

## CHAPTER 4E. PEDESTRIAN CONTROL FEATURES

### Section 4E.01 Pedestrian Signal Heads

Support:

Pedestrian signal heads provide special types of traffic signal indications exclusively intended for controlling pedestrian traffic. These signal indications consist of the illuminated symbols of a WALKING PERSON (symbolizing WALK) and an UPRAISED HAND (symbolizing DONT WALK).

Guidance:

Engineering judgment should determine the need for separate pedestrian signal heads (see Section 4D.03) and accessible pedestrian signals (see Section 4E.06).

### Section 4E.02 Meaning of Pedestrian Signal Indications

Standard:

**The pedestrian signal indications shall have the following meanings:**

- A. A steady WALKING PERSON (symbolizing WALK) signal indication means that a pedestrian facing the signal indication may start to cross the roadway in the direction of the signal indication, possibly in conflict with turning vehicles.**
- B. A flashing UPRAISED HAND (symbolizing DONT WALK) signal indication means that a pedestrian shall not start to cross the roadway in the direction of the signal indication, but that any pedestrian who has already started to cross on a steady WALKING PERSON (symbolizing WALK) signal indication shall proceed out of the traveled way.**
- C. A steady UPRAISED HAND (symbolizing DONT WALK) signal indication means that a pedestrian shall not enter the roadway in the direction of the signal indication.**
- D. A flashing WALKING PERSON (symbolizing WALK) signal indication has no meaning and shall not be used.**

**Section 4E.03 Application of Pedestrian Signal Heads****Standard:**

**Pedestrian signal heads shall be used in conjunction with vehicular traffic control signals under any of the following conditions:**

- A. If a traffic control signal is justified by a traffic engineering study and meets either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see Chapter 4C);**
- B. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped;**
- C. At an established school crossing at any signalized location; and/or**
- D. When multiphase signal indications (as with split-phase timing) would tend to confuse pedestrians guided only by vehicular signal indications.**

**Guidance:**

Pedestrian signal heads should be used under any of the following conditions:

- A. If it is necessary to assist pedestrians in making a safe crossing or if engineering judgment determines that pedestrian signal heads are justified to minimize vehicle-pedestrian conflicts;
- B. If pedestrians are permitted to cross a portion of a street, such as to or from a median of sufficient width for pedestrians to wait, during a particular interval but are not permitted to cross the remainder of the street during any part of the same interval; and/or
- C. If no vehicular signal indications are visible to pedestrians, or if the vehicular signal indications that are visible to pedestrians starting or continuing a crossing provide insufficient guidance for them to decide when it is safe to cross, such as on one-way streets, at T-intersections, or at multiphase signal operations.

**Section 4E.04 Size, Design, and Illumination of Pedestrian Signal Indications****Standard:**

All new pedestrian signal indications shall be displayed within a rectangular background and shall consist of symbolized messages, except that existing pedestrian signal indications with lettered messages may be retained for the remainder of their useful service life. The symbol designs that are set forth in the "Standard Highway Signs" book shall be used. Each signal indication shall be independently illuminated and emit a single color (see Figure 4E-1).

The UPRAISED HAND (symbolizing DONT WALK) signal section shall be mounted directly above or integral with the WALKING PERSON (symbolizing WALK) signal section.

The WALKING PERSON (symbolizing WALK) signal indication shall be white, conforming to the document entitled "Pedestrian Traffic Control Signal Indications" (see Section 1A.11), with all except the symbol obscured by an opaque material.

The UPRAISED HAND (symbolizing DONT WALK) signal indication shall be Portland orange, conforming to the document entitled "Pedestrian Traffic Control Signal Indications" (see Section 1A.11), with all except the symbol obscured by an opaque material.

When not illuminated, the WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK) symbols shall not be readily visible to pedestrians at the far end of the crosswalk that the pedestrian signal indications control.

For pedestrian signal indications, the symbols shall be at least 150 mm (6 in) high.

**Guidance:**

Pedestrian signal indications should be conspicuous and recognizable to pedestrians at all distances from the beginning of the controlled crosswalk to a point 3 m (10 ft) from the end of the controlled crosswalk during both day and night.

For crosswalks where the pedestrian enters the crosswalk more than 30 m (100 ft) from the pedestrian signal indications, the symbols should be at least 225 mm (9 in) high.

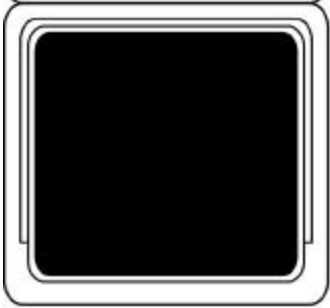
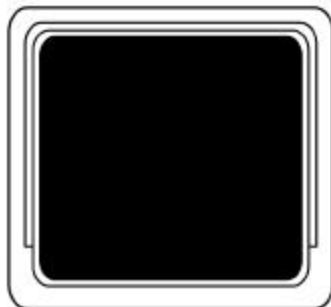
**Figure 4E-1. Typical Pedestrian Signal Indications**



**One Section (Outlined Symbol)**



**One Section (Solid Symbol)**



**Two Section**

**Section 4E.05 Location and Height of Pedestrian Signal Heads****Standard:**

**Pedestrian signal heads shall be mounted with the bottom of the signal housing including brackets not less than 2.1 m (7 ft) nor more than 3 m (10 ft) above sidewalk level, and shall be positioned and adjusted to provide maximum visibility at the beginning of the controlled crosswalk.**

**If pedestrian signal heads are mounted on the same support as vehicular signal heads, there shall be a physical separation between them.**

**Section 4E.06 Accessible Pedestrian Signals****Support:**

The primary technique that pedestrians who have visual disabilities use to cross streets at signalized intersections is to initiate their crossing when they hear the traffic in front of them stop and the traffic alongside them begin to move, corresponding to the onset of the green interval. This technique is effective at many signalized intersections. The existing environment is often sufficient to provide the information that pedestrians who have visual disabilities need to operate safely at a signalized intersection. Therefore, many signalized intersections will not require any accessible pedestrian signals.

**Guidance:**

If a particular signalized intersection presents difficulties for pedestrians who have visual disabilities to cross safely and effectively, an engineering study should be conducted that considers the safety and effectiveness for pedestrians in general, as well as the information needs of pedestrians with visual disabilities.

**Support:**

The factors that might make crossing at an intersection difficult for pedestrians who have visual disabilities include: increasingly quiet cars, right turn on red (which masks the beginning of the through phase), continuous right-turn movements, complex signal operations, traffic circles, and wide streets. Further, low traffic volumes might make it difficult for pedestrians who have visual disabilities to discern signal phase changes.

Local organizations, providing support services to pedestrians who have visual and/or hearing disabilities, can often act as important advisors to the traffic engineer when consideration is being given to the installation of devices to assist such pedestrians. Additionally, orientation and mobility specialists or similar staff also might be able to provide a wide range of advice. The U.S. Access Board's Document A-37, "Accessible Pedestrian Signals," provides various techniques for making pedestrian signal information available to persons with visual disabilities.

Accessible pedestrian signals provide information in non-visual format (such as audible tones, verbal messages, and/or vibrating surfaces).

