analysis indicates otherwise.

For design or operation speeds that are less than 35 mph, shielding is not typically required, unless an individual site analysis indicates otherwise. Designers are required to perform an individual sight analysis for speeds less than 35 mph.

Individual site analysis includes:

- Review of existing crash data
- Review of the alignment and cross sectional elements near installation
- Traffic volumes
- Character of traffic
- Impact of installing barrier systems, (e.g. grading required, purchase of R/W, drainage needs…)
- Consequences of not installing barrier system, (e.g. Could the sign fall onto the road or pedestrians, if sign does not fall but is taken out of service, what is the impact to the road network?)

Some examples that would tend to lead designers to install barrier would be:

- Segment of roadway has run-off-road (ROR) flag in metamanager.
- Substandard alignment or cross sectional elements exist near the proposed installation.
- Installation is near or in a weave, merge or diverge section of roadway.
- Roadway violates driver expectation (e.g. hidden curves, entrance /exit ramps on left side of roadway).
- Installation is in areas where ROR crashes are more likely to occur (e.g. tapers, outside of curves…).
- High AADT in area of installation (i.e. High AADT increases the probability of a vehicle leaving the roadway).
- Majority of traffic is unfamiliar with the roadway.
- Impact to roadway and users if the overhead sign support was damaged or destroyed.

Some examples that would lead a designer to not install barrier are:

- Not possible to install barrier according to standards (e.g. LON would cause the closure of side streets)
- Accident history does not indicate a problem with ROR accidents.
- No substandard features are present
- Installation is on tangent section.
- Low AADT

Document decisions to provide or not to provide barrier or crash cushions at a given location. Provide barrier systems with appropriate Length of Need (LON), adequate deflection distance from barrier to front face of sign bridge support, appropriate end terminals and grading. Document why it is not possible to provide adequate LON, deflection distance, end terminals, and grading. Documentation is to include what other alternatives were reviewed, and why a particular alternative was selected.

See FDM 11-15-1, and FDM 11-20-1 for guidance on clear zones. See FDM 11-45-1 for guidance on barrier systems.

LIST OF ATTACHMENTS

Attachment 20.1	Sign Support Base Design Process
Attachment 20.2	Full Span Overhead Sign Support Base Adequacy Check

FDM 11-55-25 Ramp Gates

June 19, 2013

25.1 Background

WisDOT uses closure gates to restrict freeway access at key entrance ramps throughout Wisconsin. The ramp closure gate design is based on the NCHRP 350 crash tested gate, the details of which were originally developed by the State of Wyoming. This gate can be installed within the clear zone because the base is designed as a breakaway component and the above ground components are designed to rotate over the vehicle during an impact.

25.2 Deployment and General Considerations

The situations in which closure methods are to be applied are summarized below:

- *Barricades* - Type III barricades are recommended for deployment on entrance ramps along interstate corridors with an average annual daily traffic (AADT) along the mainline of less than 45,000. These barricades are to be safely stored within the freeway interchange when practical. Ramp closure barricade rack(s) (refer to STSP 662-015) shall be included for storing the barricades.
- *Ramp Closure Gates* - Ramp closure gates consistent with the gates currently used in Racine and Kenosha Counties are recommended for deployment on freeway entrance ramps along interstate corridors with mainline AADT of more than 35,000. These gates are manually operated.

The overlap in AADT ranges is intended to allow for flexibility in selecting which closure method to implement at a particular location. Deployment recommendations are based on AADT; however, other factors must be evaluated before prescribing the gate treatment.

