the adjacent roadway. The purpose of a textured or patterned crosswalk is to better define the crossing location for pedestrians, and to reduce pedestrian-vehicle conflicts.

On concrete pavement, scalloped grooves may be saw cut in the travel lane to cause noise and vibration in the traveling vehicle.

Imprint®, a proprietary material, is a hot applied, synthetic bitumen compound imprinted with a mould to provide a durable, decorative surface for crosswalks and other pedestrian areas. Applied 0.5 inches thick, Imprint overlays existing concrete or blacktop surfaces and is available in various patterns and colors. It is impervious to water, can be vacuum swept and jet washed, and cannot become loose, be stolen or pried up.

Characteristics

- A textured or grooved surface used in the roadway or crosswalk causes drivers to feel a slight vibration, and also gives an audible warning;
- The enhanced visual and tactile identification of the crosswalk area emphasizes pedestrian priority;
- The texturing may extend beyond the crosswalk to provide greater visual identification of the area;
- Interlocking paving stones or colored reinforced stamped concrete and asphalt are often used;
- Texturing may incorporate two or more colors or textures.

LOCATION, PLACEMENT, EFFECTIVENESS

Road classification

Local and collector streets

Locations

Marked, unsignalized crosswalks;
Signalized crosswalks;
Intersection and mid-block crosswalks.

Effectiveness

The effectiveness of a textured crosswalk can be increased when used in combination with the following measures:

- Raised crosswalks;
- Raised intersections;
- Curb extensions;
- Curb radius reductions.

BENEFITS

Conflicts

Improved visibility of crosswalk may reduce pedestrian-vehicle conflicts.

Textured pavement visually narrows the roadway, which may help reduce pedestrian-vehicle conflicts.

Environment

Textured crosswalk treatment enhances appearance of street, particularly when combined with other streetscaping and landscaping techniques.

No reduction in traffic noise. Rough or pronounced texturing may create additional noise from vehicle wheels.

DISADVANTAGES

Significant disadvantages

May have maintenance problems depending on stability of base and frequency of heavy vehicle traffic.

Moderate disadvantages

Texturing may create traction and/or stability problems for seniors, the disabled, bicycles and motorcycles if there are rough or pronounced grooves parallel to the direction of travel.

Rough or pronounced texturing may create additional noise from vehicle wheels.

May increase street sweeping time if texturing incorporates deep grooves, and some dust and debris may remain in the grooves.

COST CONSIDERATIONS

Vary depending on width of roadway, labor, and materials costs.

DESIGN CONSIDERATIONS

The use of textured crosswalk materials is intended to improve visual and tactile identification. Consequently, their use may increase the effectiveness of other traffic measures. These textures may be created by use of concrete pavers, exposed aggregate

concrete, or imprinted concrete. The material may be brick or stone, but for safety and maintenance reasons, imprinted concrete or asphalt pavers that are less slick, less bumpy, less costly, and easier to maintain is a preferable alternative. Use of color for any of the potential paving materials will further enhance the traffic calming effect.

The design of a custom application such as textured crosswalk, particularly one that incorporates decorative paving stones set in a polychromatic pattern, will need to be approved by the Art Commission of the City of New York, or by the Landmarks Preservation Commission if in a historic district.

Geometric requirements

Since a textured crosswalk simply involves use of alternative crosswalk materials, there are no geometric requirements unique to its use.

Signing and pavement marking requirements

Use of textured crosswalk materials do not require any unique signing or pavement marking. If pavement marking is required within the textured crosswalk area, the use of colored, textured materials should be considered as an alternative to painting.

RECOMMENDATION

Use textured crosswalks only at signalized or stop-controlled locations, and only with the texture on the outside edges of the crosswalk. Keep the middle four feet smooth to comply with ADA guidelines. Use a textured road or intersection only as a part of an overall design for an area; avoid if not incorporated with other traffic calming features.

A textured or colored crosswalk design should retain retroreflective pavement striping on either side of the crosswalk to maintain nighttime visibility.

The installation of decorative treatments in the roadway such as textured or colored crosswalks is only recommended where maintenance can be guaranteed by an entity other than the City of New York, such as a business improvement district.

In general, thermoplastic is preferred for school crosswalks.

BOLLARDS

Bollards along Route 9A, Manhattan.

Bollards on E. 161st Street, Bronx.

Introduction

Bollards are a form of rigid traffic barrier used to prevent vehicles that leave the roadway from hitting a pedestrian or hitting an object that has greater crash severity potential than the bollard itself. Because bollards are a source of crash potential themselves, their use must be carefully considered.

The New York City Department of Transportation policy for bollards is given below.[61]

Purpose

The purpose of rigid bollards is to protect pedestrians from collisions with motor vehicles, usually at a location with unusual roadway geometry. This is accomplished by:

- Redirecting or decelerating errant motor vehicles away from pedestrians.
- Preventing motor vehicles from entering sidewalks or other off-street locations where frequent unlawful incursions occur.
- Defining appropriate locations for vehicles to travel and for pedestrians to assemble.

Considerations

Bollards should be considered when:

- there is a need to better manage vehicular movements;
- accident analyses demonstrate a safety issue involving off-street impacts with pedestrians;
- there are a substantial number of pedestrians present;
- the bollards would not create a significant roadway hazard to motor vehicles;
- alternatives to bollards (e.g., guide rail, planters, crash cushions) have been explored and found unsuitable.

In addition, the following factors need to be considered in the placement of bollards:

[61] This policy addresses the application of rigid bollards only. The application of flexible bollards is subject to different criteria. Moreover, this policy addresses the application of bollards when used primarily as a traffic control device, not as a security device or an element of urban design.

- loading and unloading of goods and passengers;
- access for fire, ambulance, police or other emergency vehicles;
- sidewalk access for persons parking their vehicles;
- bus stops;
- fire hydrants, utility access and other street furniture.

Design Issues

- Bollards should only be installed off-street on sidewalks or raised median refuge areas.
- Bollards should be set back from the curb from 18" to 24".
- When installed on curves, bollards should be installed on the outside of the horizontal curve of the roadway.
- Bollards should not interfere with access to pedestrian ramps.
- A minimum distance of 60" should be provided between bollards if the pedestrian path moves between the bollards, or 48" where additional impact resistance must be provided.
- Bollards should not adversely affect pedestrian level of service (i.e., maintain LOS B or better).
- Bollards may be used in conjunction with other rigid barriers including raised planters and seating.

Construction and Installation Issues

- The height of the bollard should be from 30" to 42".
- Bollards may be made of metal, stone, or a combination.
- Bollards may be of an energy-absorbing design.
- Bollards should be configured as a post, inverted U, or bell-shaped.
- Bollards should have a pleasing appearance appropriate to their surroundings.
- Bollards should be set into the ground with permanent footings.
- Maintenance agreements and revocable consent agreements should be established for installation of non-DOT bollards.

Recommendation

Bollards may have application as a school safety measure. Potential uses include placement perpendicular to the curb to delineate driveways where school buses or other vehicles may enter school property.

GATEWAYS

Fulton and South Oxford Street, Brooklyn

A gateway indicates a change in the roadway environment, such as from a higher speed arterial or collector road to a lower speed residential or commercial district. Gateways are frequently used to identify neighborhood and commercial areas within a larger urban setting. Gateways may combine pedestrian safety elements such as lane narrowing, neckdowns, medians, roundabouts, and signs, with aesthetic or architectural elements such as planting, archways, lighting, or other street furniture. Gateways are most effective when followed by a repetition of neighborhood traffic-calming treatments.

A recent pilot gateway treatment at Fulton and South Oxford Streets in Brooklyn included two 7-foot neckdowns, one on either side of South Oxford Street, steel bollards to protect pedestrians, and a raised crosswalk with a color-textured surface.

Advantages

Gateways create a unique image for an area, and prepare motorists to watch for pedestrians when entering a commercial, business, or residential district from a higher speed roadway.

When designed as a combination of several pedestrian safety elements, gateways are effective at slowing traffic, reducing conflicts, and increasing driver awareness. In the Brooklyn example, the gateway treatment has improved the discipline of turning drivers. Before the gateway treatment, drivers turning right off westbound Fulton Street were able to make a sweeping turn along the curb, running nearly parallel to pedestrians crossing South Oxford Street. Westbound pedestrians could not see these cars coming. With the gateway treatment in place, drivers do not start turning until they are perpendicular with South Oxford Street. The smaller turning radius slows drivers slightly, and also forces them to drive through the crosswalk perpendicular to pedestrians, giving both users of the road space (drivers and pedestrians) better views of one another.[62]

Cost Considerations

The cost of gateway entrance treatments will vary widely, depending on the elements chosen to define the gateway. One sample cost is given below:

[62] *Downtown Brooklyn Traffic Calming Project Final Report*. New York City DOT, May, 2003.

$30,000 per gateway. The unit cost for a gateway is a combination of the cost of necking down two corners and the cost of building an asphalt (not concrete) raised crosswalk with color-textured markings. Gateway costs include the cost to reconstruct the sidewalk, relocate the steel-faced curb, and relocate catch basins at sites where drainage is toward the gateway.[63]

Recommendation

Gateways designed to reflect elements easily attributed to a local neighborhood school can mark the entry into a school safety zone and convey a general school safety message. School zone signage itself can be the gateway treatment for entering a school zone.

[63] *Downtown Brooklyn Traffic Calming Project*, Final Report. New York City DOT, May 2003.

TREES AND PLANTERS

Waverly Place, Manhattan

Astor Place, Manhattan

Herald Square, Manhattan

Landscaping can provide separation between motorists and pedestrians, thereby making the roadway seem narrower (which encourages reduced vehicle speeds). Landscaping can include a variety of trees and planters, placed as a separator between the sidewalk and the street.

The most significant issue with any landscaping scheme is ongoing maintenance. Some communities have managed effectively by creating block associations or Business Improvement Districts (BIDs) to pay for streetscape maintenance. Consider adding irrigation systems in areas with extensive planting. Include plans for landscape irrigation and maintenance at the outset.

Choosing appropriate plants, providing adequate space for maturation, and preparing the ground can help ensure that they survive with minimal maintenance, and don't buckle the sidewalks as they mature. Plantings should not obscure signs or pedestrians' and motorists' views of each other.

