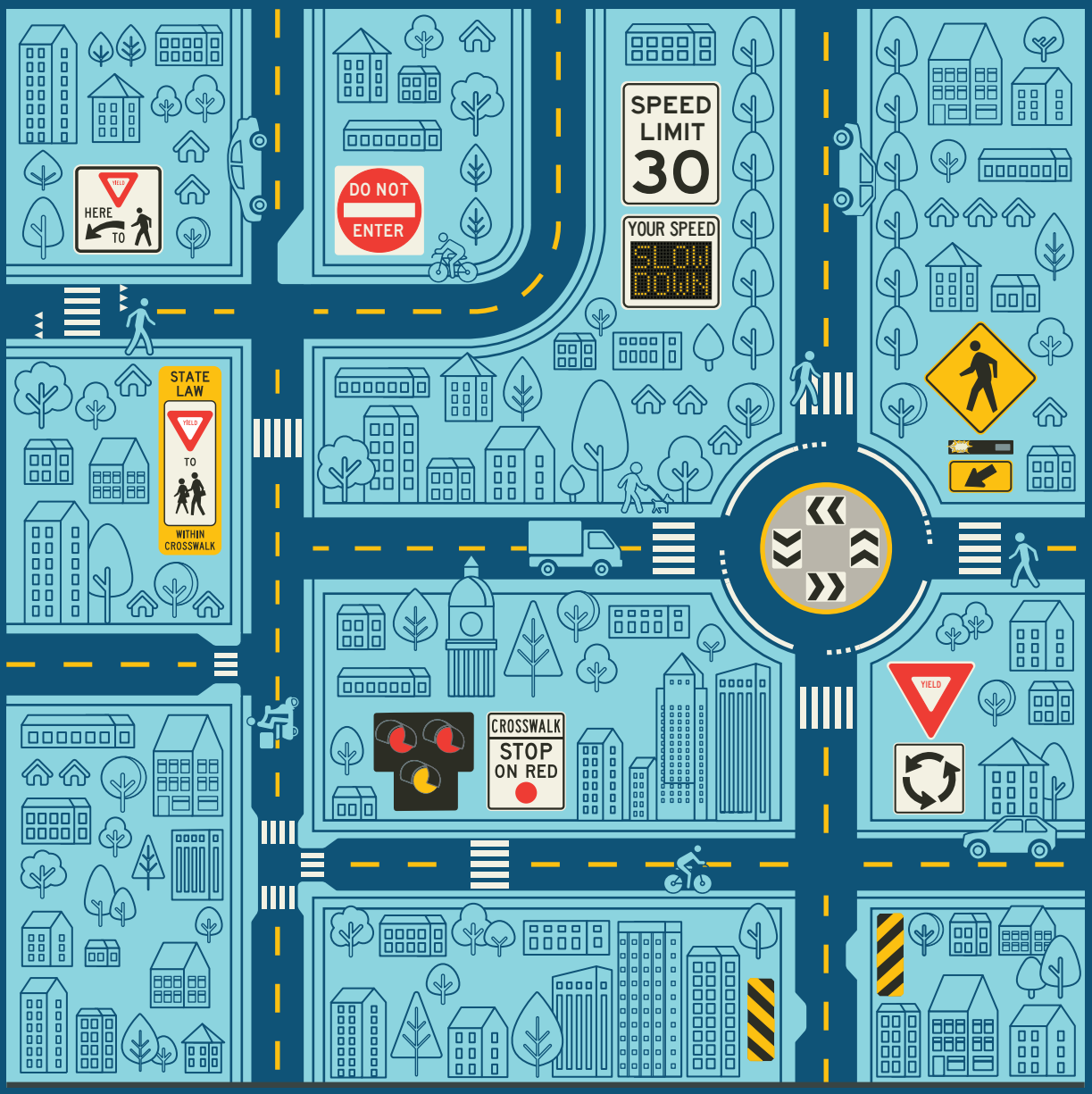


Traffic Calming Guide

A Compendium of Strategies

California Department of Transportation

Caltrans

Table of Contents

Introduction

The California Department of Transportation (Caltrans) recognizes all modes of travel are integral to our vision of delivering a brighter future for all through a world-class transportation network. As Caltrans progresses towards achieving a transportation system that improves accessibility and connectivity to essential community destinations for all users, we continue to provide guidance that contributes to the livability and safety of all users of the State highway environment.