Other Deciding Factors:

- *Site-Specific Conditions* - Site-specific conditions need to be considered when selecting a closure method. Some issues to consider include availability of a safe barricade storage location, expected personnel availability during a road closure event, crash rates in the area, and expected frequency of use. Also, some locations may require a combination of gates and barricades. For example, at signalized intersections a gate may be used to close the entrance of the ramp and barricades may be used to close left turn lanes that approach the ramp. In addition, closure devices must be placed in locations that do not trap vehicles. Engineering judgment must be exercised when selecting a closure method.
- *Corridor Consistency* - In some locations the AADT guidelines may not be followed in order to select a closure method that maintains consistency within a corridor.
- *Barricade Storage* - Barricades should be pre-positioned on-site when practical. Consideration must be given to placement outside of the clear zone, right of way availability, site topography, snow storage needs, and locations that do not obstruct sight lines. Steps should also be taken to limit weathering of the barricades' reflective sheeting.
- *Maintenance* - A maintenance plan must be followed to inspect barricades and ramp closure gates to ensure proper functionality. Barricades should be inspected a minimum of once per year, prior to the winter driving season. Special attention should be given to the condition of barricade stands and retro-reflective barricade/sign sheeting. Ramp closure gates and associated signing should be inspected a minimum of twice per year, prior to and after the winter driving season. Maintenance should follow the procedures outlined in the *Wisconsin Ramp Gates Maintenance and Inspection* graphic (refer to Attachment 25.1). A maintenance log for ramp closure gates should be kept on site inside the solar or hardwired gate cabinet.

Additional Considerations:

- *System to System Interchanges* - System to system interchanges should be closed with multiple devices brought to the site in accordance with procedures outlined in the MUTCD. Drop down gates and stored on-site barricades are generally not feasible to close system to system interchanges because of the higher vehicle speeds and resulting roadway geometries, both of which require greater closure visibility than a gate or small number of barricades can provide.
- *Roundabouts* - Roundabouts are generally amenable to closure with gates or barricades. However, each location is unique; refer to the Gate and Barricade Research Findings and Recommendations report for further discussion.
- *Signage* - Properly placed signs are an important tool in notifying the public of closures. Flip down signs should be installed in conjunction with drop down gates. For especially high volume areas, these signs could be augmented with active warning flashers to be made more effective. Refer to the "Other Design Considerations" section for additional guidance.

25.3 Gate Placement

Placing gates is a complex design process that must consider many, often competing, factors. These factors are listed below in relative order of importance, and are discussed in more detail in the remainder of this section.

- Grading
- Curb and Gutter
- Gate Knockdowns
- Vehicle Trapping
- Single vs. Multiple Gates
- Adjacent Roadway Features

- Pedestrians
- Sightlines and Driver Reaction Time
- Control Boxes and Power Supplies

25.3.1 Grading

Breakaway designs require the vehicle to properly engage the pole assembly. Proper engagement is dependent on the vehicle's bumper being close to its normal position during impact, and the mounting hardware/base being properly traversable. Place gates in locations that adhere to the following guidance:

Approach Grading:

Provide grading that is 10:1 or flatter within the approach grading area (refer to Figure 25.1).

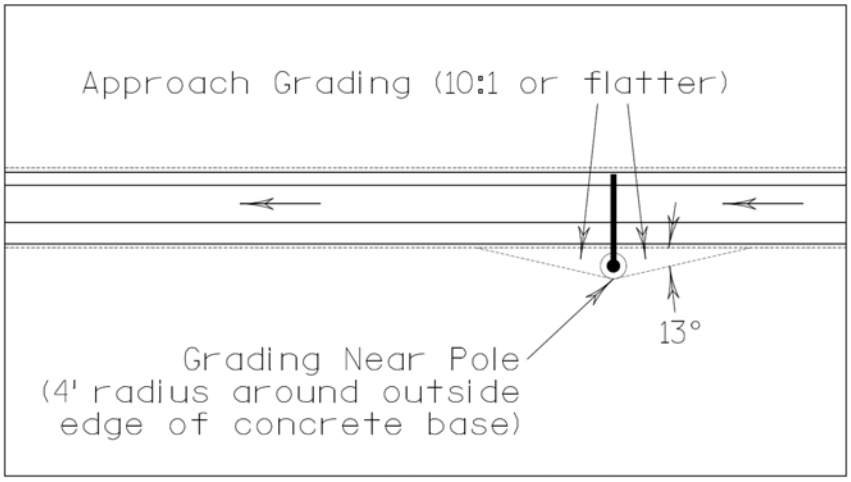

Figure 25.1 Horizontal Grading at Ramp Gate

Grading less than 10:1 may not allow for proper activation of the breakaway features of the pole or may cause the pole to contact the roof of the vehicle after initial impact. Figure 25.2 shows failure to properly break away when a vehicle did not engage a pole at the correct height.