The New York City Parks Department operates a street tree-planting program, planting upon request of the adjacent property owner, usually via the local community board, provided the proposed location meets certain placement criteria. The Parks Department retains ownership and maintenance responsibility for the trees. The New York City Department of Parks and Recreation maintains a list of trees approved for use as New York City street trees.

'Greenstreets,' a joint project with the New York City Parks Department and the New York City Department of Transportation, began in 1986 and was reintroduced in 1994. The program converts paved street properties, like triangles and malls, into green spaces. New York City has planted a total of over 2,000 Greenstreets citywide.[64]

The Greenstreets program provides opportunities for effective partnering between NYCDOT and the Parks Department.

Advantages

Landscaping creates a visual narrowing of the roadway. Like light poles, street trees planted along the curb encourage lower speeds.

Disadvantages

Trees may buckle sidewalks. Some trees drop fruits that can stain sidewalks and vehicles parked below. Trees may obscure visibility.

[64] New York City Parks Department

STREET FURNITURE:
BANNERS, BENCHES, BICYCLE RACKS, BUS SHELTERS, KIOSKS, PUBLIC ART


Route 9A, Manhattan

Beacon Street, Boston


Battery Park, Manhattan


Rochester

Banner, bus shelter, and information kiosk. At right, a lamppost decorated with mosaic tile by neighborhood residents.

Banners can be used to identify events, institutions, organizations, and neighborhoods. Banners are commonly maintained by business improvement districts or civic groups.

Benches should be comfortable, attractive, sturdy and durable, easy to maintain, and should be resistant to vandals and vagrants.

Bicycle racks should be skillfully integrated into the streetscape; they should be readily accessible to high-activity areas, such as subway stations, yet not impede vehicular or pedestrian circulation. Bicycle racks should also be located in highly visible locations to reduce theft. Bicycle parking is preferred in sheltered, well-lit, secure locations. Bicycle parking may be established on the sidewalk where the demand is sufficient to warrant it.

The New York City Department of Transportation operates the CityRacks program. Anyone may request installation of a free 'U'-shaped rack. Program staff will visit the proposed location and determine whether or not it meets placement criteria. If it does, and the adjacent property owner does not object, the rack is installed by NYCDOT. The request form is available from NYCDOT and Transportation Alternatives.

Bus shelters in New York City are placed and maintained by franchise. The New York City Transit Authority is responsible for locating bus stops. Requests for relocation of bus stops must be made to the transit authority.

Far-side bus stops generally encourage pedestrians to cross behind the bus. Relocating the bus stop to the far side of the intersection can improve pedestrian safety and traffic operations.

Information kiosks are often placed in high-density areas with the high volumes of pedestrian traffic. Kiosks can act as a mini-landmark, gathering place, and place marker; in New York City, a written maintenance agreement is also required.

Public art is most effective when it is incorporated, as a design strategy, into the planning of streetscapes from the outset and acts as a catalyst for generating activity.

Determining the purpose the art is intended to serve is also a part of this process. At times, the infrastructure itself, such as a bridge or fence, may incorporate the public art.

Note on permits, consents, and reviews

The design and placement of any street furniture must be approved by the Art Commission, or Landmarks Preservation Commission if in an historic district. Additional approval must be obtained from the Bureau of Franchises, Concessions and Consents. General information on reviews and approvals is given below:

Most above-ground structures require the approval of the New York City Art Commission. Structures proposed within a designated New York City Historic District or adjacent to a designated New York City Landmark require the approval of the New York City Landmarks Preservation Commission.

After all necessary approvals are received, NYCDOT must hold a public hearing on the terms and conditions of a proposed revocable consent as required by law. A notice of the hearing is published by NYCDOT, at the owner's expense.

If no issues arise at the hearing or during the subsequent 10-day comment period, NYCDOT prepares a revocable consent agreement and sends it to the New York City Law Department for review. The agreement is then executed and is subject to the additional approval of the Mayor.

Private improvements eligible for revocable consents include the following:

- Bench
- Bridge
- Clock
- Fenced or walled-in area not used for planting or parking; including a fenced or walled-in area containing a drainage basin
- Flagpole
- Guard rail
- Information sign or kiosk
- Planted area, including any surrounding fence or wall
- Post, pole or bollard not otherwise governed by permit procedures contained in Title 19 of the Administrative Code
- Sidewalk plaque or logo
- Sign or plaque on City-owned street lamp or other City-owned structure
- Stoop, step, ramp, vestibule or other entrance detail extending beyond limits set in Articles 8 and 9 of Title 27 of the Administrative Code
- Street lamp or fixture
- Tunnel
- Vault or underground improvement not otherwise governed by license procedures contained in Section 19-117 of Title 19 of the Administrative Code
- Enclosure for trash receptacle adjoining a building, for private use
- Litter receptacle for public use which is affixed to the sidewalk
- Planter that is larger than two feet in diameter or that occupies more than four square feet of sidewalk area.

Recommendation

Develop a coordinated street furniture program, and identify who will maintain it, before installing any street furniture.

PLAY STREETS

Manhattan

GENERAL INFORMATION

Description

Certain streets are designated for play or assembly purposes for students or other children generally between the hours of 8:00 am and one-half hour after sunset, unless different hours are otherwise specified by signs. Play streets provide security for young people when there is a need for them to be in the street.

The practice dates to 1949, when the city began to allow some schools to close their blocks during recess periods. The program was originally intended for schools lacking adequate yard or auditorium space. Only about a dozen schools have them today. The closings are typically on small side streets.[65]

Characteristics

Recommendations as to the type of control required include the following:

- STREET CLOSED -PLAY AREA
- STREET CLOSED 8 AM-4 PM SCHOOL DAYS PLAY AREA
- STREET CLOSED 11:30 AM-1 PM SCHOOL DAYS PLAY AREA
- STREET CLOSED 8 AM-1 PM SCHOOL DAYS PLAY AREA
- STREET CLOSED 8 AM-9 AM, 11:30 AM-1 PM SCHOOL PLAY AREA

NYCDOT Policy

Non-school related play streets may be provided subject to the following criteria:

- An application was submitted by the community board pursuant to the procedures set forth in the Mayor's community assistance unit's guidelines for summer play streets.
- Adequate playground or park facilities are not available within a five-block radius of the location.

[65] "Hide and Seek No More? City Scrutinizes Streets Now Closed for Schools," Erika Kinetz, *The New York Times*, December 8, 2002.

- High population density.
- The street in question is not a main or a two-way artery and does not have high vehicular volume.
- The street is not designated as a fire route, bus route or truck route.
- The street is not adjacent to a hospital.
- The street does not have commercial establishments, hotels, public buildings or other activities that would be curtailed or adversely affected.
- The street closure would not interfere with local traffic patterns.
- The physical features and topography (visibility, grades, alignment, open lots) do not create hazards.
- There is no ongoing construction.

School-related play streets may be provided subject to the following criteria:

- The street in question is adjacent to the school.
- The school has inadequate facilities for off-street assembly.
- The street is not a main or two-way artery and does not have high vehicular volume.
- The street is not designated as a fire route, bus route or truck route.
- The street is not adjacent to a hospital.
- The street does not have commercial establishments, hotel, public buildings or other activities that would be curtailed or adversely affected.
- The street closure would not interfere with local traffic patterns.
- The physical features and topography (visibility, grades, alignment) do not create hazards.
- There is no ongoing construction.

Investigation Procedure:

1. Prepare a base map of the area within a five-block radius of the street, where a map is not available.
2. Locate existing playgrounds and play streets within the area.
3. Prepare a field survey for the street; record the following:
   (a) twenty-minute count of vehicles traveling on proposed play street.
   (b) one-hour count of children playing on street (roadway and sidewalk).
   (c) curb study of both sides of the street.

PEDESTRIAN STREETS/MALLS

Nassau Street, Manhattan

Pike Place, Seattle

There are two types of pedestrian streets/malls: those, like Nassau Street in Manhattan that eliminate motor vehicle traffic (deliveries permitted during off-peak hours) and those, like Fulton Street Mall in Brooklyn and Pike Place in Seattle that allow some motor vehicle traffic at very low speeds. The second type can be thought of as a pedestrian street that allows some motor vehicles, as opposed to a motor vehicle street that allows some pedestrians.

Another option is to create a part-time pedestrian street, which uses removable barriers to close the street to motorists during the day.

Advantages

Pedestrian streets can create a significant public space in a downtown district, a tourist district, or a special events or marketplace area, and enhance the experience for people in a commercial district.

Disadvantages

Pedestrian streets (those that eliminate motor vehicles) created with the notion of attracting people in areas that are on the decline have usually been unsuccessful. Other measures may be more effective, including street narrowing/ sidewalk widening and the addition of landscaping.

Cost Considerations

A pedestrian street can be created simply by blocking either end of an existing street with nothing more than a few signs. Temporary pedestrian streets can be created for weekends or holidays. If the street is going to be a permanent public space, care should be taken in the design. Depending on the extent of the treatment (one block or several blocks) and the quality of the materials used, a true pedestrian street can cost from $100,000 to several million dollars.[66]

[66] *Pedestrian Facilities Users Guide*, March 2002.

APPENDIX

- Maintenance Issues—
    - General Maintenance Issues
    - Snow Removal

- Description of Crash Groups
    - Mid-block dart/dash
    - Multiple threat
    - Failure to yield at uncontrolled location
    - Bus related
    - Turning vehicle at intersection
    - Through vehicle at intersection
    - Walking along roadway
    - Not in road: sidewalk, driveway, parking lot
    - Backing vehicle

- Table 1: General Measures Comparison Matrix

- Product Information—
    - ColorSet colorized asphalt treatment
    - Rainline textured pavement
    - StreetPrint pavement texturing

GENERAL MAINTENANCE ISSUES

Introduction of new signs, markings, or physical devices in the roadway will have an impact on maintenance costs. Signs or posts may require the establishment of new inventory to be maintained and replaced. Use of new materials for roadway markings or textures may require the purchase of additional equipment. Other devices may increase costs for street sweeping, snow removal, electricity, or landscaping, or may require changes to existing practices. For each proposed mitigation measure, consideration to the time and increased cost associated with maintenance must be given prior to emplacement of a measure or device.