Information regarding detectors for accessible pedestrian signals is found in Section 4E.08.

**Standard:**

**When used, accessible pedestrian signals shall be used in combination with pedestrian signal timing. The information provided by an accessible pedestrian signal shall clearly indicate which pedestrian crossing is served by each device.**

**Under stop-and-go operation, accessible pedestrian signals shall not be limited in operation by the time of day or day of week.**

Guidance:

The installation of accessible pedestrian signals at signalized intersections should be based on an engineering study, which should consider the following factors:

- A. Potential demand for accessible pedestrian signals.
- B. A request for accessible pedestrian signals.
- C. Traffic volumes during times when pedestrians might be present; including periods of low traffic volumes or high turn-on-red volumes.
- D. The complexity of traffic signal phasing.
- E. The complexity of intersection geometry.

Support:

Technology that provides different sounds for each non-concurrent signal phase has frequently been found to provide ambiguous information.

**Standard:**

**When choosing audible tones, possible extraneous sources of sounds (such as wind, rain, vehicle back-up warnings, or birds) shall be considered in order to eliminate potential confusion to pedestrians who have visual disabilities.**

Guidance:

Audible pedestrian tones should be carefully selected to avoid misleading pedestrians who have visual disabilities when the following conditions exist:

- A. Where there is an island that allows unsignalized right turns across a crosswalk between the island and the sidewalk.
- B. Where multi-leg approaches or complex signal phasing require more than two pedestrian phases, such that it might be unclear which crosswalk is served by each audible tone.
- C. At intersections where a diagonal pedestrian crossing is allowed, or where one street receives a WALKING PERSON (symbolizing WALK) signal indication simultaneously with another street.

**Standard:**

**When accessible pedestrian signals have an audible tone(s), they shall have a tone for the walk interval. The audible tone(s) shall be audible from the beginning of the associated crosswalk. If the tone for the walk interval is similar to the pushbutton locator tone, the walk interval tone shall have a faster repetition rate than the associated pushbutton locator tone.**

**Support:**

A pushbutton locator tone is a repeating sound that informs approaching pedestrians that they are required to push a button to actuate pedestrian timing, and that enables visually-impaired pedestrians to locate the pushbutton.

**Guidance:**

The accessible walk signal tone should be no louder than the locator tone, except when there is optional activation to provide a louder signal tone for a single pedestrian phase.

Automatic volume adjustment in response to ambient traffic sound level should be provided up to a maximum volume of 89 dB. Where automatic volume adjustment is used, tones should be no more than 5 dB louder than ambient sound.

**Standard:**

**When verbal messages are used to communicate the pedestrian interval, they shall provide a clear message that the walk interval is in effect, as well as to which crossing it applies.**

**The verbal message that is provided at regular intervals throughout the timing of the walk interval shall be the term "walk sign," which may be followed by the name of the street to be crossed.**

**A verbal message is not required at times when the walk interval is not timing, but, if provided:**

**A. It shall be the term "wait."**

**B. It need not be repeated for the entire time that the walk interval is not timing.**

Option:

Accessible pedestrian signals that provide verbal messages may provide similar messages in languages other than English, if needed, except for the terms "walk sign" and "wait."

Support:

A vibrotactile pedestrian device communicates information about pedestrian timing through a vibrating surface by touch.

**Standard:**

**Vibrotactile pedestrian devices, where used, shall indicate that the walk interval is in effect, and for which direction it applies, through the use of a vibrating directional arrow or some other means.**

Guidance:

When provided, vibrotactile pedestrian devices should be located next to, and on the same pole as, the pedestrian pushbutton, if any, and adjacent to the intended crosswalk.

#### **Section 4E.07 Pedestrian Detectors**

Guidance:

When pedestrian actuation is used, pedestrian pushbutton detectors should be easy to use and conveniently located near each end of the crosswalks.

**Standard:**

**Signs (see Section 2B.40) shall be mounted adjacent to or integral with pedestrian pushbutton detectors, explaining their purpose and use.**



**Option:**

At certain locations, a sign in a more visible location may be used to call attention to the pedestrian detector.

**Guidance:**

If two crosswalks, oriented in different directions, end at or near the same location, the positioning of pedestrian detectors and/or the legends on the pedestrian detector signs should clearly indicate which crosswalk signal is actuated by each pedestrian detector.

**Standard:**

**If the pedestrian clearance time is sufficient only to cross from the curb or shoulder to a median of sufficient width for pedestrians to wait and the signals are pedestrian actuated, an additional pedestrian detector shall be provided in the median.**

**Guidance:**

The use of additional pedestrian detectors on islands or medians where a pedestrian might become stranded should be considered.

A mounting height of approximately 1.1 m (3.5 ft) above the sidewalk should be used for pedestrian pushbutton detectors.

If used, special purpose pushbuttons (to be operated only by authorized persons) should include a housing capable of being locked to prevent access by the general public.

**Standard:**

**If special purpose pushbuttons are used, instructional signs shall not be required.**

**If used, a pilot light or other means of indication installed with a pedestrian pushbutton shall not be illuminated until actuation. Once it is actuated, it shall remain illuminated until the pedestrian's green or WALKING PERSON (symbolizing WALK) signal indication is displayed.**

**Section 4E.08 Accessible Pedestrian Signal Detectors****Support:**

An accessible pedestrian signal detector is a device designated to assist the pedestrian who has visual or physical disabilities in activating the pedestrian phase.

**Option:**

Accessible pedestrian signal detectors may be pushbuttons or passive detection devices.

Pushbutton locator tones may be used with accessible pedestrian signals.

**Standard:**

**At accessible pedestrian signal locations with pedestrian actuation, each pushbutton shall activate both the walk interval and the accessible pedestrian signals.**

**Guidance:**

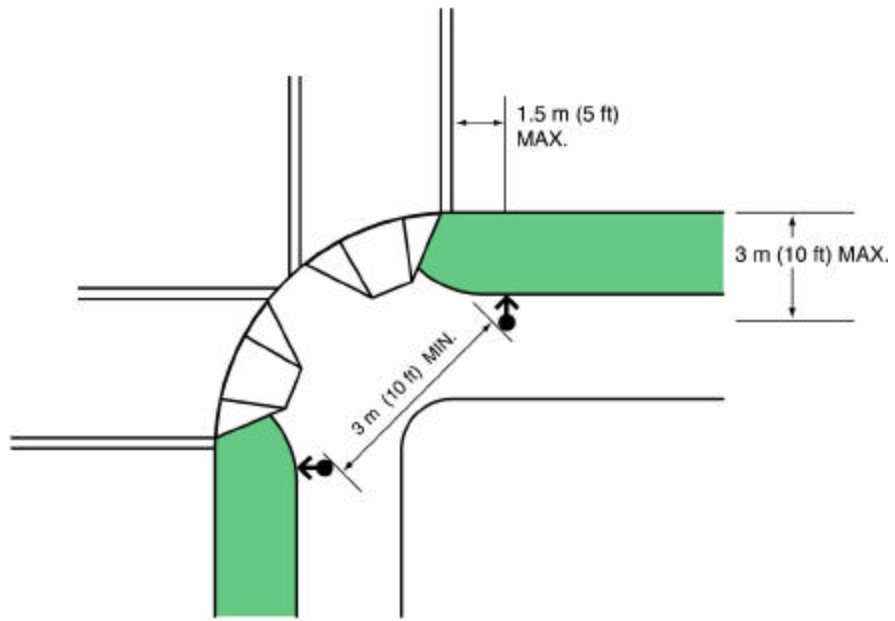
At accessible pedestrian signal locations, pushbuttons should clearly indicate which crosswalk signal is actuated by each pushbutton. Pushbuttons and tactile arrows should have high visual contrast (see the Department of Justice's Americans with Disabilities Act Standards for Accessible Design, 1991). Tactile arrows should point in the same direction as the associated crosswalk. At corners of signalized locations with accessible pedestrian signals where two pedestrian pushbuttons are provided, the pushbuttons should be separated by a distance of at least 3 m (10 ft). This enables pedestrians who have visual disabilities to distinguish and locate the appropriate pushbutton.