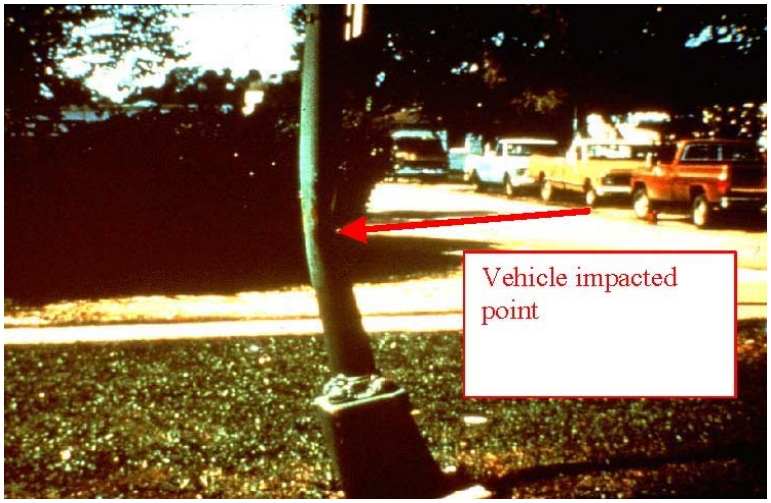

Figure 25.2 Improper Grading Causing Pole Not Breakaway [1]

Vertical Grading at Pole:

For a vehicle to effectively traverse the pole mounting hardware or concrete footing, the stub height of the gate's breakaway support is required to be less than 4" on a 5-foot chord (see Figure 25.3). If the stub height is greater than 4" on a 5-foot chord, a vehicle may decelerate too rapidly or be tripped by the stub. Provide 10:1 or flatter grades near the pole to make sure the vehicle does not snag on the stub or concrete footing.

[1] NHI Roadside Design Presentation, 2009

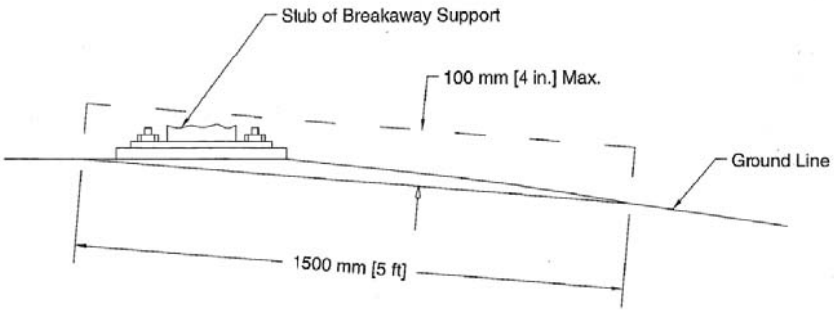

Figure 25.3 Grading Profile [2]

Figure 25.4 shows an installation where the concrete footings for a breakaway road sign are too far out of the ground, resulting in a roadside hazard even though the sign has breakaway hardware.

Figure 25.4 Improperly Installed Concrete Footing [3]

25.3.2 Curb and Gutter

After impact with a 6" high barrier curb, it is difficult to predict the vertical trajectory of a vehicle's bumper. Thus, impact with a curb increases the probability that a vehicle will not engage a ramp closure gate correctly. Crash testing has indicated that a distance of 8' is needed from the flow line of a curb and gutter to the face of rail so that a vehicle properly engages beam guard [4]. This crash testing serves as a basis for gate placement guidance in the presence of curb and gutter. In the area of approach grading shown in Figure 25.1, ensure the following conditions are met:

- For operating speeds ≥ 35 MPH - three options are recommended:
  - Place gate 8' from the flow line of the ramp curb and gutter (see Figure 25.5)
  - Remove curb and replace with mountable curb less than 2" high (driveway entrance curb, per SDD 8d1, less than 2" high is exempt from the 8' requirement)
  - Provide shielding per FDM 11-45
- For operating speeds < 35 MPH - there are no restrictions on the use of curb.