Maintenance issues related to traffic management devices arise because these measures frequently alter the geometry of a street, whether vertically or horizontally, and thus may impact the smooth movement of service or maintenance vehicles, typically street sweepers or snow plows. New devices may mean that additional time will be required to sweep or to snowplow a street. For areas receiving significant amounts of snowfall, using object markers to indicate the location of a traffic-management device will be necessary to notify snowplow drivers that the device may be covered with snow.

A secondary maintenance concern resulting from traffic mitigation measures is landscaping. Some measures create new open spaces and potential areas for landscaping. Setting standards for planting and assigning responsibility for maintaining landscaping must be done at the outset of a traffic-calming program.

If mitigation measures are installed, it is important to accurately assess costs and assign responsibility to maintain the measures.

A recent report prepared for the New York City Department of Transportation highlighted the following maintenance issues that arose as a result of a traffic calming pilot program:

Catch basins and other utilities

The need to relocate catch basins and other utilities to accommodate treatments can add significantly to the cost of some of the mitigation measures. In designing mitigation treatments, NYCDOT should investigate design options that minimize the need for relocation of utilities. However, the realities of maintenance and cleaning practice in New York City mean that it is generally not possible to avoid relocating catch basins or raising service pits.

The additional manual effort required to clean a traffic calming measure may be regarded as too onerous by the Department of Sanitation, which relies almost exclusively on street cleaning vehicles. Mitigation solutions should not place an additional burden on cleaning staff.

Quality of materials

The use of temporary materials in traffic calming treatments can be counterproductive. Physical treatments implemented temporarily can generate opposition to permanent implementation. When doubts arise about construction materials, NYCDOT should use familiar materials whose installation, reliability and maintenance schedules are

predictable. This is particularly important when testing new treatments, which may need to be removed if they prove unsuccessful.

Color-textured concrete treatments

Some color-texture surface treatments are effective. However, they demand ongoing maintenance due to inevitable utility and resurfacing projects and the time and skill required to maintain a nonstandard road surface. Traffic volumes, surface conditions, and weather in New York all require extremely durable surface treatments. When identifying quality color-textured surfacing materials, they should be installed at multiple locations to allow NYCDOT to justify procuring a large enough supply to support ongoing maintenance required by utility and resurfacing projects.

Emergency services

Emergency service concerns about the impact of traffic calming treatments on their operations are generally not borne out by experience. Appropriately designed physical treatments do not hinder emergency service access or movement. Emergency service workers are accustomed to taking actions necessary to access their destinations and typically allow their vehicles to mount curbs if absolutely necessary to enter a street. Police, fire, and ambulance services must be consulted and worked with in a collaborative manner so that implementation does not impede their operation.

Sanitation services

The design of traffic calming treatments must recognize the Department of Sanitation's vehicle operations and cleaning practices. Unlike emergency vehicles, street sweepers do not have the ability to mount curbs and still be effective, and hard-to-sweep locations will impact operations.

Road surface maintenance

Maintenance of the road surface is a major issue in New York City. Coordinating maintenance, installation and construction activities is extremely problematic, with the result that road surfaces are routinely opened by any of a number of agencies authorized to do so. In many cases, the quality of road reinstatement is poor, with the result that road surfaces very quickly become uneven and inconsistent. In this environment, any unusual road surface treatments are extremely difficult to maintain. This is a problem that cannot be solved through specification but through implementation of much more stringent maintenance practices. Therefore, ease of maintenance and installation of treatment should be considered when selecting materials.[67]

[67] *Downtown Brooklyn Traffic Calming Project*, Final Report, May 2003. New York City DOT.

SNOW REMOVAL AND TRAFFIC MANAGEMENT MEASURES[68]

The issue of snow removal frequently arises in discussions on traffic calming. Humps, circles, chokers, and closures have not been reported to prevent snow removal, leave streets unsafe due to residual snow and ice, damage snowplows, or suffer serious damage themselves. But they may add to workload and expense.

In general, communities have dealt with snow removal on traffic-calmed streets by marking traffic calming measures, using appropriate or specialized equipment, innovating in geometric design of measures, familiarizing personnel with snowplow routes, and, in all cases, devoting more time to the task.

Below are examples of how cities with traffic calming measures handle snow removal:

Dayton, Ohio

Measures: full street closures and speed humps

Each speed hump is marked with an advance warning sign. Operators slowly ride up and over the humps. Snowplow blades are rubber-tipped to avoid damage to humps.

Bellevue, Washington

Measures: speed humps and raised pavement markers

In Bellevue, the task of snow clearance is complicated by the widespread use of raised pavement markers, even on humps. Rather than plow down to the surface of the roadway, operators leave an inch of snow and then apply sand to the surface. The snow/sand combination is thought to provide better traction than the thin layer of ice or snow left by conventional plowing.

Montgomery County, Maryland

Measures: speed humps and chokers

In Montgomery County, plows have rollers on their blades that cause them to rise up and over when they strike something. This system tends to scrape snow off the front of humps but to leave a wedge of snow on the back. Plows are equipped with salt applicators to deal with the latter. They often require a second application to melt this snow. Plastic posts are used to mark chokers so that plow operators know exactly where to slow down and diverge from a straight path.

Minneapolis, Minnesota

Measures: speed humps, speed tables, traffic circles, chokers, T intersections, temporary curbs

Given the frequent need to remove ice under a layer of snow, the blades on Minneapolis' snowplows are steel-tipped and outfitted with metal extensions to protect against damage. Plows thus leave a thin layer of ice, which is removed with a mix of salt and sand. These customized plows have no difficulty with the majority of Minneapolis' traffic calming measures, except traffic circles. Unable to plow all the way around, plows leave a windrow, which must be removed with a front-end loader. Temporary curbs for testing measures also create a problem; without landscaping or object markers, temporary curbs are occasionally struck by snowplows.

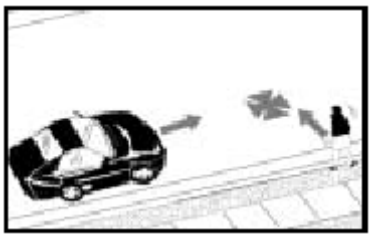
[68] Adapted from: *Traffic Calming: State of the Practice*, Reid Ewing for FHWA and ITE, December 1999 (pp. 152-153).

The various general measures included in this guide are intended to address a range of roadway types and situations. However, the following matrix gives shorthand guidance on which pedestrian measures are appropriate to address certain types of pedestrian crashes.

Based on a similar table developed for FHWA's *Pedestrian Facilities Users Guide* (March 2002), the matrix includes nine crash types, which are compared against the list of 66 general measures. Only the primary effects of a measure are given; secondary benefits are recognized, but may not be starred in the corresponding column.

Before using the matrix, please familiarize yourself with the following description of the crash types. Although the matrix gives general guidance, it must be acknowledged that many crashes are the result of careless or illegal driver behavior, and/or unsafe pedestrian behavior. In these cases, roadway improvements alone are not enough to address the problem. Instead, pedestrian and/or motorist education and enforcement activities may be helpful in enhancing pedestrian safety.

MID-BLOCK DART/DASH



The pedestrian walked or ran into the roadway and was struck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before impact, and/or the motorist may have been speeding.

Possible Cause #1

Child runs into neighborhood/collector street.
Pedestrian tries to cross high-speed and/or high-volume arterial street.

Proposed general measures

Implement speed humps, speed tables, or chicanes.
Remove or restrict on-street parking.
Provide adequate lighting.
Provide curb extensions.
Install spot street narrowing at mid-block crossing locations.
Narrow travel lanes.
Install street closure or diagonal diverter at selected intersections.
Provide adult crossing guard in school zone.
Educate children about safe crossing behavior; educate adults about speeding.
Add on-street bike lanes.
Convert street to pedestrian street.
Design a gateway to alert motorists that they are entering an area of pedestrian activity.
Provide a raised pedestrian crossing.

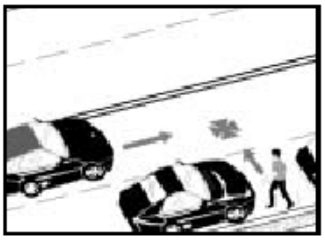
Possible Cause #2

Pedestrian tries to cross high-speed and/or high-volume arterial street.

Proposed general measures

Install medians or pedestrian crossing islands.
Provide a staggered crosswalk which forces pedestrians to walk and look to the right for oncoming traffic in the second half of the street.

MULTIPLE THREAT



The pedestrian entered the traffic lane in front of stopped traffic and was struck by a vehicle traveling in the same direction as the stopped vehicle. The stopped vehicle may have blocked the visibility between the pedestrian and the striking vehicle, and/or the motorist may have been speeding.

Possible Cause #1

Motorist's view of pedestrian is blocked and motorist fails to yield.

Proposed General Measures

Recess stop lines in advance of crosswalk.
Install traffic signals with pedestrian heads, if warranted.
Provide mid-block or intersection curb extensions.
Install traffic calming devices such as speed tables or raised pedestrian crossings.
Install barriers or signs to prohibit crossings and direct pedestrians to safer crossing locations.
Provide raised crosswalks to improve pedestrian visibility.
Install advance warning signs or flashers.
Relocate bus stop to far side of crossing area.
Improve roadway lighting.
Enforce crosswalk laws.

Possible Cause #2

Pedestrian tries to cross high-speed and/or high-volume arterial street.
Pedestrian does not have time to cross multi-lane roadway.

Proposed General Measures

Narrow travel lanes to slow vehicle speeds.
Reduce roadway width: modify four-lane road to two lanes plus bike lanes and sidewalks.
Increase police enforcement of speed limit.
Construct overpass or underpass.
Install raised median or pedestrian crossing island.

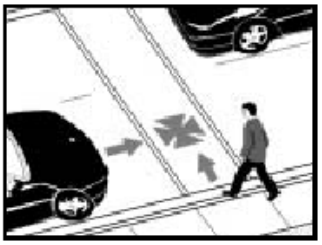
Possible Cause #3

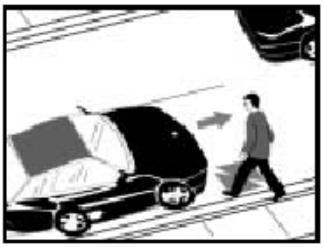
Pedestrian does not have time to cross multi-lane roadway.