Pushbuttons for accessible pedestrian signals should be located as follows:

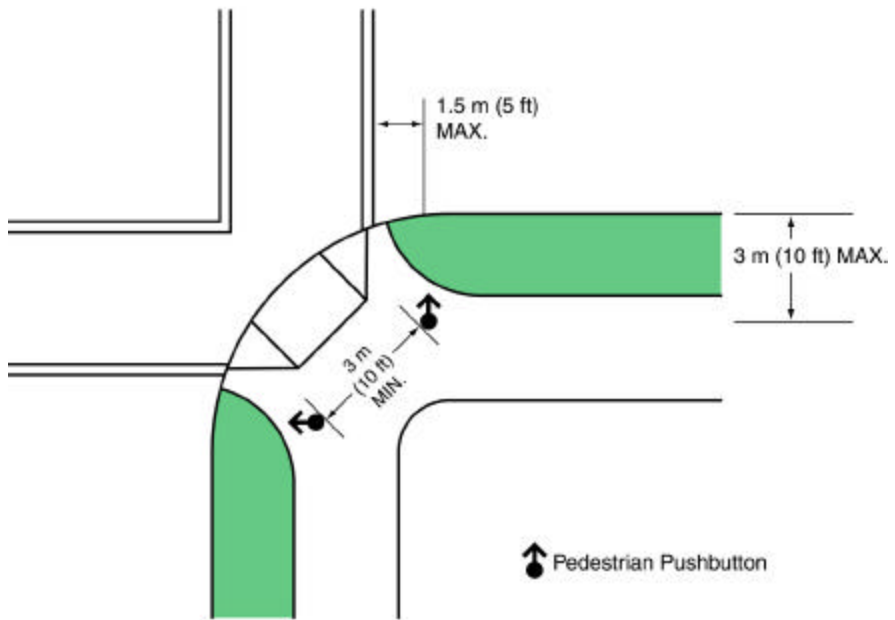
- A. Adjacent to a level all-weather surface to provide access from a wheelchair, and where there is an all-weather surface, wheelchair accessible route to the ramp;
- B. Within 1.5 m (5 ft) of the crosswalk extended;
- C. Within 3 m (10 ft) of the edge of the curb, shoulder, or pavement; and
- D. Parallel to the crosswalk to be used (see Figure 4E-2).

If the pedestrian clearance time is sufficient only to cross from the curb or shoulder to a median of sufficient width for pedestrians to wait and accessible pedestrian detectors are used, an additional accessible pedestrian detector should be provided in the median.

**Figure 4E-2. Recommended Pushbutton Locations for Accessible Pedestrian Signals**



**Two Curb-Cut Ramps**



**One Curb-Cut Ramp**

**Standard:**

**When used, pushbutton locator tones shall be easily locatable, shall have a duration of 0.15 seconds or less, and shall repeat at 1-second intervals.**

## Guidance:

Pushbuttons should be audibly locatable. Pushbutton locator tones should be intensity responsive to ambient sound, and be audible 1.8 to 3.7 m (6 to 12 ft) from the pushbutton, or to the building line, whichever is less. Pushbutton locator tones should be no more than 5 dB louder than ambient sound.

Pushbutton locator tones should be deactivated during flashing operation of the traffic control signal.

## Option:

At locations with pretimed traffic signals or nonactuated approaches, pedestrian pushbuttons may be used to activate the accessible pedestrian signals.

The audible tone(s) may be made louder (up to a maximum of 89 dB) by holding down the pushbutton for a minimum of 3 seconds. The louder audible tone(s) may also alternate back and forth across the crosswalk, thus providing optimal directional information.

The name of the street to be crossed may also be provided in accessible format, such as Braille or raised print.

**Section 4E.09 Pedestrian Intervals and Signal Phases****Standard:**

**When pedestrian signal heads are used, a WALKING PERSON (symbolizing WALK) signal indication shall be displayed only when pedestrians are permitted to leave the curb or shoulder.**

**A pedestrian clearance time shall begin immediately following the WALKING PERSON (symbolizing WALK) signal indication. The first portion of the pedestrian clearance time shall consist of a pedestrian change interval during which a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication shall be displayed. The remaining portions shall consist of the yellow change interval and any red clearance interval (prior to a conflicting green being displayed), during which a flashing or steady UPRAISED HAND (symbolizing DONT WALK) signal indication shall be displayed.**

**At intersections equipped with pedestrian signal heads, the pedestrian signal indications shall be displayed except when the vehicular traffic control signal is being operated in the flashing mode. At those times, the pedestrian signal lenses shall not be illuminated.**

Guidance:

Except as noted in the Option, the walk interval should be at least 7 seconds in length so that pedestrians will have adequate opportunity to leave the curb or shoulder before the pedestrian clearance time begins.

Option:

If it is desired to favor the length of an opposing signal phase and if pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used.

Support:

The walk interval itself need not equal or exceed the pedestrian clearance time calculated for the roadway width, because many pedestrians will complete their crossing during the pedestrian clearance time.

Guidance:

The pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder during the WALKING PERSON (symbolizing WALK) signal indication to travel at a normal walking speed of 1.2 m (4 ft) per second, to at least the center of the farthest traveled lane or to a median of sufficient width for pedestrians to wait. Where pedestrians who walk slower than normal, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 1.2 m (4 ft) per second should be considered in determining the pedestrian clearance time.

Option:

Passive pedestrian detection equipment, which can detect pedestrians who need more time to complete their crossing and can extend the length of the pedestrian clearance time for that particular cycle, may be used in order to avoid using a lower walking speed to determine the pedestrian clearance time.

Guidance:

Where the pedestrian clearance time is sufficient only for crossing from the curb or shoulder to a median of sufficient width for pedestrians to wait, additional measures should be considered, such as median-mounted pedestrian signals or additional signing.

Option:

The pedestrian clearance time may be entirely contained within the vehicular green interval.

On a street with a median of sufficient width for pedestrians to wait, a pedestrian clearance time that allows the pedestrian to cross only from the curb or shoulder to the median may be provided.

During the transition into preemption, the walk interval and the pedestrian change interval may be shortened or omitted as described in Section 4D.13.