[2] AASHTO Roadside Design Guide, 2006
[3] NHI Roadside Design Presentation, 2009
[4] Zhu, L., Reid, J.D., R.K., Lechtenberg, K.A., Brenner, C.D. and Bielenberg, R.W., "Draft Performance Limits for 152-mm (6-inch) High Curb Placed in Advance of the MGS using MASH 08 Vehicles - Part 1: Vehicle-Curb Testing and LS-DYNA Analysis", TRP-03-205-08

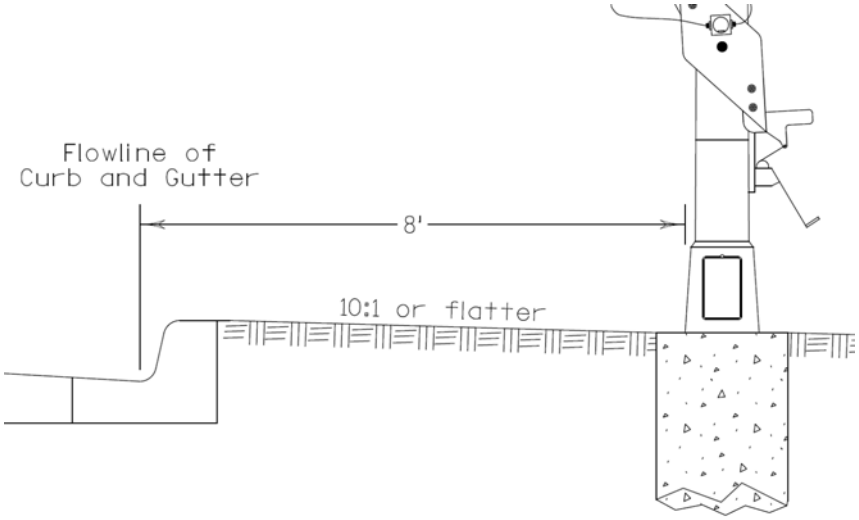

Figure 25.5 Footing

25.3.3 Gate Knockdowns

Special considerations should be made with regard to the potential for gate knockdowns from errant mainline vehicles and oversize vehicles, especially when the mainline roadway is a designated long truck route. To lessen the chance of a knockdown from an errant mainline vehicle, gates should be located outside the mainline roadway's clear zone. Locating gates at the edge of or outside mainline clear zones will also lessen the chance of an errant mainline vehicle spearing a deployed gate arm.

As previously indicated, place gates 8' from the flow line of a ramp curb and gutter (see Figure 25.5). In locations without curb and gutter, place gates 6' from the edge of ramp pavement (see Figure 25.6). Analysis of long truck turning movements indicates that gates located within the infield of a standard diamond interchange are less likely to be struck by a trailer than gates placed to the outside of the interchange. Thus, consider placing gates within the infield of a standard diamond interchange (see Figure 25.7). Make similar considerations for other types of interchanges.