As established in Director's Policy 36 (DP-36): Road Safety, Caltrans has a vision to eliminate fatalities and serious injuries on California's roadways by 2050 and provide safer outcomes for all communities. To support this vision, Caltrans has adopted the Safe System Approach which is an international best practice in road safety. It includes the following five elements : safe road users, safe speeds, safe roads, safe vehicles, and post-crash care. Despite State highways being planned, designed, and constructed based on geometric criteria such as design speed, the highway will not function as intended with drivers who operate at excessive speeds. The data collected from the Statewide Integrated Traffic Records System (SWITRS) between 2011 to 2021 showed that 34% of single vehicle crashes related to fatalities and serious injuries were due to speeding and aggressive driving. Speed management is critical to the success of the Safe System Approach which is why "safe speeds" is one element of this Approach. As kinetic energy increases, the probability of a crash and the severity of that crash increases too. The Safe System Approach aims to reduce impact forces to levels that are tolerable for the human body to sustain. Operating speeds, roads, and vehicles should be designed and managed to reduce risk of fatalities and serious injuries when a crash occurs. The focus of this Traffic Calming Guide is to build self-enforcing roadways that guide road users to travel at a safe speed, especially through conflict points. To this end, the Traffic Calming Guide was developed from recommendations of the Zero Traffic Fatalities Task Force.

Caltrans recognizes that walking, biking, transit, and passenger rail are integral to our transportation network as established in Director's Policy 37 (DP-37) and developed guidance inclusive of this document to meet the goals stated in DP-37. Main Street, California discusses the possibilities and the types of questions that needed to be asked in order to foster a main street that helps people, communities, and the transportation system thrive. Design Information Bulletin 94 provides contextual guidance for complete street projects or facilities in Urban Area, Suburban Area, and Rural Main Street place types. These documents, along with the Traffic Calming Guide, provide guidance to those who implement traffic calming strategies to help achieve goals set forth by communities and agencies.

Traffic calming strategies should be implemented at locations along the State Highway System (SHS) where vehicle speed will have a negative impact on the non-motorized modes of travel. The Traffic Calming Guide provides best practices, relevant standards, and resources discussed in the FHWA Traffic Calming ePrimer. The traffic calming measures encompass various strategies including law enforcement, public education, as well as temporary and permanent highway features that become part of the highway infrastructure. Other important considerations should include the accommodation of emergency response services and the guidance published in Design Information Bulletin 93, Evacuation Route Design Guidance. The State Highway System should be reviewed from a holistic perspective and discussed with local agency partners and communities when working with adjacent private and public access.

Design flexibility is essential when implementing traffic calming strategies. A "one-size-fits-all" design philosophy is not Caltrans' Departmental policy. Designers and planners need to consider land use, community context, and the associated user needs of each facility. Project decisions should be made to balance pertinent values (e.g., modal priorities, community goals and objectives, environmental resources, social impact, economic impacts, fiscal resources, etc.) alongside exercising engineering judgment and experience. The key to a successful project includes weighing and carefully considering each of these values and utilizing engineering judgment to achieve the desired traffic calming needs.

The traffic calming measures discussed in this guide can be implemented separately or be used in conjunction with other calming measures. The Speed Reduction category within this document refers to the speed that is being reduced by installing that specific measure. Additional analysis is required to capture the cumulative benefits when implementing multiple calming measures at a specific location. It is advisable to conduct spot speed surveys following the implementation of traffic calming measures. Engineering judgement should be exercised to evaluate whether the roadway warrants a lower posted speed limit.

The Traffic Calming Guide is prepared for Caltrans for use on the California State highway system and it is not a substitute for engineering knowledge, experience, or judgment. It is neither intended as, nor does it establish, a legal standard for these functions. The traffic calming strategies established and discussed herein are for the information and guidance of the officers and employees of Caltrans. Many instructions given herein are subject to amendment as conditions and experience warrant. Special situations may call for deviation from this guide. The publication of this guide shall not create, nor is it intended to be, a standard of conduct or duty toward the public.