## CHAPTER 4F. TRAFFIC CONTROL SIGNALS FOR EMERGENCY VEHICLE ACCESS

### Section 4F.01 Applications of Emergency-Vehicle Traffic Control Signals

#### Support:

An emergency-vehicle traffic control signal is a special traffic control signal that assigns the right-of-way to an authorized emergency vehicle.

#### Option:

An emergency-vehicle traffic control signal may be installed at a location that does not meet other traffic signal warrants such as at an intersection or other location to permit direct access from a building housing the emergency vehicle.

#### Guidance:

If a traffic control signal is not justified under the signal warrants of Chapter 4C and if gaps in traffic are not adequate to permit safe entrance of emergency vehicles, or the stopping sight distance for vehicles approaching on the major street is insufficient to permit safe entrance of emergency vehicles, installing an emergency-vehicle traffic control signal should be considered. If a traffic control signal is justified under the signal warrants of Chapter 4C, and a decision is made to install a traffic control signal, it should be installed to the Standards required for that type of signal (see Chapter 4D).

The sight distance determination should be based on the location of the visibility obstruction for the critical approach lane for each street or drive and the posted or statutory speed limit or 85th-percentile speed on the major street, whichever is higher.

### Section 4F.02 Design of Emergency-Vehicle Traffic Control Signals

#### Standard:

**Except as specified in this Section, an emergency-vehicle traffic control signal shall meet the requirements of this Manual.**

**An Emergency Vehicle (W11-8) sign with an EMERGENCY SIGNAL AHEAD (W11-12P) supplemental plaque shall be placed in advance of all emergency-vehicle traffic control signals. If a warning beacon is installed to supplement the W11-8 sign, the design and location of the beacon shall conform to the Standards specified in Sections 4K.01 and 4K.03.**

**Guidance:**

At least one signal face for each approach on the major street should be located over the roadway.

The following size signal lenses should be used for emergency-vehicle traffic control signals: 300 mm (12 in) diameter for red and steady yellow signal indications, and 200 mm (8 in) diameter for flashing yellow or steady green signal indications.

**Standard:**

**An EMERGENCY SIGNAL (R10-13) sign shall be mounted adjacent to a signal face on each major street approach (see Section 2B.40). If an overhead signal face is provided, the EMERGENCY SIGNAL sign shall be mounted adjacent to the overhead signal face.**

**Option:**

An approach that only serves emergency vehicles may be provided with only one signal face.

Besides using a 200 mm (8 in) diameter signal indication, other appropriate means to reduce the flashing yellow light output may be used.

**Section 4F.03 Operation of Emergency-Vehicle Traffic Control Signals****Standard:**

**Right-of-way for emergency vehicles at signalized locations operating in the steady (stop-and-go) mode shall be obtained as specified in Section 4D.13.**

**As a minimum, the signal indications, sequence, and manner of operation of an emergency-vehicle traffic control signal installed at a mid-block location shall be as follows:**

- A. The signal indication, between emergency-vehicle actuations, shall be either steady green or flashing yellow. If the flashing yellow signal indication is used instead of the steady green signal indication, it shall be displayed in the normal position of the steady green signal indication, while the red and steady yellow signal indications shall be displayed in their normal positions.**
- B. When an emergency vehicle actuation occurs, a steady yellow change interval followed by a steady red interval shall be displayed to traffic on the major street.**
- C. A yellow change interval is not required following the green interval for the**



**emergency-vehicle driveway.**

**Emergency-vehicle traffic control signals located at intersections shall either be operated in the flashing mode between emergency-vehicle actuations (see Section 4D.12) or be semi- or fully traffic-actuated, to accommodate normal vehicular and pedestrian traffic on the streets.**

**Warning beacons, if used with an emergency-vehicle traffic control signal, shall be flashed only:**

- A. For an appropriate time in advance of and during the steady yellow change interval for the major street; and**
- B. During the steady red interval for the major street.**

Guidance:

The duration of the red interval for traffic on the major street should be determined by on-site test-run time studies, but should not exceed 1.5 times the time required for the emergency vehicle to clear the path of conflicting vehicles.

Option:

An emergency-vehicle traffic control signal sequence may be initiated manually from a local control point such as a fire station or police headquarters or from an emergency vehicle equipped for remote operation of the signal.



## **4G. TRAFFIC CONTROL SIGNALS FOR ONE-LANE, TWO-WAY FACILITIES**

### **Section 4G.01 Application of Traffic Control Signals for One-Lane, Two-Way Facilities**

#### Support:

A traffic control signal at a narrow bridge, tunnel, or roadway section is a special signal that assigns the right-of-way for vehicles passing over a bridge or through a tunnel or roadway section that is not of sufficient width for two opposing vehicles to pass safely.

Temporary traffic control signals (see Section 4D.20) are the most frequent application of one-lane, two-way facilities.

#### Guidance:

Sight distance across or through the one-lane, two-way facility should be considered as well as the approach speed and sight distance approaching the facility when determining whether traffic control signals should be installed.

#### Option:

At a narrow bridge, tunnel, or roadway section where a traffic control signal is not justified under the conditions of Chapter 4C, a traffic control signal may be used if gaps in opposing traffic do not permit the safe flow of traffic through the one-lane section of roadway.

### **Section 4G.02 Design of Traffic Control Signals for One-Lane, Two-Way Facilities**

#### Guidance:

The provisions of Chapter 4D shall apply to traffic control signals for one-lane, two-way facilities, except that:

- A. Durations of red clearance intervals should be adequate to clear the one-lane section of conflicting vehicles.
- B. Adequate means, such as interconnection, should be provided to prevent conflicting signal indications, such as green and green, at opposite ends of the section.

**Section 4G.03 Operation of Traffic Control Signals for One-Lane, Two-Way Facilities**

**Standard:**

**Traffic control signals at one-lane, two-way facilities shall operate in a manner consistent with traffic requirements.**

**When in the flashing mode, the signal indications shall flash red.**

**Guidance:**

Adequate time should be provided to allow traffic to clear the narrow facility before opposing traffic is allowed to move. Engineering judgment should be used to determine the proper timing for the signal.

## **CHAPTER 4H. TRAFFIC CONTROL SIGNALS FOR FREEWAY ENTRANCE RAMPS**

### **Section 4H.01 Application of Freeway Entrance Ramp Control Signals**

#### **Support:**

Ramp control signals are traffic control signals that control the flow of traffic entering the freeway facility.

Freeway entrance ramp control signals are sometimes used if controlling traffic entering the freeway could reduce the total expected delay to traffic in the freeway corridor, including freeway ramps and local streets, and if at least one of the following conditions is present:

- A. Congestion recurs on the freeway because traffic demand is in excess of the capacity, or congestion recurs or a high frequency of crashes exist at the freeway entrance because of inadequate ramp merging area. A good indicator of recurring freeway congestion is freeway operating speeds less than 80 km/h (50 mph) occurring regularly for at least a half-hour period. Freeway operating speeds less than 50 km/h (30 mph) for a half-hour period or more would indicate severe congestion.
- B. Controlling traffic entering a freeway assists in meeting local transportation system management objectives identified for freeway traffic flow, such as the following:
  - 1. Maintenance of a specific freeway level of service.
  - 2. Priority treatments with higher levels of service for mass transit and carpools.
  - 3. Redistribution of freeway access demand to other on-ramps.
- C. Predictable, sporadic congestion occurs on isolated sections of freeway because of short-period peak traffic loads from special events or from severe peak loads of recreational traffic.