Proposed General Measures

Install traffic signals with pedestrian heads, if warranted.
Adjust pedestrian signal timing.
Provide raised crosswalks to improve pedestrian visibility.
Provide mid-block or intersection curb extensions.
Install raised pedestrian crossing island.
Enforce crosswalk laws.
Reduce roadway width.

FAILURE TO YIELD AT UNCONTROLLED LOCATION





At an uncontrolled intersection or mid-block location, a pedestrian stepped into the roadway and was struck by a vehicle. The motorist failed to yield to the pedestrian and/or the pedestrian stepped directly into the path of the oncoming vehicle.

Possible Cause #1

Motorist fails to yield to pedestrian at two-lane, low-speed road crosswalk (or unmarked crossing).

Proposed General Measures

Install raised crosswalk, raised intersection, speed table, or speed humps with truncated domes at both ends.
Install overhead CROSSWALK, SCHOOL ZONE, or other warning signs.
Install curb extensions or choker.
Construct raised pedestrian crossing island.
Install traffic signal, with pedestrian head, if warranted.
Add chicane, use serpentine design or use special paving treatments along street to slow traffic.
Use landscaping that slows vehicle speeds without impeding sightlines.
Reduce curb radius to slow vehicle speeds.

Possible Cause #2

Pedestrian has difficulty crossing multi-lane road.

Proposed General Measures

Install raised medians or pedestrian crossing islands.
Install traffic signal, with pedestrian head, if warranted.
Modify four-lane undivided street to two lanes, plus two-way left turn lane, or median with turning pockets and bike lane.
Install lighting.
Use police speed enforcement.
Use far-side bus stops.
Narrow lanes, reduce number of lanes, and/or install bike lanes.
Construct overpass or underpass.
Ensure that curb ramps are provided to make crossing easier for all pedestrians.

Possible Cause #3

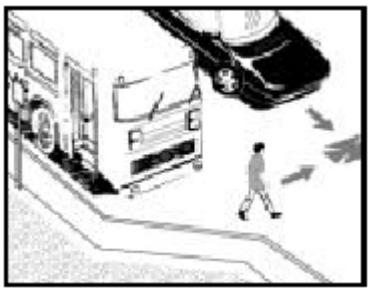
Motorist unwilling to yield due to high motorist speeds or high traffic volumes.

Proposed General Measures

Implement traffic calming measures.
Install traffic signal, with pedestrian head, if warranted.
Narrow lanes, reduce number of lanes, and/or install bike lanes.

Provide gateway, identify neighborhood with signs, and/or create a pedestrian street.
Increase police speed limit enforcement.
Install signs or sidewalk barriers to guide pedestrians to safer crossing locations.
Use speed monitoring trailer.

BUS RELATED



The pedestrian was struck by a vehicle either: by crossing in front of a bus stopped at a bus stop; going to or from a school bus stop; or going to or from a bus stop.

Possible Cause #1

Motorist fails to yield to pedestrian or pedestrian crosses during inadequate gap in traffic due to limited sight distance at intersection.

Proposed General Measures

Move bus stop to far side of intersection or crosswalk.
Install curb extension.
Consider an alternative bus stop location.
Install pedestrian crossing islands or raised crosswalk.
Install or improve roadway lighting.
Install crosswalk markings to encourage pedestrians to cross in the crosswalk behind bus.
Mark bus stop area with pedestrian warning signs.
Remove parking in areas that obstruct the vision of motorists and pedestrians.

Possible Cause #2

Pedestrian has difficulty walking along roadway and crossing at mid-block location with high vehicle speeds and/or high volumes.

Proposed General Measures

Provide bus pull-off area.
Consider an alternative bus stop location.
Install mid-block curb extensions.
Provide curb ramps and an accessible sidewalk.
Install sidewalk and/or sidewalk barriers to direct pedestrians to a nearby crossing.
Provide pedestrian education/training.
Add bike lanes or painted shoulder.
Add recessed stop lines.
Increase police speed enforcement.
Install or improve roadway lighting.
Reduce number of roadway lanes.
Install traffic and pedestrian signals, if warranted.

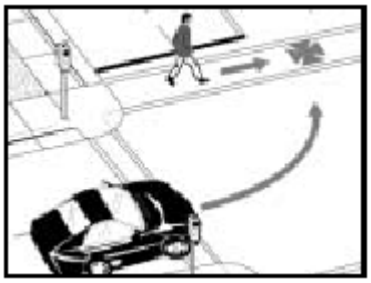
Possible Cause #3

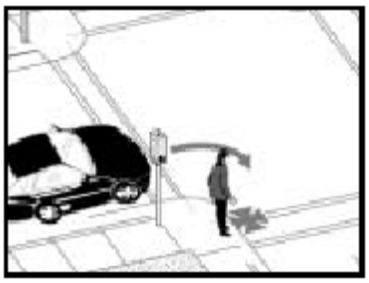
Pedestrian has difficult time crossing or walking in the vicinity of school bus stop.

Proposed General Measures

Select safer location for school bus stop.
Implement pedestrian/driver education programs.
Involve school, neighborhood groups, and PTA in promoting enforcement and education.
Provide street furniture or other amenities at bus stop.
Install or improve roadway lighting.
Enforce regulations against passing stopped school bus.
Educate pedestrians to cross behind the bus.

TURNING VEHICLE AT INTERSECTION





The pedestrian was attempting to cross at an intersection and was struck by a vehicle that was turning right or left.

Possible Cause #1

Conflict between pedestrian and left-turning vehicle.

Proposed General Measures

Prohibit left turns.
Provide separate left-turn and WALK/DON'T WALK signals.
Add special pedestrian signal phasing (e.g., exclusive protected pedestrian signal or leading pedestrian interval).
Convert to one-way street network (if justified by surrounding area-wide pedestrian and traffic volume study).
Install warning signs for pedestrians and/or motorists (see MUTCD).
Develop/provide public safety announcement safety messages.
Add curb extensions or curb ramps.
Convert intersection to modern roundabout or mini-circle where all motorists turn right.
Consider closing street or using modified T-intersection, diverter, or intersection median barrier.
Construct overpass or underpass.
Install pedestrian crossing island and raised median.
Use traffic-calming devices, such as a raised intersection or raised pedestrian crossing, to reduce vehicle speeds.

Possible Cause #2

Conflict between pedestrian and right-turning vehicle.

Proposed General Measures

Prohibit right turn on red (RTOR).
Reduce right-turn radii.
Add curb extensions or curb ramps.
Improve right-turn slip-lane design.
Install warning signs for pedestrians and/or motorists.
Provide leading pedestrian interval.
Remove intersection snow/clutter at the corner to improve visibility and give pedestrian space to stand outside of roadway.
Improve intersection lighting to improve visibility.
Provide advanced stop lines and marked crosswalks.
Consider street closure.

Move bus stop to far side of intersection.
Construct overpass or underpass.
Install pedestrian crossing island and raised median.
Use a traffic-calming device, such as a raised intersection or raised pedestrian crossing, to reduce vehicle speeds.
Remove on-street parking from the approaches to crosswalks.

Possible Cause #3

Substantial number of schoolchildren crossing and large turning vehicle movement.

Proposed General Measures

Provide adult crossing guards during school crossing periods, or two guards for wide streets.
Provide police enforcement at the intersection.
Educate children about safe crossing behavior.
Install pedestrian crossing islands for wide two-way streets.
Prohibit left turns.
Add exclusive pedestrian phase or leading pedestrian interval.
Improve intersection lighting.
Consider closing street or using modified T-intersection, diverter, or intersection median barrier.

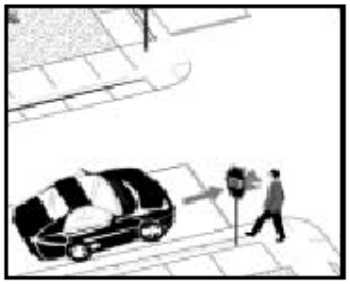
Possible Cause #4

Inadequate sight distance and/or intersection geometrics.

Proposed General Measures

Remove sight obstructions and/or roadside obstacles (e.g., trees/shrubs, mailboxes, poles, newsstands, trash cans).
Provide special pedestrian signal phasing (e.g., exclusive protected pedestrian signal interval).
Install pedestrian warning signs and/or motorist regulatory signs (see MUTCD).
Prohibit left turns.
Reduce turn radii.
Install right-turn slip lane with pedestrian safety islands.
Improve intersection lighting.
Add paving treatments that improve visibility of pedestrian crossing areas.
Prohibit right turn on red (RTOR).

THROUGH VEHICLE AT INTERSECTION




The pedestrian was struck at a signalized or unsignalized intersection by a vehicle that was traveling straight ahead.

Possible Cause #1

Pedestrian could not see traffic signal.

Proposed General Measures

Install new or larger pedestrian WALK/DON'T WALK or automated pedestrian signals.
Move bus stop to far side of intersection.

Possible Cause #2

Children crossing in school zones.

Proposed General Measures

Provide adult crossing guards, or two guards for wide streets.
Install pedestrian overpass or underpass.
Install pedestrian signals.
Install school regulatory flashers (e.g., SPEED LIMIT 25 MPH WHEN FLASHING).
Provide school zone signs and pavement markings.
Provide pedestrian education to students and motorists.
Increase police enforcement.
Use traffic-calming devices such as raised intersection or mini-circle to reduce vehicle speeds.
Consider closing the street or using a diverter or intersection median barrier.
Provide advanced stop lines.
Provide curb extensions to reduce crossing distance.
Provide curb ramps to make crossing easier for all pedestrians.
Provide a raised pedestrian crossing.
Convert to one-way street network (if justified by surrounding area-wide pedestrian and traffic volume study).

Possible Cause #3

Excessive delay to pedestrians prior to getting the 'WALK' interval.

Proposed General Measures

Re-time signal to be more responsive to pedestrian needs (e.g., shorter cycle lengths or convert to fixed-time operation).
Provide quick-response pedestrian push-buttons or automatic (e.g., infrared) detectors.
Install pedestrian overpass or underpass (if justified based on high pedestrian volumes with high traffic speeds or volumes).
Provide pedestrian crossing islands.

Possible Cause #4

Lack of pedestrian compliance with the 'WALK' phase due to other causes.