Identifying the Need for Traffic Calming

Based on engineering judgment, traffic calming strategies should be considered whenever there is a need to reduce vehicle speeds and/or traffic volumes on a roadway or roadway network. Increased consideration should be given to the following areas: 1) Along Safety Corridors or roadway segments with a high percentage of speed-related collisions, 2) In locations or facilities that generate high concentrations of bicyclists and pedestrians (refer to CA MUTCD Section 2B.13 for definition of “Safety Corridor” and “land or facility that generates high concentrations of bicyclists or pedestrians”), 3) To support transitions from high speed to low speed contexts, such as in the Transitional Area place type or when approaching a Rural Main Street. Caltrans recognizes that the implementation of traffic calming strategies may not be suitable for some project types and scope of work. Caltrans may collaborate with local agencies and the community to identify the roadway segments of need and select the appropriate traffic calming strategies early in the project development phase.

How This Guide Is Organized

The Traffic Calming Guide consists of six categories: Signings and Markings, Physical Intersection Modifications, Roadway Narrowing, Vertical Roadway Elements, Physical Roadway Segment Modifications, and Others. Each category contains several traffic calming measures that belong to the category and information related to measures is presented in the following sub articles: Description, Placement, Performance, Maintenance Considerations, Other Considerations, References, and Sample Projects.

This guide was produced in close collaboration between Division of Safety Programs, Traffic Operations, and Design. Each individual calming measure was written by an editor, who is the subject matter expert in their respective Division. Any future updates after the initial publication will have a vertical line in the left or right-side margin with a revision date at the footer to mark the updated content to the readers.

Category A. Signings and Markings

Vehicle Speed Feedback Signs

Description

Vehicle Speed Feedback Signs (SFS), also known as Dynamic Speed Displays, provide drivers with a feedback display of vehicles speed, while reminding drivers of the posted speed limit. SFS can be an effective method for reducing speeds at a desired location when appropriately complemented with police enforcement.

SFS assembly with R2-1

Placement

Vehicle Speed Feedback signs can only collect and display the speed of one vehicle at a time. Vehicle Speed Feedback signs are most effective when there is only one lane of traffic in each direction with daily volumes low enough to allow for gaps in traffic. The usage can vary depending on the purpose of placement and site conditions.

Functional Classification: Principal Arterials, Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: These signs are most effective on roadways where there are gaps between vehicles.

Maximum Posted Speed Limit: CA MUTCD section 2B does not indicate maximum posted speed limits for this countermeasure.

Performance

Speed Reduction: The FHWA cited 7 studies that ranged from a 2 MPH to 7 MPH speed reduction. This countermeasure is most effective when paired with enforcement and can lose its effectiveness over time as drivers become desensitized to the notification when it is not accompanied by enforcement.

Volume Reduction: N/A (This was not well documented and is not generally a goal of this measure)

Impact on Emergency Response: None

Mobility Impacts: Nominal

Maintenance Considerations

- Need to consider speed accuracy to avoid underestimation of speed
- Signs need to be calibrated regularly. The frequency can vary, but yearly is common
- Need to consider overall sign visibility
- Need to consider power source and need for backup power
- Contact Caltrans maintenance for maintainability, roles, and responsibilities when placed on the SHS

Other Considerations

- More effective if used with other information indicators or signs to reduce speed. Consider pairing with police enforcement
- Consider placement within School Zones
- Consider setting a maximum speed threshold over the speed limit to flash, “SLOW DOWN” instead of reporting the speed. A maximum of 10-15 MPH over the posted limit is common
- Specifications of the signs should be reviewed ahead of installation
- Consider the existing and future landscape on the visibility of the sign

References

1. California MUTCD - Caltrans
2. Traffic Calming ePrimer - FHWA

Sample Projects

H Street in Sacramento, CA (Google Earth)