#### **Guidance:**

The installation of ramp control signals should be preceded by an engineering study of the physical and traffic conditions on the highway facilities likely to be affected. The study should include the ramps and ramp connections and the surface streets that would be affected by the ramp control, as well as the freeway section concerned. Types of traffic data that should be obtained include, but are not limited to, traffic volumes, traffic crashes, freeway operating speeds, and travel time and delay on the freeway, approaches, ramps, and alternate surface routes.

Capacities and demand/capacity relationships should be determined for each freeway section. The locations and causes of capacity restrictions and those sections where demand exceeds capacity should be identified. From these and other data, estimates should be made of desirable metering rates, probable reductions in the delay of freeway traffic, likely increases in delay to ramp traffic, and the potential impact on surface streets. The study should include an evaluation of the ramp's storage capacities for vehicles delayed at the signal, the impact of queued traffic on the local street intersection, and the availability of suitable alternate surface routes having adequate capacity to accommodate any additional traffic volume.

Before installing ramp control signals, consideration should be given to their potential acceptance by the public and the requirements for enforcing ramp control, as well as alternate means of increasing the capacity, reducing the demand, or improving the characteristics of the freeway.

#### **Section 4H.02 Design of Freeway Entrance Ramp Control Signals**

##### **Standard:**

**Ramp control signals shall meet all of the standard design specifications for traffic control signals, except as noted herein:**

- A. The signal face for freeway entrance ramp control signals shall be either a two-lens signal face containing red and green signal lenses or a three-lens signal face containing red, yellow, and green signal lenses.**
- B. A minimum of two signal faces per ramp shall face entering traffic.**
- C. Ramp control signal faces need not be illuminated when not in use.**

**Ramp control signals shall be located and designed to minimize their viewing by mainline freeway traffic.**

##### **Option:**

The required signal faces, if located at the side of the ramp roadway, may be mounted such that the height above the pavement grade at the center of the ramp roadway to the bottom of the signal housing of the lowest signal face is between 1.4 m (4.5 ft) and 1.8 m (6 ft).

## CHAPTER 4I. TRAFFIC CONTROL SIGNALS FOR MOVABLE BRIDGES

### Section 4I.01 Application of Traffic Control for Movable Bridges

#### Support:

Traffic control signals for movable bridges are a special type of highway traffic signal installed at movable bridges to notify road users to stop because of a road closure rather than alternately giving the right-of-way to conflicting traffic movements. The signals are operated in coordination with the opening and closing of the movable bridge, and with the operation of movable bridge warning and resistance gates, or other devices and features used to warn, control, and stop traffic.

Movable bridge warning gates installed at movable bridges decrease the likelihood of vehicles and pedestrians passing the stop line and entering an area where potential hazards exist because of bridge operations.

A movable bridge resistance gate is sometimes used at movable bridges and located downstream of the movable bridge warning gate. A movable bridge resistance gate may provide a physical deterrent to road users when placed in the appropriate position. The movable bridge resistance gates are considered a design feature and not a traffic control device; requirements for them are contained in the "Standard Specifications for Movable Highway Bridges" (see Page i for AASHTO's address).

#### Standard:

**Traffic control at movable bridges shall include both signals and gates, except that:**

- A. Neither is required if other traffic control devices or measures considered appropriate are used under either of the following conditions:**
  - 1. On low-volume roads (roads of less than 400 vehicles average daily traffic); or**
  - 2. At manually operated bridges if electric power is not available.**
- B. Only signals are required in urban areas if intersecting streets or driveways make gates ineffective.**
- C. Only movable bridge warning gates are required if a traffic control signal that is controlled as part of the bridge operations exists within 150 m (500 ft) of the movable bridge resistance gates and no intervening traffic entrances exist.**

**Section 4I.02 Design and Location of Movable Bridge Signals and Gates****Standard:**

The signal heads and mountings of movable bridge signals shall follow the provisions of Chapter 4D except as noted in this Section.

Since movable bridge operations cover a variable range of time periods between openings, the signal faces shall be one of the following types:

- A. Three-section signal faces with red, yellow, and green signal lenses, generally to be used if movable bridge operation is quite frequent; and
- B. Two one-section signal faces with red signal lenses in a vertical array separated by a STOP HERE ON RED sign (R10-6) (see Section 2B.40).

Regardless of which signal type is selected, two signal faces shall be provided for each approach to the movable span.

If physical conditions prevent a road user from having a continuous view of at least two signal indications for the distance specified in Table 4D-1 in Section 4D.15, an auxiliary device (either a supplemental signal face or the mandatory DRAWBRIDGE AHEAD warning sign to which has been added a warning beacon that is interconnected with the movable bridge controller unit) shall be provided in advance of movable bridge signals and gates.

A DRAWBRIDGE AHEAD warning sign shall be used in advance of movable bridge signals and gates to give warning to road users, except in urban conditions where such signing would not be practical.

Movable bridge warning gates, if used, shall extend at least across the full width of the approach lanes if movable bridge resistance gates are used. On divided highways in which the roadways are separated by a barrier median, movable bridge warning gates, if used, shall extend across all roadway lanes approaching the span openings. Except as indicated below, wherever practical, movable bridge warning gates shall be located 30 m (100 ft) or more from the movable bridge resistance gates or, if movable bridge resistance gates are not used, 30 m (100 ft) or more from the movable span.

Movable bridge warning gates shall be at least standard railroad size, striped with 400 mm (16 in) alternate diagonal, fully reflectorized red and white stripes. Flashing red lights in accordance with the Standards for those on railroad gates (see Section 8D.04) shall be included on the gate arm and they shall only be operated if the gate is closed or in the process of being opened or closed. In the horizontal position, the top of the gate shall be approximately 1.25 m (4 ft) above the pavement.



**If two sets of gates (both a warning and a resistance gate) are used on long bridges or causeways for a single direction, traffic signals need not accompany the resistance gate nearest the span opening, but there shall be flashing red lights on the movable bridge warning gate.**

Guidance:

Signal faces with 300 mm (12 in) diameter signal lenses should be used for movable bridge signals.

Insofar as practical, the height and lateral placement of signal faces should conform to the requirements for other traffic control signals in accordance with Section 4D.15. They should be located not more than 15 m (50 ft) in advance of the movable bridge warning gate.

Movable bridge warning gates should be of lightweight construction. In its normal upright position, the gate arm should provide adequate lateral clearance. If the movable bridge is close to a highway-rail grade crossing and traffic might possibly be stopped on the crossing as a result of the bridge opening, a traffic control device should notify the road users to not stop on the railroad tracks.

If movable bridge resistance gates are not used on undivided highways, movable bridge warning gates, if used, should extend across the full width of the roadway.

On bridges or causeways that cross a long reach of water and that might be hit by large marine vessels, within the limits of practicality, traffic should not be halted on a section of the bridge or causeway that is subject to impact.

In cases where it is not practical to halt traffic on a span that is completely safe from impact, traffic should be halted at least one span from the opening. If traffic is halted by signals and gates more than 100 m (330 ft) from the movable bridge warning gates (or from the span opening if movable bridge warning gates are not used), a second set of gates should be installed approximately 30 m (100 ft) from the gate or span opening.