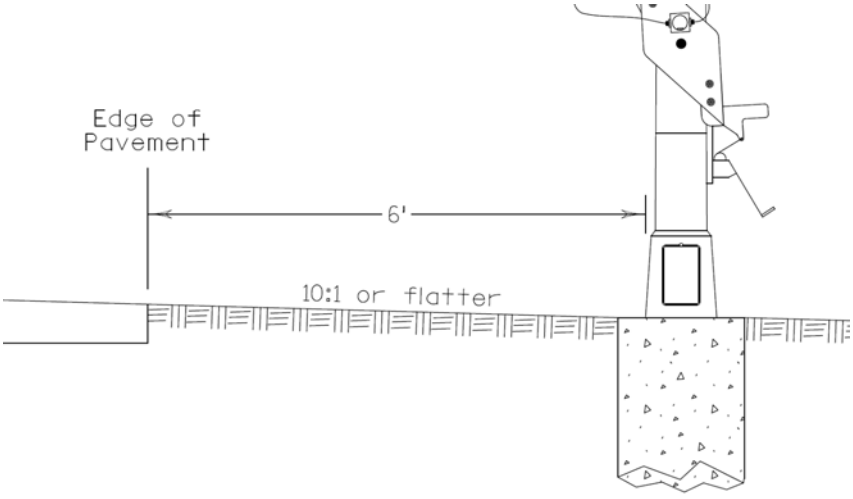

Figure 25.6 Footing

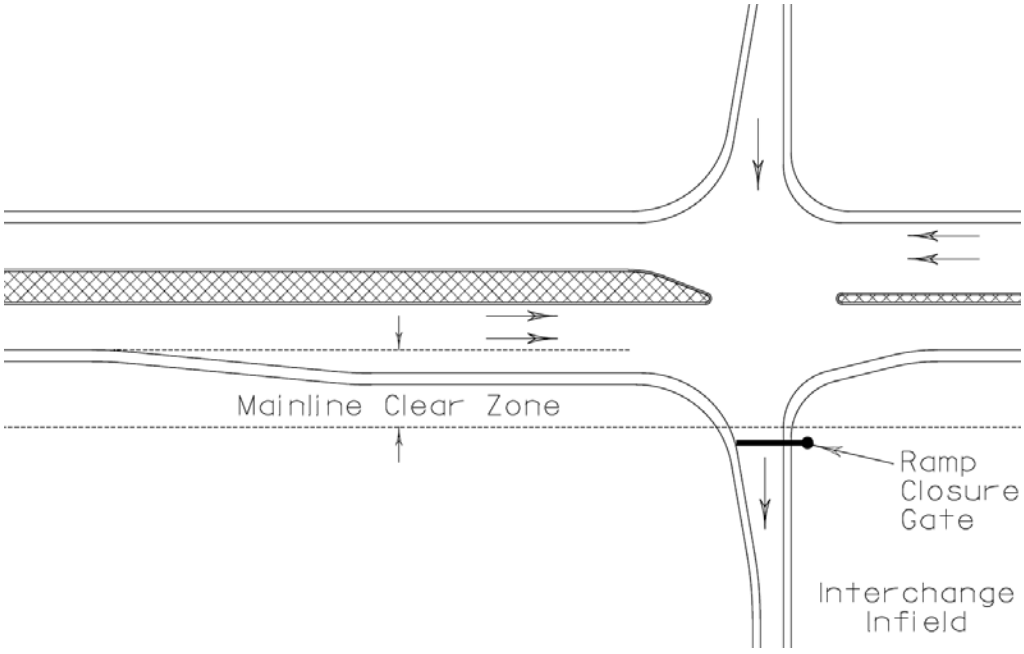

Figure 25.7 Ramp Gate Placement at Diamond Interchange (Typical)

25.3.4 Vehicle Trapping

If possible, gates should be located outside the mainline roadway's clear zone. However, gates should be placed close enough to the intersection to prevent "trapping" vehicles between the gate and the intersection. Gates located near the downstream ramp curb return (or a similar edge of pavement return for ramps without curb and gutter) will often put a gate outside the mainline roadway's clear zone while keeping the possibility of trapping vehicles to a minimum (refer to Figure 25.8).

25.3.5 Single vs. Multiple Gates

Using a single gate to close a ramp is highly desirable, as installation costs, maintenance costs and the possibility of a gate being struck all increase with the placement of multiple gates. Choose a gate arm length to cover at least the distance between the mounting pole and a point three feet from either the opposite side curb face or opposite side edge of shoulder to prevent drivers from maneuvering around the gate structure (refer to Figure 25.8). The minimum gate arm length is 24' while the maximum gate arm length is 40' (gate arm lengths are measured beginning at a point offset approximately 1.33' from the center of the mounting pole).