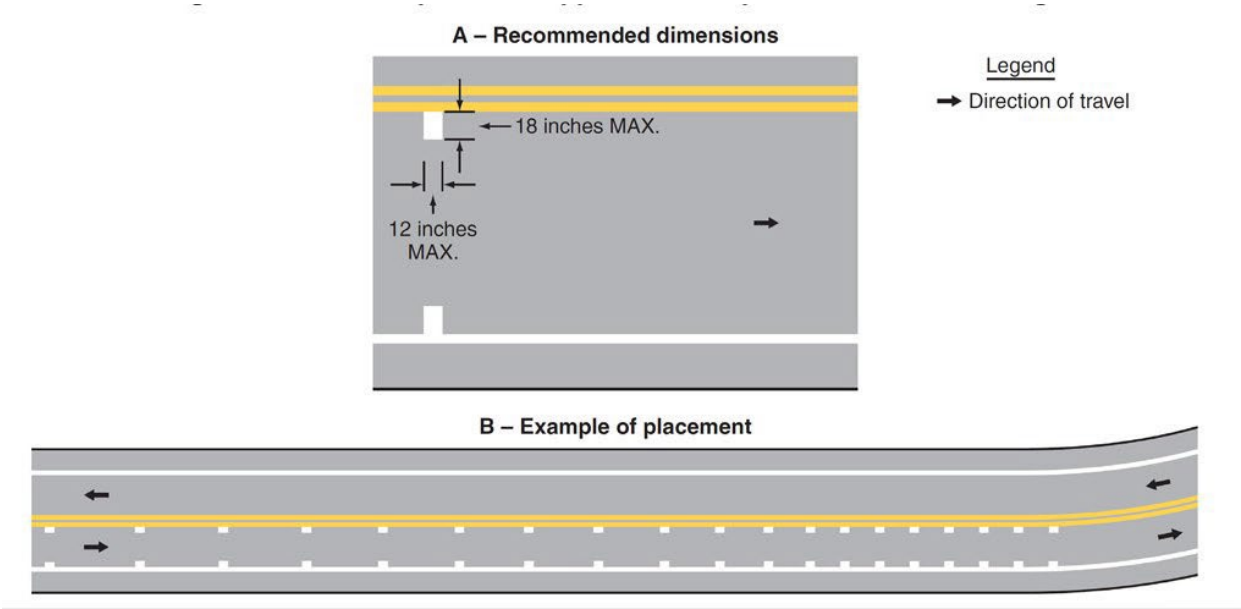
Project Description:

Vehicle Speed Feedback sign was installed along H Street in Sacramento to discourage excessive speeding through the residential neighborhood.

Speed Reduction Markings

Description

Speed Reduction Markings (also known as Optical Speed Bars) are transverse pavement markings placed with progressively reduced spacing on both edges of the traveled way to create the perception of increased speed. This illusion encourages drivers to slow down as they pass by the markings. Durable marking materials should be used as markings are exposed to increased wear from tires. See California MUTCD Section 3B.22 for additional details.



Speed Reduction Markings (CA MUTCD)

Placement

Speed reduction markings should be reserved for unexpected curves and should not be used on long tangent sections of roadway or in locations frequented mainly by local or familiar drivers. Speed reduction markings shall not be used in lanes that do not have a longitudinal line (center line, edge line, or lane line) on both sides of the lane.

Functional Classification: Collectors and Local Roads

Appropriate Daily Volume Range: Any

Maximum Posted Speed Limit: Table 3 in FHWA's Low-Cost Treatments for Horizontal Curve Safety 2016 contains guidelines for approach speeds from 45 MPH to 70 MPH and curve speeds from 15 MPH to 50 MPH.

Performance

Speed Reduction: 0-5 MPH reduction (FHWA)

Impact on Emergency Response: None

Maintenance Considerations

SNOW

- Impact of salt and other road treatments on markings
- Use durable marking materials that can withstand snowplow operations
- Use of depressions for markings, so that road plowing operations pass over the top without impacting the markings

OTHER

- Impact of constant traffic wear of the pavement markings

Other Considerations

- Where significant eradication of existing markings is required, it is recommended that this measure is implemented within a re-paving project
- CA MUTCD and latest applicable standards/other manuals should be utilized
- Check if there are conflicts with other pavement delineation and markers

References

1. California MUTCD (Section 3B.22) - Caltrans
2. Low-Cost Treatments for Horizontal Curve Safety 2016 (Chapter 3) - FHWA

Sample Project

Folsom Blvd approaching US 50 WB on-ramp in Folsom, CA (Google Earth)

Project Description:

Speed reduction markings were placed on the Folsom Blvd turn lane leading to the on-ramp. The pavement markings were placed in a pattern of progressively reduced spacing to give drivers the impression of increased speed, so drivers will slow down prior to entering the horizontal curve.