Option:

Movable bridge signals may be supplemented with audible warning devices to provide additional warning to drivers and pedestrians.

If prevailing approach speeds are 40 km/h (25 mph) or less, signal heads with 200 mm (8 in) diameter lenses may be used.

The movable bridge resistance gates may be delineated, if practical, in a manner similar to the movable bridge warning gate.

The DRAWBRIDGE AHEAD sign may be supplemented by a warning beacon (see Section 4K.03).

A single full-width gate or two half-width gates may be used.

Support:

Traffic signals need not accompany the gates nearest the span opening.

The locations of movable bridge signals and gates are determined by the location of the movable bridge resistance gate (if used) rather than by the location of the movable spans. The movable bridge resistance gates for high-speed highways are preferably located 15 m (50 ft) or more from the span opening except for bascule and lift bridges, where they are often attached to, or are a part of, the structure.

### **Section 4I.03 Operation of Movable Bridge Signals and Gates**

**Standard:**

**Traffic control devices at movable bridges shall be coordinated with the movable spans, so that the signals, gates, and movable spans are controlled by the bridge tender through an interlocked control.**

**If the three-section type of signal face is used, the green signal indication shall be illuminated at all times between bridge openings, except that if the bridge is not expected to open during continuous periods in excess of 5 hours, a flashing yellow signal indication may be used. The signal shall display a steady red signal indication when traffic is required to stop. The duration of the yellow change interval between the display of the steady green and steady red signal indications, or flashing yellow and steady red signal indications, shall be predetermined.**

**If the vertical array of red signal lenses is the type of signal face selected, the red signal lenses shall flash alternately only when traffic is required to stop.**

Guidance:

The duration of the yellow change interval should have a range from 3 to 6 seconds.

Signals on adjacent streets and highways should be interconnected with the drawbridge control if indicated by engineering judgment.

## CHAPTER 4J. LANE-USE CONTROL SIGNALS

### Section 4J.01 Application of Lane-Use Control Signals

#### Support:

Lane-use control signals are special overhead signals that permit or prohibit the use of specific lanes of a street or highway or that indicate the impending prohibition of their use. Lane-use control signals are distinguished by placement of special signal faces over a certain lane or lanes of the roadway and by their distinctive shapes and symbols. Supplementary signs are sometimes used to explain their meaning and intent.

Lane-use control signals are most commonly used for reversible-lane control, but are also used in nonreversible freeway lane applications.

#### Guidance:

A traffic engineering study should be conducted to determine whether a reversible-lane operation can be controlled satisfactorily by static signs (see Section 2B.23) or whether lane-use control signals are necessary. Lane-use control signals should be used to control reversible-lane operations if any of the following conditions are present:

- A. More than one lane is reversed in direction;
- B. Two-way or one-way left turns are allowed during peak-period reversible operations, but those turns are from a different lane than used during off-peak periods;
- C. Other unusual or complex operations are included in the reversible-lane pattern;
- D. Demonstrated crash experience occurring with reversible-lane operation controlled by static signs that can be corrected by using lane-use control signals at the times of transition between peak and off-peak patterns; and/or
- E. An engineering study indicates that safer and more efficient operation of a reversible-lane system would be provided by lane-use control signals.

#### Option:

Lane-use control signals also may be used for reversible-lane operations at toll booths. They may also be used if there is no intent or need to reverse lanes, including:

- A. On a freeway, if it is desired to keep traffic out of certain lanes at certain hours to facilitate the merging of traffic from a ramp or other freeway;
- B. On a freeway, near its terminus, to indicate a lane that ends; and
- C. On a freeway or long bridge, to indicate that a lane may be temporarily blocked by a crash, breakdown, construction or maintenance activities, and so forth.

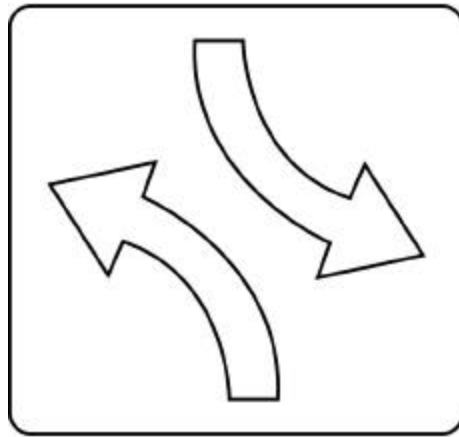
#### **Section 4J.02 Meaning of Lane-Use Control Signal Indications**

##### **Standard:**

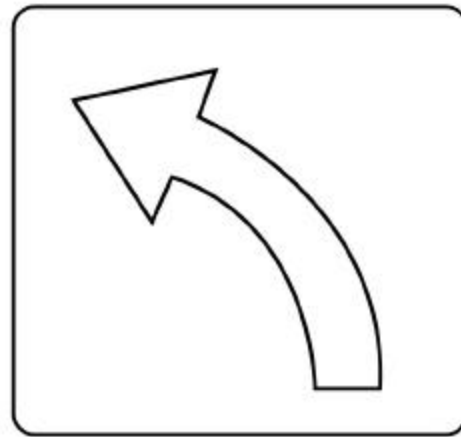
**The meanings of lane-use control signal indications are as follows:**

- A. A steady **DOWNWARD GREEN ARROW** signal indication shall mean that a road user is permitted to drive in the lane over which the arrow signal indication is located.
- B. A steady **YELLOW X** signal indication shall mean that a road user is to prepare to vacate, in a safe manner, the lane over which the signal indication is located because a lane control change is being made to a steady **RED X** signal indication.
- C. A steady **WHITE TWO-WAY LEFT-TURN ARROW** signal indication (see Figure 4J-1) shall mean that a road user is permitted to use a lane over which the signal indication is located for a left turn, but not for through travel, with the understanding that common use of the lane by oncoming road users for left turns is also permitted.
- D. A steady **WHITE ONE WAY LEFT-TURN ARROW** signal indication (see Figure 4J-1) shall mean that a road user is permitted to use a lane over which the signal indication is located for a left turn (without opposing turns in the same lane), but not for through travel.
- E. A steady **RED X** signal indication shall mean that a road user is not permitted to use the lane over which the signal indication is located and that this signal indication shall modify accordingly the meaning of all other traffic controls present. The road user shall obey all other traffic controls and follow normal safe driving practices.

**Pavement markings (see Section 3B.03) shall be used in conjunction with reversible-lane control signals.**

**Figure 4J-1. Left-Turn Lane-Use Control Signals**

Two-way left-turn arrow



One-way left-turn arrow

White arrows on opaque background  
 750 x 750 mm  
 (30 x 30 in)

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### Section 4J.03 Design of Lane-Use Control Signals

#### Standard:

All lane-use control signal indications shall be in units with rectangular signal faces and shall have opaque backgrounds. Nominal minimum height and width of each **DOWNWARD GREEN ARROW**, **YELLOW X**, and **RED X** signal face shall be 450 mm (18 in) for typical applications. The **WHITE TWO-WAY LEFT-TURN ARROW** and **WHITE ONE WAY LEFT-TURN ARROW** signal faces shall have a nominal minimum height and width of 750 mm (30 in).