Proposed General Measures

Re-time signal to be more responsive to pedestrian needs (e.g., shorter cycle length).
Provide adequate WALK and clearance intervals.
Provide leading pedestrian interval.
Provide pedestrian education to students and motorists.
Provide adult crossing guard at school crossings.

Possible Cause #5

Motorist did not see pedestrian in time to stop.

Proposed General Measures

Remove sight obstructions such as mailboxes or parked vehicles.
Add pedestrian crossing islands or raised crosswalk.
Remove on-street parking near intersection (e.g., up to 100 ft.).
Use traffic-calming devices, such as speed tables or a speed-monitoring trailer, on streets approaching the intersection if speed is an issue.
Add curb extensions.
Construct raised intersection.
Improve nighttime lighting.
Move bus stop to far side of intersection.
Add paving treatments that improve visibility of pedestrian crossing areas.

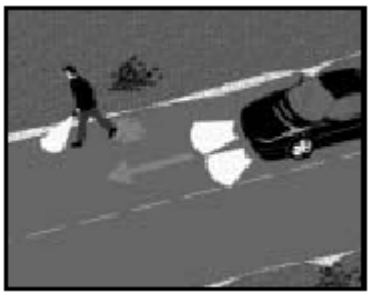
Possible Cause #6

Motorist ran red light at signalized intersection.

Proposed General Measures

Increase police enforcement.
Install camera enforcement.
Add short all-red interval at signal.

WALKING ALONG ROADWAY



The pedestrian was walking or running along the roadway and was struck from the front or from behind by a vehicle.

Possible Cause #1
Inadequate walking area.

Proposed General Measures
Provide a sidewalk on both sides of road.
Provide an asphalt path or paved shoulder.
Reduce number of lanes (e.g., four lanes to three lanes) and add sidewalk, planting strip, bike lanes, or painted shoulder.
Construct and maintain sidewalks and curb ramps to be usable by people with disabilities.

Possible Cause #2
High vehicle speeds and/or volumes.

Proposed General Measures
Add sidewalk or walkway.
Provide nighttime lighting.
Install WALK ON LEFT FACING TRAFFIC signs.
Increase separation between pedestrians and motor vehicles (e.g., bike lanes or landscape buffers).
Increase police enforcement of speed limit.
Construct and maintain sidewalks and curb ramps to be usable by people with disabilities.
Use speed-monitoring trailers.
Construct gateway or install signs to identify neighborhood as area with high pedestrian activity.

Possible Cause #3
There is no adequate route to school.

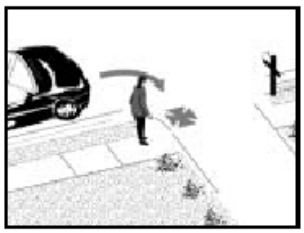
Proposed General Measures
Provide sidewalks.
Involve school groups and PTA in evaluating safe routes to school and promoting education and enforcement.
Provide adult crossing guards.
Implement traffic-calming methods at selected sites.
Construct and maintain sidewalks and curb ramps to be usable by people with disabilities.

Possible Cause #4
Sidewalks are not accessible to all pedestrians.

Proposed General Measures

Construct curb ramps.
Remove obstacles in sidewalk.
Build missing sidewalk segments.
Relocate poles and street furniture to provide continuous passage in sidewalk area.
Enforce parking laws to prevent cars from blocking sidewalks.

NOT IN ROAD: SIDEWALK, DRIVEWAY, PARKING LOT



The pedestrian was standing or walking near the roadway edge, on the sidewalk, in a driveway or alley, or in a parking lot, when struck by a vehicle.

Possible Cause #1

Pedestrian was struck while waiting to cross roadway, standing at or near curb.

Proposed General Measures

Provide accessible sidewalks/walkways and crosswalks.
Install curb extensions for better line of sight between pedestrians and motor vehicles.
Reduce curb radii to slow turning cars.
Implement driver education program.
Install sidewalk barriers.
Improve nighttime lighting.
Increase speed enforcement.
Provide sidewalk buffer (landscape strip or bike lane).
Use adult crossing guard.

Possible Cause #2

Pedestrian was struck in parking lot, driveway, private road, gas station, or alley.

Proposed General Measures

Redesign or re-stripe parking lot to provide pedestrian access.
Maintain level sidewalk across driveway area.
Implement pedestrian and motorist education programs.
Move sidewalk farther back so that driver will have more time to stop for a pedestrian crossing a driveway.
Improve nighttime lighting.
Build/improve local parks for child activities.
Provide clear pedestrian path across parking lot.
Remove landscaping or other visual obstructions near driveways.

Possible Cause #3

Vehicle entered or exited a driveway or alley and struck pedestrian.

Proposed General Measures

Provide sidewalk or walkway.
Add adequate planting strip or sidewalk separation.
Remove sight obstructions (e.g., trim hedges or lower fencing).
Maintain level sidewalks across driveways or alleys.
Narrow driveways and reduce turning radii.
Provide clear walking path across driveway.
Remove unneeded driveways and alleys.
Provide advance warning signs for drivers.

BACKING VEHICLE

The pedestrian was struck by a backing vehicle on a street, in a driveway, on a sidewalk, in a parking lot, or at another location.

Possible Cause

Pedestrian struck by backing vehicle.

Proposed General Measures

Enhance pedestrian education.
Enhance motorist education.
Provide auditory backing alert on vehicle.
Eliminate, modify, or relocate parking if feasible.
Remove unneeded driveways and alleys.
Remove landscaping or other sight obstruction near driveways.
Provide clearly delineated walkways for pedestrians in parking lots.
Relocate pedestrian walkways.
Improve nighttime lighting.
Provide raised pedestrian crossings or curb extensions to improve the visibility of pedestrians to backing motorists.

COLORSET® ASPHALT PAVEMENT COLOR SYSTEM

Description

The contractor shall furnish and apply pigmented asphalt coating material at the location shown on the plans. Upon hardening, the pigmented asphalt coating material will be of the thickness, width and color shown in the plans. Pigmented asphalt coating shall be ColorSet® as supplied by Statewide Traffic Safety, LLC, 499 Pomeroy Road, Parsippany, NJ 07054

Materials

The pigmented asphalt coating shall consist of two separate components; component A, a polymerizable methyl mehtacrylate based resin with integral color pigment and component B, a polymerization catalyst. When combined, these two components will start a chemical reaction, hardening the materials into a plastic suitable for application as a pavement coating during the pot life of the mixture. Pot life is 10 minutes. In its hardened state the plastic shall present a marking whose color and chemical resistance will not degrade under normal exposure to calcium chloride, sodium chloride or automotive oils and fuels.

A. Component A – The liquid component of the material shall be based on a low viscosity methyl methacrylate resin combined with inert fillers and plasticisers for use as a road marking material. Component A will contain the color pigment described below.
B. Component B – The polymerization catalyst shall be a 50% benzoyl peroxide powder.
C. Zero Grade Quartz Silica Sand – Quartz silica sand shall be zero grade in quality and shall meet the following sieve distribution requirements:
    - 00% - 10% shall pass an ASTM-11 sieve No. 30
    - 10% - 30% shall pass an ASTM-11 sieve No. 40
    - 15% - 35% shall pass an ASTM-11 sieve No. 50
    - 15% - 35% shall pass an ASTM-11 sieve No. 70
    - 10% - 25% shall pass an ASTM-11 sieve No. 100
    - 05% - 15% shall pass an ASTM-11 sieve No. 140
    - 00% - 05% shall pass an ASTM-11 sieve No. 200
    - 00% - 05% shall pass an ASTM-11 sieve No. PAN
D. Color Pigment – Pigments used shall remain stable under exposure to ultraviolet light. In its hardened state the color shall be as specified in the contract plans.

Construction Details

All surfaces to which pigmented asphalt coating material is to be applied shall be clean and free of all curing compounds, dust and dirt. Pigmented asphalt coating shall be applied directly to asphalt top course where shown on plans. Pigmented asphalt coating shall be applied as follows:

1. Border the area to which pigmented asphalt coating is to be applied using masking or duct tape.
2. Thoroughly mix component A using a power drill before adding component B. While mixing component A, add component B and continue mixing for 60 seconds to ensure the dispersion of the catalyst. Once mixed, pot life is 10 minutes.
3. Pour the resulting pigmented asphalt coating material onto surface and spread with a squeegee or medium textured paint roller. The material shall be applied to the pavement surface while in a plastic state. In a uniform thickness of 889 microns +/- 51 microns measured dry. The material shall be applied when the pavement surface temperature is 4.4 degrees C and above. The maximum surface temperature shall be 38 degrees C. The maximum relative humidity shall be 70%.
4. Quartz silica sand shall be excessively and uniformly distributed across the pigmented asphalt coating prior to curing (cure time at 24 degrees C. is 15 minutes, 30 minutes at 16 degrees C. Glass beads may be added at this time for retro-reflectivity.
5. Remove masking materials prior to curing.
6. Excess sand shall be swept up after the material has cured.

The contractor shall prepare a test panel of not less than one square meter at a location to be determined by the engineer for the inspection and approval by the engineer. The contractor shall not proceed with the coating of the areas specified on the plans until directed to do so by the engineer.

Method of Measurement

The work will be measured as the number of square meters of surface coated in accordance with the plans and specifications, or as directed by the field engineer.

SPECIFICATIONS FOR RAINLINE® INLAID INVERTED PROFILE TRAFFIC STRIPE MATERIAL

1. Description:

This section shall cover the work of furnishing all materials, equipment, and the application of the materials to form an inlaid inverted profile thermoplastic traffic stripe that is hot applied to the inside of a recessed groove flush with the pavement surface. This traffic stripe shall be formed during applications with an inverted profile that will rapidly drain water from the highway surface. This rapid draining shall allow the traffic stripe to be highly reflective in heavy rain. This stripe shall be flush with the pavement surface in order to minimize damage from snowplows or other harmful surface influences.

This type of traffic stripe shall be designated as "Inlaid Inverted Profile Traffic Stripe".

2. Materials:

2.1 General

This provision covers machine applied hot Hydrocarbon thermoplastic pavement marking material with both intermixed and drop-on glass beads for use in Inlaid Inverted Profile Traffic Stripe.

2.2 Thermoplastic Material

The thermoplastic material used for hot Hydrocarbon applications shall consist of homogeneously mixed pigments, fillers, resins, fibers, glass beads, and shall be available in both white and yellow colors.