In-Street Pedestrian Crossing Signs

Description

In-street Pedestrian Crossing signs are placed within a roadway, either between travel lanes or in a median. The sign may be used to remind road users of laws regarding right of way at an unsignalized pedestrian crossing. In California, the R1-6 usage is limited because the sign does not enforce vehicles to stop per CVC 21950.

The In-street Pedestrian Crossing sign is used with other crosswalk visibility enhancements to indicate preferred locations for people to cross and help reinforce the driver requirement to yield the right of way to pedestrians at designated pedestrian crossing locations.

In-Street Pedestrian Crossing Signs (R1-6) (FHWA)

Placement

Most uncontrolled pedestrian crossings with high pedestrian volumes, especially on roadway crossings with 10,000+ ADT (FHWA). See Table 1 for additional recommendation for placement.

Functional Classification: Minor Arterials, Collectors, and Local Roads

Posted Speed Limit: 30 MPH or less (FHWA)

Performance

Speed Reduction: N/A (Driver compliance, such as drivers yielding for pedestrians increased significantly)

Volume Reduction: N/A

Impact to Emergency Response: None

Maintenance Considerations

SNOW

- Need appropriate width to avoid damaging the sign
- Consider seasonal removal of signs

OTHER

- Consider mountable design to avoid conflicts with commercial vehicles

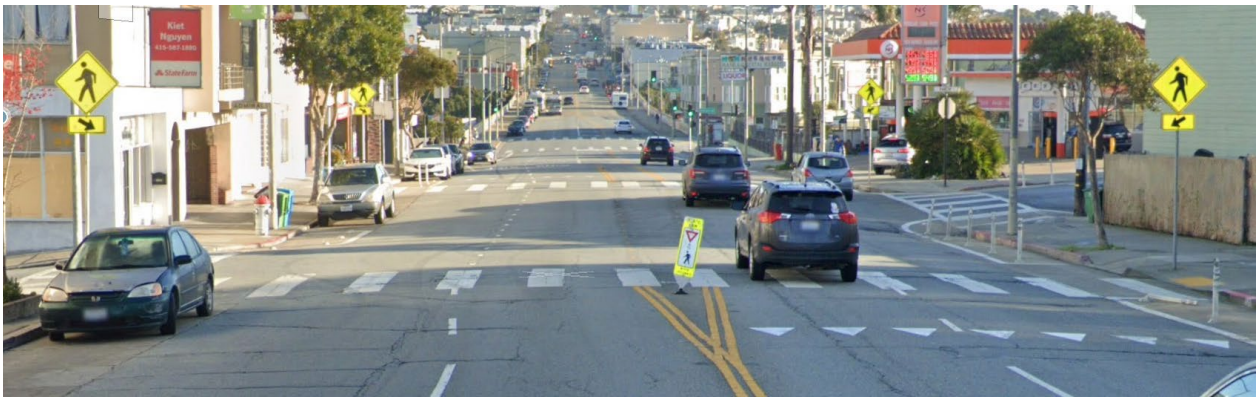
Other Considerations

- Should only be used at uncontrolled pedestrian crossing locations
- Consult with the District Pedestrians and Bicyclists Safety Engineer
- Must meet AASHTO breakaway requirements
- Should be removable for roadway maintenance
- Background can be yellow or fluorescent optic yellow

References

1. Crosswalk Visibility Enhancements - FHWA
2. California MUTCD - Caltrans
3. In-Street Pedestrian Crossing Sign - PEDSAFE

Sample Project



Mission St and Admiral Ave in San Francisco, CA (Google Earth)

Project Description:

The In-Street Pedestrian Crossing sign (R1-6) was installed at this intersection to remind drivers of pedestrian right of way laws.

Crosswalk Enhancement

Description

Poor lighting and other factors that reduce driver visibility can cause safety issues at pedestrian crosswalks. In high speed or high vehicle traffic conditions, a substantially visible roadway crossing area could prevent or reduce the amount of pedestrian-related collisions. Any number of enhancements may be combined to increase vehicle operators' visibility of the crosswalk and pedestrian users. Enhancement options include:

- High-visibility crosswalk markings and marking patterns
- In-Street Pedestrian Crossing Sign
- Improved lighting
- Advance Stop/Yield/Pedestrian Crossing markings and signs
- Parking restrictions
- Curb Extension
- Raised Crosswalk
- Rectangular Rapid-Flashing Beacons (RRFB)
- Pedestrian Hybrid Beacons (see CA MUTCD Chapter 4F)

Crosswalk Enhancement Example (FHWA)

Placement

At a crosswalk location, especially on multilane roadways with vehicle volumes

exceeding 10,000 ADT (FHWA).