Each lane to be reversed or closed shall have signal faces with a **DOWNWARD GREEN ARROW** and a **RED X** symbol.

Each reversible lane that also operates as a two-way or one-way left-turn lane during certain periods shall have signal faces that also include the applicable **WHITE TWO-WAY LEFT-TURN ARROW** or **WHITE ONE WAY LEFT-TURN ARROW** symbol.

Each nonreversible lane immediately adjacent to a reversible lane shall have signal indications that display a **DOWNWARD GREEN ARROW** to traffic traveling in the permitted direction and a **RED X** to traffic traveling in the opposite direction.

**If in separate signal sections, the relative positions, from left to right, of the signal indications shall be RED X, YELLOW X, DOWNWARD GREEN ARROW, WHITE TWO-WAY LEFT-TURN ARROW, WHITE ONE WAY LEFT-TURN ARROW.**

**The color of lane-use control signal indications shall be clearly visible for 700 m (2,300 ft) at all times under normal atmospheric conditions, unless otherwise physically obstructed.**

**Lane-use control signal faces shall be located approximately over the center of the lane controlled.**

**If the area to be controlled is more than 700 m (2,300 ft) in length, or if the vertical or horizontal alignment is curved, intermediate lane-use control signal faces shall be located over each controlled lane at frequent intervals. This location shall be such that road users will at all times be able to see at least one signal indication and preferably two along the roadway, and will have a definite indication of the lanes specifically reserved for their use.**

**All lane-use control signal faces shall be located in a straight line across the roadway approximately at right angles to the roadway alignment.**

**The bottom of the signal housing of any lane-use control signal face shall be at least 4.6 m (15 ft) but not more than 5.8 m (19 ft) above the pavement grade.**

**On roadways having intersections controlled by traffic control signals, the lane-use control signal face shall be located sufficiently far in advance of or beyond such traffic control signals to prevent them from being misconstrued as traffic control signals.**

Option:

In areas with minimal visual clutter and with speeds of 70 km/h (45 mph) or less, lane-use control signal faces with nominal height and width of 300 mm (12 in) may be used for the DOWNWARD GREEN ARROW, YELLOW X, and RED X signal faces.

Other sizes of lane-use control signal faces larger than 450 mm (18 in) with message recognition distances appropriate to signal spacing may be used for the DOWNWARD GREEN ARROW, YELLOW X, and RED X signal faces.

Signal faces with a YELLOW X symbol on an opaque background may be used as described in Section 4J.04.

Nonreversible lanes not immediately adjacent to a reversible lane on any street so controlled may also be provided with signal indications that display a DOWNWARD GREEN ARROW to traffic traveling in the permitted direction and a RED X to traffic traveling in the opposite direction.

The signal indications provided for each lane may be in separate signal sections or may be superimposed in the same signal section.

#### **Section 4J.04 Operation of Lane-Use Control Signals**

##### **Standard:**

**All lane-use control signals shall be coordinated so that all the signal indications along the controlled section of roadway are operated uniformly and consistently. The lane-use control signal system shall be designed to reliably guard against showing any prohibited combination of signal indications to any traffic at any point in the controlled lanes.**

**For reversible-lane control signals, the following combination of signal indications shall not be shown simultaneously over the same lane to both directions of travel:**

- A. DOWNWARD GREEN ARROW in both directions;**
- B. YELLOW X in both directions;**
- C. WHITE ONE WAY LEFT-TURN ARROW in both directions;**
- D. DOWNWARD GREEN ARROW in one direction and YELLOW X in the other direction;**
- E. WHITE TWO-WAY LEFT-TURN ARROW or WHITE ONE WAY LEFT-TURN ARROW in one direction and DOWNWARD GREEN ARROW in the other direction;**
- F. WHITE TWO-WAY LEFT-TURN ARROW in one direction and WHITE ONE WAY LEFT-TURN ARROW in the other direction; and**
- G. WHITE ONE WAY LEFT-TURN ARROW in one direction and YELLOW X in the other direction.**

**A moving condition in one direction shall be terminated either by the immediate display of a RED X signal indication or by a YELLOW X signal indication followed by a RED X signal indication. In either case, the duration of the RED X signal indication shall be sufficient to allow clearance of the lane before any moving condition is allowed in the opposing direction.**

**Whenever a DOWNWARD GREEN ARROW signal indication is changed to a WHITE TWO-WAY LEFT-TURN ARROW signal indication, the RED X signal**

**indication shall continue to be displayed to the opposite direction of travel for an appropriate duration to allow traffic time to vacate the lane being converted to a two-way left-turn lane.**

**If an automatic control system is used, a manual control to override the automatic control shall be provided.**

Guidance:

The type of control provided for reversible-lane operation should be such as to permit either automatic or manual operation of the lane-use control signals.

**Standard:**

**If used, lane-use control signals shall be operated continuously, except that lane-use control signals that are used only for special events or other infrequent occurrences and lane-use control signals on nonreversible freeway lanes may be darkened when not in operation. The change from normal operation to nonoperation shall occur only when the lane-use control signals display signal indications that are appropriate for the lane use that applies when the signals are not operated. The lane-use control signals shall display signal indications that are appropriate for the existing lane use when changed from nonoperation to normal operations. Also, traffic control devices shall clearly indicate the proper lane use when the lane control signals are not in operation.**

Support:

Section 2B.23 contains additional information concerning considerations involving left-turn prohibitions in conjunction with reversible-lane operations.



## CHAPTER 4K. FLASHING BEACONS

### Section 4K.01 General Design and Operation of Flashing Beacons

#### Support:

A Flashing Beacon is a highway traffic signal with one or more signal sections that operates in a flashing mode. It can provide traffic control when used as an intersection control beacon or warning in alternative uses.

#### Standard:

**Flashing Beacon units and their mountings shall follow the provisions of Chapter 4D, except as specified herein.**

**Beacons shall be flashed at a rate of not less than 50 nor more than 60 times per minute. The illuminated period of each flash shall not be less than one-half and not more than two-thirds of the total cycle.**

#### Guidance:

If used to supplement a warning or regulatory sign, the edge of the beacon signal housing should normally be located no closer than 300 mm (12 in) outside of the nearest edge of the sign.

#### Option:

An automatic dimming device may be used to reduce the brilliance of flashing yellow signal indications during night operation.

### Section 4K.02 Intersection Control Beacon

#### Standard:

**An Intersection Control Beacon shall consist of one or more signal faces directed toward each approach to an intersection. Each signal face shall consist of one or more signal sections of a standard traffic signal face, with flashing CIRCULAR YELLOW or CIRCULAR RED signal indications in each signal face. They shall be installed and used only at an intersection to control two or more directions of travel.**

**Application of Intersection Control Beacon signal indications shall be limited to the following:**

**A. Yellow on one route (normally the major street) and red for the remaining approaches; and**

**B. Red for all approaches (if the warrant for a multiway stop is satisfied).**

**Flashing yellow signal indications shall not face conflicting vehicular approaches.**

**A STOP sign shall be used on approaches to which a flashing red signal indication is shown on an Intersection Control Beacon (see Section 2B.04).**

Guidance:

An Intersection Control Beacon should not be mounted on a pedestal in the roadway unless the pedestal is within the confines of a traffic or pedestrian island.