The thermoplastic material shall be free of contaminates and shall be dry blended from 100% virgin stock using no reprocessed materials. The thermoplastic material, while on the roadway surface and at any natural ambient temperature shall exist in a hard solid state with cold ductility that permits normal movement with the road surface without chipping and or cracking.

The material manufacturer shall meet the minimum requirements specified herein including, but not limited to, composition, physical characteristics, etc. The physical and chemical properties contained in this specification shall apply regardless of the type of formulation used.

The thermoplastic material upon heating shall not exude fumes, which are toxic, or injurious to persons or property.

The thermoplastic material shall not deteriorate or discolor when held at the application temperature for periods of time up to 4 hours, or upon reheating to the application temperature for a period of time not to exceed 4 hours.

The thermoplastic material shall be readily applicable at temperatures between 400°F and 430°F (204°-221° C) from the approved equipment to produce lines of the required type and thickness above the pavement surface as described elsewhere in the specification.

2.3 Composition

The pigment, beads, resin, and filler shall be a uniform blend. The material shall be free from all skins, dirt, and foreign objects and shall comply with requirements according to Table I.

TABLE I

Components	Composition By Mass	
	White	Yellow
Binder	20% Minimum	20% Minimum
Glass Beads (Intermixed)	35%	35%
Titanium Dioxide (for white material only)	10% Minimum	N/A
Yellow Pigment (for yellow material only)	N/A	4% Minimum
Calcium Carbonate & Inert Filler	See Note "A"	See Note "A"
Cross Link Fibers	0.5%	0.5%
NOTE "A": The amount of calcium carbonate and inert fillers shall be at the option of the manufacturer, providing all other requirements of the specifications are met.		
OTHER INGREDIENTS: Titanium Dioxide ASTM D 476, Type II		

2.4 Intermix Glass Beads (Class A)

The thermoplastic composition shall have a minimum total Intermix Glass Bead content of 35% by mass. The glass beads shall be AASHTO M 247 Type I with an AC 07 adhesion coating, or equivalent silane coating, and 70% round or true spheres.

2.5 Drop-on Glass Beads

Drop on glass beads used in both coats shall conform to State Standard Specifications and shall have a moisture proof coating. Sampling shall be done according to the applicable State Specification.

2.6 Physical Characteristics

(a) COLOR

The thermoplastic pavement marking material shall meet the following requirements for daylight reflectance and color when tested using a standard color difference meter (0°-45°) CIE, Illuminant C, and a magnesium oxide standard or an approved secondary standard. (ASTM reference number 1925)

White: Daylight reflectance at 45°-0° of 80% minimum and match federal test standard number 595a, Color 17886)

Yellow: Daylight reflectance at 45°-0° of 45% minimum and match federal test standard number 595a, (Color 13538), which shall fall within the limits of FHWA highway color tolerance chart, PR color #1.

Chromaticity: Coordinates X and Y shall fall in an area bordered by these coordinates:

X	0.470	0.510	0.490	4.537
Y	0.455	0.489	0.432	0.462

(b) REFLECTIVITY

The initial reflectance for the in-place marking shall have the minimum reflectance values shown as follows, as obtained with a Mirolux 12 Retroreflectometer.

Dry Night	White – 450 mcd/lux/m^2	Yellow – 300 mcd/lux/m^2
Wet Night	White – 200 mcd/lux/m^2	Yellow – 175 mcd/lux/m^2

(c) WET NIGHT TEST PROCEDURE

Mark or delineate a 1 m long section of pavement marking to be tested. Utilizing a pump type garden sprayer, wet the test section for 5 seconds with water so that the pavement marking is thoroughly wet. Wait 30 seconds after wetting the stripe and place the Mirolux 12 Retroreflectometer on the previously wet test section.

(d) YELLOWNESS INDEX

The white thermoplastic material shall not exceed a yellowness index of 0.15. (AASHTO T 250)

(e) BOND STRENGTH

The bond strength of the thermoplastic material to Portland Cement Concrete shall exceed 180 Psi (1.24 Mpa). (ASTM D 4796-88)

(f) CRACKING RESISTANCE AT LOW TEMPERATURE

The thermoplastic pavement marking material shall pass. (AASHTO T 250)

(g) IMPACT RESISTANCE

The impact resistance of the thermoplastic pavement marking material shall be a minimum of 10 inch pounds (1.1 Joules). (AASHTO T 250)

(h) SOFTENING POINT

The thermoplastic material shall have a softening point of not less than 248° ± 17.1°F (120° ± 9.5°C). (ASTM D 36)

(i) DRYING TIME

When applied at a temperature of between 380°F and 410°F (193°-210°C), and at a thickness of .160" (4 mm), the thermoplastic material shall set to bear traffic in not more than two minutes when the air temperature is 50°F (11°C) and not more than 10 minutes when the air temperature is 90°F (32°C).

(j) PROFILABILITY

The thermoplastic pavement marking material shall be formulated so that when applied at a temperature of between 380°F and 410°F (193°-210°C), the individual profiles shall be a minimum of .160" (4 mm) when measured at the highest point of the profile and shall not excessively run back together. Individual profiles shall not compress more than 0.02" (0.50 mm) under traffic. (See Figure 1.) It is normal for some areas of the stripe to be a different line thickness. Horizontal slump shall be not less than 0.22" (5.56 mm) when tested by RLC-1PS.

(k) FLASHPOINT

The thermoplastic material shall have a flashpoint not less than 475°F (246°C). (ASTM D 92, "Flash and Fire Points made by Cleveland Open Cup.")

(l) INDENTATION RESISTANCE

After 15 seconds with the sample panels and Shore Durometer (TY-A2) reading 90°F (32°C), and applying a 2 kg load, the reading shall not be less than 45. (ASTM D 2240)

(m) PLATE TEST

Place a test cube of thermoplastic material measuring 40 mm x 100 mm x 15 mm under a static mass of 2500 g in an oven at a temperature of 185°F (85°C) for 4 hours. Remove and allow it to cool to room temperature. Determine the surface area of the cube. The maximum allowable increase in the surface area of the cube shall be no more than 10%. (RLC-1PT)

(n) FLEXIBILITY

(o) SKID RESISTANCE

Minimum vehicle skid resistance of the in place markings shall not be less than 55.

(p) STORAGE LIFE

The thermoplastic material shall meet the requirements of this specification for a period of one year. The thermoplastic shall also melt uniformly with no evidence of skins or unmelted particles for the one-year period. The manufacturer shall replace any material not meeting the above requirements.

(q) PACKAGING AND MARKING

The thermoplastic material shall be packaged in suitable containers to which it will not adhere during shipment and storage. The bags of thermoplastic material shall be approximately 22" x 14" x 4" (559 mm x 356 mm x 100 mm) and shall have a mass of approximately 50 lb (23 kg). Each container label shall designate the color, manufacturer's name, batch number, and date of manufacture. Each batch manufactured shall have its own separate number. The label shall warn the user that the material shall be heated to 400°F to 430° F (204°-221°C) during application

The Contractor shall assume all costs resulting from the use of patented materials, equipment, devices or processes used on or incorporated in the work, agrees to indemnify and save harmless the purchaser and his duly authorized representatives from all suits at law, or action of every nature for or on account of the use of any patented materials, equipment, devices, or processes.

Construction Specifications

Prior to application of striping materials a slotted groove of the specified dimensions shall be cut into the asphalt pavement surface. This slot shall have a nominally flat bottom with straight sides. The bottom and sides of the slot shall not vary in depth or width more than 1/16" in any given 12" distance. The slot shall be cut to an average depth of .250" (6mm) and an average width of 4.125" (105mm). All recesses shall be completely clean and dry before applying thermoplastic. A power-operated blower shall be used to remove debris from recesses prior to thermoplastic operation.

"IP CLASS 3" type thermoplastic material meeting State Specification for inverted profile type thermoplastic material shall be used for this delineation. The application equipment shall utilize a screed shoe which will lay down a base line stripe of hot 400°F to 430°F (204°-221°C) thermoplastic material at the specified width. A moveable gate or door, which controls the flow of thermoplastic onto the pavement, shall be incorporated into the die/shoe for starting/stopping and skip-line application. All thermoplastic tanks, lines, manifolds and the extrusion shoe itself, should be surrounded by a heated jacket in order to maintain proper application temperature.

Two low-pressure glass bead applicator guns shall apply a minimum of 70 kg of drop-on glass beads per kilometer of 100 mm wide stripe or 106 kg of drop-on beads per kilometer of 150 mm wide stripe. The first applicator shall be located behind the point where the thermoplastic material flows onto the pavement (See Figure 2.) and shall use Standard State Specification coated drop on beads at the rate of 28 kg/km of 100 mm stripe or 42 kg/km of 150 mm stripe. The second glass bead applicator shall be located just ahead of the Profiling Wheel and shall utilize Standard State Specification waterproof coated drop on beads at the rate of 42 kg/km of 100 mm stripe or 63 kg/km of 150 mm stripe.

A profiling wheel approximately 7" (178 mm) in diameter shall be located approximately 15-21" (381-533 mm) behind the thermoplastic applicator. This profiling wheel shall emboss a pattern of circular corrugations onto the hot thermoplastic ribbon, leaving it profiled as shown in Figure 1. This profiling wheel shall be mounted on the same carriage as the extrusion shoe and glass bead guns, and shall be free to move up and down over pavement undulations. The profiling wheel shall emboss a pattern across the entire width of the stripe within the slotted groove that has been prepared in the asphalt pavement. The depth of molten thermoplastic in the slotted groove shall be adjusted so as to completely fill the groove plus .025" (.5 mm) above the pavement riding surface after profiling, as measured at the highest point of the profile (see figure 3). These grooves shall be .090-.311" (2.4 – 7.9 mm) wide and shall occur regularly at approximately .945" (24 mm) intervals (See Figure 1). The Contractor shall provide a wet film thickness checker, such as a RainLine model 025C to the Engineer for use during the duration of the project.

A fine mist of water shall be applied from an air-atomized spray gun at an exact rate onto the top of the profiling wheel to cool the wheel and keep the thermoplastic from sticking to it. This water spray shall be kept to a minimum so that no pools of water greater than .252" (6.4 mm) in diameter accumulate along the striping. Application speed shall be such that no more than one second elapses between the extrusion of the thermoplastic onto the pavement and the passage of the profiling wheel over the hot material.