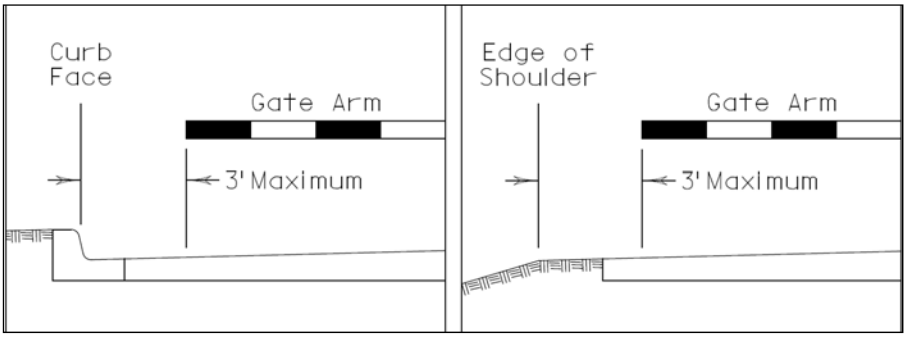

Figure 25.8 Ramp Gate Arm Lengths

25.3.6 Adjacent Roadway Features

If gates adhering to the above gate placement guidelines are in conflict with utilities, traffic signals, lighting, beam guard or other adjacent roadway features, shifting the gate location may be required. Increasing the offset from the ramp and moving a gate slightly downstream or to the opposite side of the ramp are the simplest measures for reducing conflicts with adjacent roadway features.

Always ensure that gates are not in conflict with the indications on traffic signal heads. Placing a gate along a ramp downstream from an adjacent traffic signal standard and mast arm should avoid such conflicts.

On a ramp lined with beam guard, place gates 6’ behind the face of the beam guard to allow for deflection (refer to Figure 25.9).

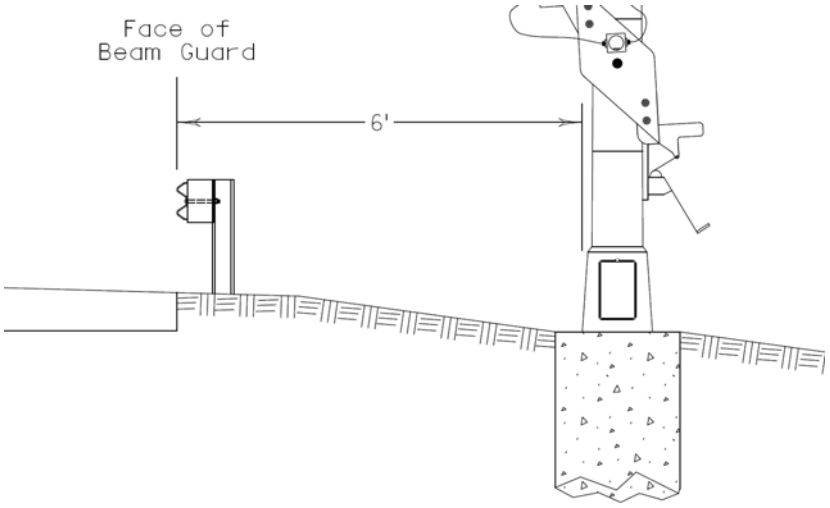

Figure 25.9 Ramp Gate Offset behind Conflict

Ensure the gate pivot assembly is installed at a proper height on the mounting pole so as to allow for free gate arm movement above the beam guard (see Figure 25.10).