Option:

Supplemental signal indications may be used on one or more approaches in order to provide adequate visibility to approaching road users.

Intersection Control Beacons may be used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of a special need.

An Intersection Control Beacon is generally located over the center of an intersection; however, it may be used at other suitable locations.

### **Section 4K.03 Warning Beacon**

Support:

Typical applications of Warning Beacons include the following:

- A. At obstructions in or immediately adjacent to the roadway;
- B. As supplement emphasis to regulatory or warning signs;
- C. As emphasis for midblock crosswalks;
- D. On approaches to intersections where additional warning is required, or where special conditions exist; and
- E. As supplements to regulatory signs, except STOP, YIELD, DO NOT ENTER, and SPEED LIMIT signs.

**Standard:**

**A Warning Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR YELLOW signal indication in each signal section.**

**A Warning Beacon shall be used only to supplement an appropriate warning or regulatory sign or marker. The beacon shall not be included within the border of the sign except for SCHOOL SPEED LIMIT sign beacons.**

**Warning Beacons, if used at intersections, shall not face conflicting vehicular approaches.**

**If a Warning Beacon is suspended over the roadway, the clearance above the pavement shall be at least 4.6 m (15 ft) but not more than 5.8 m (19 ft).**

**Guidance:**

The condition or regulation justifying Warning Beacons should largely govern their location with respect to the roadway.

If an obstruction is in or adjacent to the roadway, illumination of the lower portion or the beginning of the obstruction or a sign on or in front of the obstruction, in addition to the beacon, should be considered.

Warning Beacons should be operated only during those hours when the condition or regulation exists.

**Option:**

If Warning Beacons have more than one signal section, they may be flashed either alternately or simultaneously.

A flashing yellow beacon interconnected with a traffic signal controller assembly may be used with a traffic signal warning sign (see Section 2C.26).

**Section 4K.04 Speed Limit Sign Beacon****Standard:**

**A Speed Limit Sign Beacon shall consist of one or more signal sections of a standard traffic control signal face, with a flashing CIRCULAR YELLOW signal indication in each signal section. The signal lenses shall have a nominal diameter of not less than 200 mm (8 in). If two lenses are used, they shall be vertically aligned, except that they may be horizontally aligned if the Speed Limit (R2-1) sign is longer horizontally than vertically. If two lenses are used, they shall be alternately flashed.**

**Option:**

A Speed Limit Sign Beacon may be used with a fixed or variable Speed Limit sign. If applicable, a flashing Speed Limit Sign Beacon (with an appropriate accompanying sign) may be used to indicate that the speed limit shown is in effect.

**Support:**

Section 7B.11 contains additional Options for the use of Speed Limit Sign Beacons with SCHOOL SPEED LIMIT signs.

**Section 4K.05 Stop Beacon****Standard:**

**A Stop Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR RED signal indication in each signal section. If two horizontally aligned signal lenses are used, they shall be flashed simultaneously to avoid being confused with a highway-rail grade crossing flashing-light signals. If two vertically aligned signal lenses are used, they shall be flashed alternately.**

**The bottom of the signal housing of a Stop Beacon shall be not less than 300 mm (12 in) nor more than 600 mm (24 in) above the top of a STOP sign (see Section 2B.04).**

## CHAPTER 4L. IN-ROADWAY LIGHTS

### Section 4L.01 Application of In-Roadway Lights

Support:

In-Roadway Lights are special types of highway traffic signals installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent and might require the road users to slow down and/or come to a stop. This includes, but is not necessarily limited to, situations warning of marked school crosswalks, marked midblock crosswalks, marked crosswalks on uncontrolled approaches, and other roadway situations involving pedestrian crossings.

#### **Standard:**

**If used, In-Roadway Lights shall not exceed a height of 19 mm (0.75 in) above the roadway surface.**

Option:

The flash rate for In-Roadway Lights may be different from the flash rate of standard beacons.

### Section 4L.02 In-Roadway Warning Lights at Crosswalks

#### **Standard:**

**If used, In-Roadway Warning Lights at crosswalks shall be installed only at marked crosswalks with applicable warning signs. They shall not be used at crosswalks controlled by YIELD signs, STOP signs, or traffic control signals.**

**If used, In-Roadway Warning Lights at crosswalks shall be installed along both sides of the crosswalk and shall span its entire length.**

**If used, In-Roadway Warning Lights at crosswalks shall initiate operation based on pedestrian actuation and shall cease operation at a predetermined time after the pedestrian actuation or, with passive detection, after the pedestrian clears the crosswalk.**

**If used, In-Roadway Warning Lights at crosswalks shall display a flashing yellow signal indication when actuated. The flash rate for In-Roadway Warning Lights at crosswalks shall be at least 50, but not more than 60, flash periods per minute. The flash rate shall not be between 5 and 30 flashes per second to avoid frequencies that might cause seizures.**

**If used on one-lane, one-way roadways, a minimum of two In-Roadway Warning Lights shall be installed on the approach side of the crosswalk. If used on two-lane roadways, a minimum of three In-Roadway Warning Lights shall be installed along both sides of the crosswalk. If used on roadways with more than two lanes, a minimum of one In-Roadway Warning Light per lane shall be installed along both sides of the crosswalk.**

**If used, In-Roadway Warning Lights shall be installed in the area between the outside edge of the crosswalk line and 3 m (10 ft) from the outside edge of the crosswalk. In-Roadway Warning Lights shall face away from the crosswalk if unidirectional, or shall face away from and across the crosswalk if bidirectional.**

Guidance:

If used, the period of operation of the In-Roadway Warning Lights following each actuation should be sufficient to allow a pedestrian crossing in the crosswalk to leave the curb or shoulder and travel at a normal walking speed of 1.2 m (4 ft) per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait. Where pedestrians who walk slower than normal, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 1.2 m (4 ft) per second should be considered in determining the period of operation. Where the period of operation is sufficient only for crossing from a curb or shoulder to a median of sufficient width for pedestrians to wait, additional measures should be considered, such as median-mounted pedestrian actuators.

If used, In-Roadway Warning Lights should be installed in the center of each travel lane, at the centerline of the roadway, at each edge of the roadway or parking lanes, or at other suitable locations away from the normal tire track paths.

The location of the In-Roadway Warning Lights within the lanes should be based on engineering judgment.

Option:

In-Roadway Warning Lights at crosswalks may use pedestrian detectors to determine the duration of the operation instead of ceasing operation after a predetermined time.

On one-way streets, In-Roadway Warning Lights may be omitted on the departure side of the crosswalk.

Based on engineering judgment, the In-Roadway Warning Lights on the departure side of the crosswalk on the left side of a median may be omitted.

Unidirectional In-Roadway Warning Lights installed at crosswalk locations may have an optional, additional yellow light indication in each unit that is visible to pedestrians in the crosswalk. These lights may flash with and at the same flash rate as the light module in which each is installed. The purpose of these optional additional lights is to indicate to pedestrians in the crosswalk that the In-Roadway Warning Lights are in fact flashing as they cross the street.