The thermoplastic material shall have sufficient viscosity at application temperatures so that it will not flow or lose its profile while cooling. After cooling, the hardness of the thermoplastic material shall be such that the profile is not deformed white bearing traffic.

Application of Inlaid Inverted Profile Thermoplastic Striping shall not be done unless the ambient and pavement temperatures exceed 61°F (16°C). The pavement shall be completely dry.

All existing paints and pavement markings, other than a single thin coat of temporary paint, shall be removed before applying Inlaid Inverted Profile Thermoplastic Striping. Removal of existing stripe will be paid for as a separate item of work.

When striping over existing painted stripe, old bleached asphalt, on all Portland Cement Concrete, or on all surfaces when ambient temperatures are below 72°F (22°C), a primer sealer shall be used and installed as recommended in writing by the thermoplastic material supplier.

Warranty

The contractor will provide a 4-year warranty that all markings will stay in place, and will maintain a minimum 150 millicandellas reflectance for white and 125 millicandellas reflectance for yellow.

The Warranty period will start on the date the Engineer accepts the work and authorized final payment.

If reflectivity becomes a concern at any time during the warranty period, the Department will measure the retro-reflectivity of the area in question, using a Mirolux 12 or comparable device to measure a clean portion of the roadway.

The contractor will be required to repair or replace (at the discretion of the Department) all markings that drop below the required minimum retro-reflectivity during the warranty period, within 6 months of request to do so.

For the purpose of the warranty, a cumulative 5% or greater loss of line due to non-adhesion on any 100 meter segment of marking will constitute failure of the material in that segment.

Inspection Procedure

PURPOSE

To provide supervising department of transportation personnel with procedure for insuring compliance with various items in the performance specification, for in-place Inlaid Inverted Profile Thermoplastic traffic stripe pavement markings, as listed below.

APPARATUS

- Measuring tape or ruler
- Mirolux 12 Retroreflectometer
- Magnifying glass
- RainLine Model 025C (Cold Thickness Checker)

LINE SELECTION PROCEDURE

The engineer throughout the project shall select periodic random inspection stations. Measurements of line thickness, width, apparent bond strength and retroreflectivity shall be taken. In a given 3' section, several reflectance readings will be taken and averaged to yield a net reading.

PROCEDURE – THICKNESS

After the striper unit has passed a given point by a distance of 40 feet use a RainLine Model 025W Line Thickness Checker to test the line thickness. Place the checker over the stripe so that the two end flats rest on the road surface on either side of the stripe. Slide the checker forward along the stripe for about a 6" distance. The middle flat of the checker should make a slight indention in the highest point of the stripe. From this you can accurately estimate the wet film thickness of the stripe.

NOTE**:** Minimum required in place thickness of Inverted Profile Traffic Stripe shall be .025 inches (.5 mm) above the pavement riding surface as measured at the highest point of the profile (see figure 3).

PROCEDURE – WIDTH.

Measure the line width across the stripe at the bottom of the Inverted Profile. The line width should be 4' (range of 3 7/8" to 4 3/8").

REFLECTIVITY.

The initial reflectance for the in-place marking shall have the minimum reflectance values shown as follows, as obtained with a Mirolux 12 Retroreflectometer.

Dry Night	White – 450 mcd/lux/m^2	Yellow – 300 mcd/lux/m^2
Wet Night	White – 200 mcd/lux/m^2	Yellow – 175 mcd/lux/m^2

Wet Night Test Procedure – Mark or delineate a three (3) foot long section of pavement marking to be tested. Utilizing a pump type garden sprayer, wet the test section for 5 seconds with water so that the pavement marking is thoroughly wet. Wait 30 seconds after wetting the stripe and place the Mirolux 12 Retroreflectometer on the previously wet test section.

RETAINED REFLETIVITY.

The thermoplastic pavement marking material shall retain the minimum reflectance value of 150 mcd/lux/m^2 for at least 36 months after placement. Failure to meet this requirement shall require the

manufacturer to replace the portion of the material shown to be below these minimums. The manufacturer shall supply a written warranty indicating the terms of this requirement.

PROCEDURE – GENERAL.

Beads – 50% of glass beads should be embedded to approximately 60% of their diameter to insure proper adherence to the thermoplastic marking material and provide maximum initial retroreflectivity. Shallow embedment allows the beads to debond and deep embedment reduces retroreflectivity. Use a magnifying glass to view bead embedment.

Bonding – The thermoplastic Inverted Profile Traffic Stripe shall be properly bonded to the pavement surface. This can be checked with a knife or screwdriver while the material is still pliable. If the material is properly bonded it should bring up some asphalt with it. When completely cured, it should be almost impossible to get a knife or screwdriver blade between the marking and the roadway.

SPECIFICATIONS FOR STREETPRINT™ PAVEMENT TEXTURING

Description

The work shall be described as "StreetPrint™ Pavement Texturing" or "StreetPrint™" on the drawings and documents related to the project. The contractor doing this work shall be an Authorized StreetPrint™ Applicator as licensed by Integrated Paving Concepts Inc.

1.2 Definitions

StreetPrint™ Pavement Texturing comprises methods and products to imprint Hot Mix Asphalt Concrete (HMA) and treat the patterned surface to create the appearance of hand-laid decorative paving products.

The StreetPrint™ Contractor is the Authorized StreetPrint™ Applicator.

1.3 Scope of Work

StreetPrint™ Pavement Texturing is a finishing system, which treats the surface of Hot Mix Asphalt Concrete (HMA). The performance of StreetPrint™ will be dependent upon the proper design and construction of the subgrade, base and asphalt upon which StreetPrint™ is installed. In general, a subgrade, base and asphalt structure which complies with good practice given the expected service conditions for a HMA surface which will not be finished with StreetPrint™, would also provide an appropriate structure upon which the StreetPrint™ Pavement Texturing system can be applied.

The Scope of Work for the Authorized StreetPrint™ Applicator shall include items **1.3.4** and **1.3.5** and may include items **1.3.1**, **1.3.2** and/or **1.3.3**.

The (owner)(contractor) shall engage an experienced Geotechnical Engineer to provide recommendations for preparing the subgrade and/or base upon which the pavement structure shall be placed. Refer to The Asphalt Institute Manual Series No. 1 (latest revision) "Thickness Design, Asphalt Pavements for Highways and Streets", or recognized alternative.

Where approved standards are not in place the (owner) (contractor) shall engage an experienced Materials or Pavements Engineer to provide recommendations for the pavement structure. The Pavements Engineer shall define the pavement structure, including granular sub-base and base components, which will provide serviceability for the intended design life, having regard for the subgrade support parameter provided by the Geotechnical Engineer. Thickness design shall be undertaken using the Asphalt Institute Method (MS-1), the Shell Pavement Design Manual, or other recognized alternative procedure.

1.3.1 Subgrade Preparation

Supply and install subgrade material including removal and disposal of existing material, as required by the jurisdiction having authority or the Owner's Geotechnical Engineer.

1.3.2 Base Preparation

Supply and install base material, including removal and disposal of existing material, as required by the jurisdiction having authority or the Owner's Geotechnical Engineer.

1.3.3 Installation of Hot Mix Asphalt Concrete

Supply and install Hot Mix Asphalt Concrete as required by the jurisdiction having authority or the Owner's Materials or Pavements Engineer.

1.3.4 Imprinting of Hot Mix Asphalt Concrete

Layout and imprint the pattern into the surface of the HMA as per the specifications.

1.3.5 Application of StreetBond™ Surfacing System

Supply and install “StreetBond™ Surfacing System” products as per the specifications.

Materials

Hot Mix Asphalt Concrete (HMA): The HMA shall conform with the requirements of the state (or other) authority having jurisdiction or shall be specified by the Pavement/Materials Engineer, having regard for annual ambient temperature extremes and type of anticipated traffic. HMA additives are available to produce high performance asphalt. Where the specifier believes this may be necessary to achieve the level of stability required for the application, contact your local Authorized StreetPrint™ Applicator or Integrated Paving Concepts Inc. before specifying.

"StreetBond™ Surfacing Systems" The Owner or Owner's representative shall specify the number of applications of the "StreetBond™ Surfacing System" that will be installed. Commercial applications exposed to vehicular traffic should receive a minimum of two applications of StreetBond™ Standard Formula. StreetBond™ Traffic Formula should be used for the first layer for commercial installations where higher traffic loads will come in contact with the StreetPrint surface. At least one application of StreetBond™ Standard Formula should be used on top of the StreetBond™ Traffic Formula. Contact your local Authorized StreetPrint™ Applicator or Integrated Paving Concepts Inc. before specifying.

Physical and Performance Properties

The products used in the surfacing system shall meet the minimum physical and performance properties described in the following "StreetBond™ Surfacing System" Product Descriptions and Specifications.

"StreetBond™ Surfacing System" Product Descriptions and Specifications

StreetBond™ Standard Formula: StreetBond™ Standard Formula is a unique, integrally-colored, cement modified, acrylic polymer surfacing product developed specifically for use over imprinted asphalt. It has superior adhesion, flexibility and abrasion resistance characteristics as well as color stability, chemical resistance and scrubability. The combination of characteristics required of a StreetPrint™ application are very demanding and StreetBond™ Standard Formula has been developed to meet these unique demands. StreetBond™ Standard Formula is available in eight standard colors: Granite, Slate, Terra Cotta, Brick, Bedrock, Sierra, Burnt Sienna and Hunter Green. Custom colors are available for an additional cost. One application of StreetBond™ Standard Formula will provide a surface build between 10 – 15 mils. (For physical and performance properties see Tables 1 & 3.)

StreetBond™ Traffic Formula: StreetBond™ Traffic Formula is also a unique, integrally-colored, cement modified, acrylic polymer surfacing product designed to provide a thicker build. This product is specifically designed to be used as the first layer for higher traffic areas. StreetBond™ Traffic Formula is available in three standard colors: Granite, Slate & Burnt Sienna. No custom colors are available at this time. One layer of StreetBond™ Traffic Formula plus one layer of StreetBond™ Standard Formula will provide a surface build between 20 – 25 mils. (For physical and performance properties see Tables 1 & 3.)