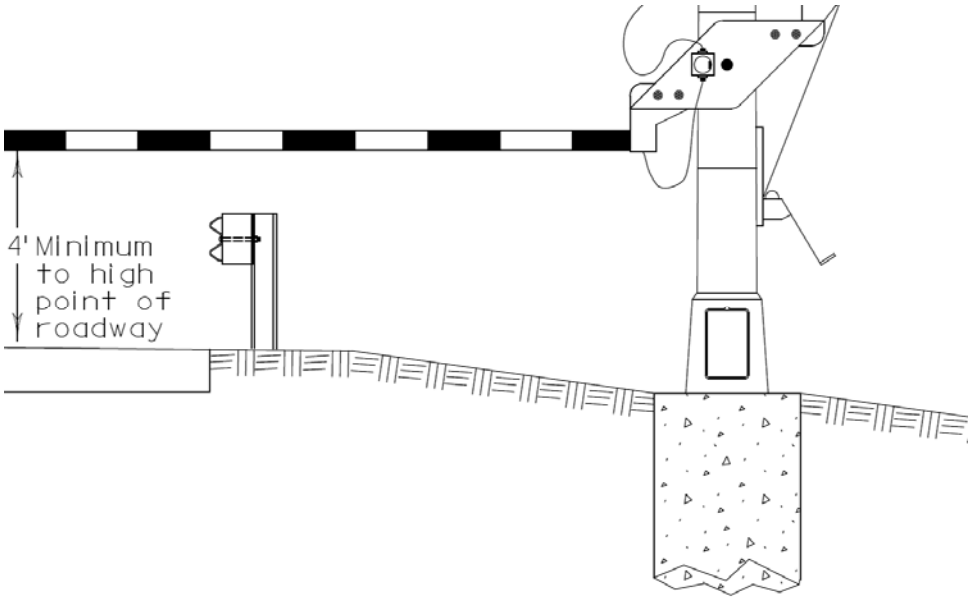

Figure 25.10 Ramp Gate Height behind Conflict

25.3.7 Pedestrian

Place gates so as to not block a pedestrian sidewalk or crosswalk when the gate arm is deployed.

If gates must be placed in areas of significant pedestrian traffic, the potential exists for pedestrian injuries due to a knockdown. Several options should be considered for mitigation:

- If possible, place the gate in an area where there is less pedestrian exposure
- Place the gate in an area where knockdowns are less likely
- As a last resort, provide beam guard shielding to prevent a vehicle from hitting the gate

If beam guard is needed to shield a gate, it is required that the barrier is of sufficient length to protect the gate (i.e. length of need), has appropriate end terminals and appropriate grading is provided for the barrier and end terminals.

25.3.8 Sightlines and Driver Reaction

Consider sightlines and driver reaction time when locating gates. Ideally, drivers would be able to observe a deployed gate arm far enough in advance to avoid entering a closed ramp and becoming trapped. If adequate sightlines and driver reaction time cannot be provided at a particular location, consider supplementing the gate with advance flasher assemblies.

25.3.9 Control Boxes and Power Supplies

Locate control boxes and power supplies (e.g. utility services, solar panels) outside of mainline and ramp clear zones.

25.3 Guideline Compliance Documentation

If it is not feasible to follow the aforementioned gate placement guidelines, document why a particular location was selected, what alternatives were reviewed and why a particular alternative was selected.

25.4 Other Design Considerations

25.4.1 Operating Speeds

Operating speeds on the ramp near a gate may be lower than the design speed used for the mainline roadway due to vehicles turning onto the ramp. Use acceleration tables from *AASHTO's A Policy on Geometric Design of Highways and Streets* to calculate operating speeds near a gate as this will influence run out length for barrier (if needed due to pedestrian concerns), clear zones and potentially grading leading up to a gate base.

25.4.2 Signing

The designer should supplement the visual cues of the ramp closure gate arm and attached flashers by installing WisDOT Standard Sign R11-54F (Folding "RAMP CLOSED USE ALT ROUTE") on or near each approach to the ramp to be closed by the gate to reinforce a closure. Include these details on the signing plan and in the signing quantities. This advance signing may be upgraded to a beacon assembly for an additional cue as described in the next section.