StreetBond™ Sealer Concentrate: StreetBond™ Sealer Concentrate is a breathable, high quality, acrylic polymer, clear sealer designed specifically for use with the "StreetBond™ Surfacing System." When applied over either the StreetBond™ Standard Formula or StreetBond™ Traffic Formula, StreetBond™ Sealer Concentrate provides a breathable sealing membrane, which adds both durability and longevity to the StreetBond™ products. It is absolutely necessary to seal both StreetBond™ products with StreetBond™ Sealer Concentrate. (For physical properties see table below.)

Installation

Subgrade Preparation: Complete in accordance with guidelines and standards specified by the jurisdiction having authority or the Geotechnical Engineer (see Section 1.3 of this Specification).

Asphalt Concrete Paving: Complete in accordance with guidelines and standards specified by the jurisdiction having authority or the Materials or Pavements Engineer (see Section 1.3 of this Specification). Where no such authority is in place construction of the HMA shall be in accordance with "Principles of Construction of Hot-Mix Asphalt Pavements" as published by the Asphalt Institute or equivalent. The placement of the asphalt shall be carried out with regard for the imprinting process to avoid visible seams.

Contact your Authorized StreetPrint™ Applicator or Integrated Paving Concepts Inc. for advice on designing a pattern layout, which allows for an optimal finished appearance.

Surface Imprinting: The Contractor shall follow procedures detailed in the latest revision of StreetPrint™ Application Procedures as issued by Integrated Paving Concepts Inc. The pattern shall be created in accordance with the design as agreed by the Owner or Owner's representative. Patterning shall begin once the asphalt has reached its final density and while there is still sufficient heat in the asphalt to permit imprinting. Patterning shall be achieved using steel rollers and/or vibratory plates and shall be of consistent depth.

Surfacing System: The Contractor shall apply the "StreetBond™ Surfacing System" as specified under *Materials*, above. The "StreetBond™ Surfacing System" should never be applied in temperatures below 45°F and rising, or when precipitation can be expected within 24 hours. Installation shall be in accordance with the latest revision of the StreetPrint™ Application Procedures as issued by Integrated Paving Concepts Inc. The StreetBond™ products shall be spray applied and broomed using a broom or brushes to cut in small areas where required. Once the StreetBond™ products are fully dried StreetBond™ Sealer Concentrate will be applied as a curing membrane. StreetBond™ Sealer Concentrate shall be tinted using the resin from the StreetBond™ products, spray applied and broomed into the surface. Care shall be taken to ensure that the entire surface is covered, including the imprinted surfaces. Sufficient masking shall be used to ensure that the surfacing products are applied only where specified.

PHYSICAL PROPERTIES: "STREETBOND™ "

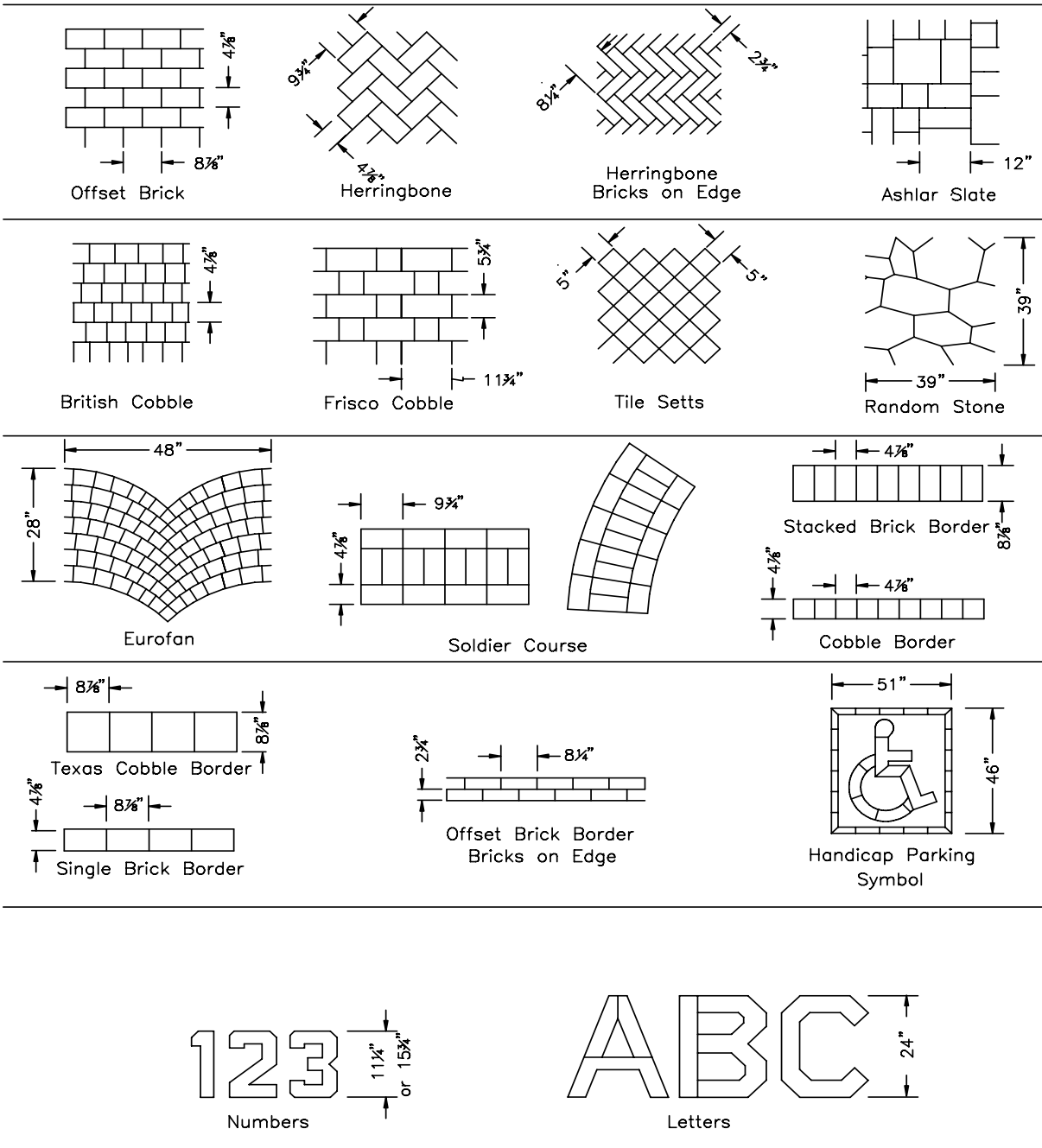
Characteristic	***Test Specification***	***StreetBond™ Standard Formula***	***StreetBond™ Traffic formula***
Solids by Volume (%)	ASTM D-5201	53+/-3 %	62.8+/-2 %
Solids by Weight (%)	ASTM D-1351	75.5 +/- 2%	80 +/- 2%
Density (lbs./gal)	ASTM D-1475	14.6 +/- 0.2 (1.75 gr. / l)	15 +/- 0.2 (1.80 gr. / l)
Flash Point	ASTM D-3278	>200°F (93°C)	>200°F (93°C)
Percent Pigment (by weight including cement)	ASTM D-3723	62 +/- 2%	70 +/- 2%
Sheen (85°)	ASTM D-523	< 3 @ 85°	< 3 @ 85°

PHYSICAL PROPERTIES: "STREETBOND™ SEALER CONCENTRATE"

Characteristics	***Test Specifications***	***StreetBond™ Sealer Concentrate***
Solids by Volume (%)	ASTM D-5201	24 +/-2
Solids by Weight (%)	ASTM D-1353	27+/-2
Density (lbs./gal)	ASTM D-1475	8.59
Spec. Gravity	ASTM D-1475	1.03
Sheen (85°)	ASTM D-523	> 75 @ 85°
VOC Coating	ASTM D-3960	> 200
Flash Point	ASTM D-3278	> 200°F (93°C)

PERFORMANCE PROPERTIES: "STREETBOND™ SURFACING SYSTEM"

Characteristics	***TEST SPECIFICATIONS***	***Min. Criteria StreetBond™ Standard Formula***	*Min. Criteria StreetBond™ Traffic Formula*
Tensile Strength (PSI)	ASTM D-412	>650 PSI	>650 PSI
Flexibility Mandrel (High)	ASTM D-1737	Pass 1" @ 70°F	Pass 1" @ 70°F
Flexibility Mandrel (Low)	ASTM D-1737	Pass 2" @ O°F	Pass 2" @ O°F
Dry Time (to re-coat)	ASTM D-711	20 Mins. - 4 Hrs.	20 Mins. - 4 Hrs.
Dry Time (for traffic) 75°F/30%RH	N/A	≅ 80% strength @ 6-8Hrs.	≅ 80% strength @ 6-8Hrs.
Taber Abrasion (H-10)	ASTM D-4060	< .18 g/1000 cycles	< .18 g/1000 cycles
Adhesion (PLI) To an Asphalt substrate	ASTM D-4640	Cohesive failure of asphalt prior to adhesive failure	Cohesive failure of asphalt prior to adhesive failure
QUV ΔE	ASTM G-53	300 hours 2.35 CIE units	300 hours 2.35 CIE units
Hydrophobicity (3days)	ASTM D-570	< 12% wt. gain	< 12% wt. gain
Shore Hardness	ASTM D-2240	80 D	80 D
Temperature Limits for Service	Dry, cured material	-30°F to 160°F	-30°F to 160°F
Surface Build	N/A	10 – 15 mils. (1 application)	20 – 25 mils. (2 applications)


4⅞"
8⅞"
Offset Brick
9¾"
4½"
Herringbone
8½"
2¾"
Herringbone
Bricks on Edge
12"
Ashlar Slate
4⅞"
British Cobble
5¾"
11¾"
Frisco Cobble
5"
5"
Tile Setts
39"
39"
Random Stone
48"
28"
Eurofan
9¾"
4⅞"
Soldier Course
4⅞"
Stacked Brick Border
8⅞"
4⅞"
4⅞"
Cobble Border
8⅞"
8⅞"
Texas Cobble Border
4⅞"
8⅞"
Single Brick Border
2¾"
8¼"
Offset Brick Border
Bricks on Edge
51"
46"
Handicap Parking
Symbol
123
11¼"
or 15¾"
Numbers
ABC
24"
Letters