Guidance for the R11-54F sign installation:

- For two-lane rural crossroads, the folding R11-54F sign shall be placed at the ramp gate or barricade rack. If possible, a folding R11-54F sign should be placed in advance for traffic turning onto the ramp (see Attachment 25.2).
- For multi-lane crossroads, the folding R11-54F sign shall be placed at the ramp gate or barricade rack. Advance folding R11-54F signs should be considered at roundabout bypass lanes and look ahead left turn lanes, left turn lanes and right turn lanes (see Attachment 25.2).

25.4.3 Advanced Beacon Assembly

Evaluate and assess viable alternate routes, especially for heavy commercial vehicles, given the deployment of a gate arm. Install WisDOT Standard Sign R11-53 ("RAMP CLOSED WHEN FLASHING USE ALT ROUTE") with beacon if interchange geometrics prohibit a heavy commercial vehicle from turning around and going back from the direction it came or prohibit the use of a parallel route to mainline for accessing the next entrance ramp.

Also consider Advanced Beacon Assembles when sightlines are inadequate so as to not allow drivers enough time to observe a deployed gate arm and consider alternatives to the closed ramp. Select locations to enable use of an alternate route by placing them prior to a decision point for selecting an alternate route.

Connect beacon to the gate source of power, when available, and install such that beacons activate when the gate is lowered.

25.5 Identification Plaques

Ensure proper installation of structure identification plaques per SDD 12a4.

25.6 Barricades in Conjunction with Ramp Closure Gates

Where slotted turn lanes create the potential for a vehicle virtual trap, and ramp closure gate deployment is not feasible, type III barricades should be deployed (see Figure 25.11).

Refer to the "Deployment and General Considerations" section for additional barricade guidance.

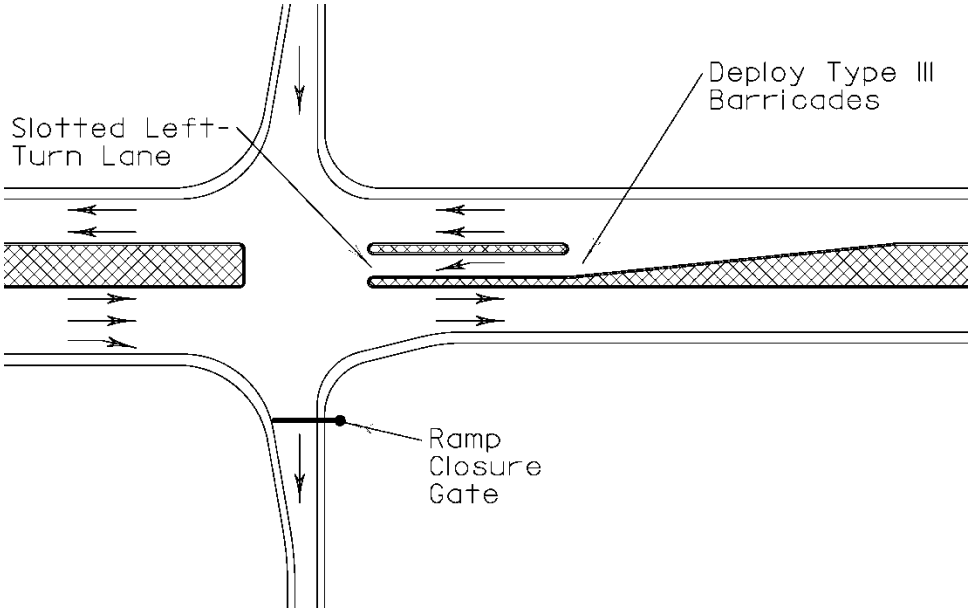

Figure 25.11 Barricades in Conjunction with Ramp Closure Gates

25.4 Additional Information

Designers should refer to standard detail drawings (SDD 15d34 (a-d), 15d35 (a-d) and 15d36) and standardized special provisions (refer to http://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/tools/stsp.aspx) for solar and hardwired ramp gates and barricade racks.

LIST OF ATTACHMENTS

Attachment 25.1	Wisconsin Ramp Gate Maintenance and Inspection Guideline
Attachment 25.2	Example Ramp Closed Use Alternative Route (R11-54F) Sign Details