Functional Classification: Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: Varies per improvement. See Table 1 below.

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	● 2 4 5 6	● 5 6 7 9	○ 5 6 ● 9	● 4 5 6	● 5 6 7 9	○ 5 6 ● 9	● 4 5 6 7 9	○ 5 6 7 9	○ 5 6 ● 9
3 lanes with raised median (1 lane in each direction)	● 2 3 4 5 ● 7 9	● ❸ 5 ● 9	○ ❸ 5 ● 9	○ 3 4 5 ● 7 9	○ ❸ 5 ● 9	○ ❸ 5 ● 9	○ ❸ 4 5 ● 7 9	○ ❸ 5 ● 9	○ ❸ 5 ● 9
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	● 2 3 4 5 6 7 9	● ❸ 5 6 7 9	○ ❸ 5 6 9	○ 3 4 5 6 7 9	○ ❸ 5 6 ● 9	○ ❸ 5 6 9	○ ❸ 4 5 6 7 9	○ ❸ 5 6 9	○ ❸ 5 6 9
4+ lanes with raised median (2 or more lanes in each direction)	● ❸ 5 7 8 9	● ❸ 5 7 8 9	○ ❸ 5 8 ● 9	○ ❸ 5 7 8 ● 9	○ ❸ 5 ● 8 9	○ ❸ 5 8 ● 9	○ ❸ 5 ● 7 8 9	○ ❸ 5 8 ● 9	○ ❸ 5 8 ● 9
4+ lanes w/o raised median (2 or more lanes in each direction)	● ❸ 5 6 7 8 9	○ ❸ 5 ❻ 7 8 9	○ ❸ 5 ❻ 8 ● 9	○ ❸ 5 ❻ 7 8 9	○ ❸ 5 ❻ ● 8 9	○ ❸ 5 ❻ 8 ● 9	○ ❸ 5 ❻ ● 7 8 9	○ ❸ 5 ❻ 8 ● 9	○ ❸ 5 ❻ 8 ● 9

Given the set of conditions in a cell,

- # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

*Refer to Chapter 4 from Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations for more information using multiple countermeasures.
**It should be noted that the PHB and RRFB are not both installed at the same crossing location.

Table 1: Application of pedestrian crash countermeasures by roadway feature (Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, FHWA)

Posted Speed Limit: N/A

Performance

Speed Reduction: N/A (Driver compliance, such as drivers slowing down/stopping for pedestrians have increased significantly, but the references did not analyze the reduction of speeds across the entire corridor)

Volume Reduction: N/A

Impact on Emergency Response: None

Maintenance Considerations

SNOW

- Provide sufficient lane width to avoid in-roadway signs and markings being damaged by snowplows
- Road salt and snowplows can shorten the lifespan of high-visibility crosswalk markings. Road salt can interfere with the bonding agent.

OTHER

- Marking durability
- The reflectivity of the markings will fade and lose effectiveness, so they will need to be monitored/updated regularly
- R1-6 signs may be damaged by vehicles if placed in the middle of the roadway

Other Considerations

- More complex installations such as lights or pavement treatments can be costly
- Inlayed thermoplastic markings can be more reflective than paint or brick
- Lighting should be placed in forward locations to avoid a silhouette effect of the pedestrian
- In-street signing should be considered for roadways with posted speeds of 30 MPH or less
- Consult with the District Pedestrians and Bicyclists Safety Engineer

References

1. The Relative Effectiveness of Pedestrian Safety Countermeasures at Urban Intersections – Crash Modification Factors Clearinghouse
2. Crosswalk Visibility Enhancements - FHWA
3. California MUTCD (Section 3B.16, 3B.18; Chapters 4E, 4F, 4L) - Caltrans
4. Proven Safety Countermeasures - FHWA
5. FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
6. Field Guide for Selecting Countermeasures at Uncontrolled Pedestrian Crossing Locations - FHWA

Sample Project

Mission Ave in San Rafael, CA (Google Earth)

Project Description:

The City of San Rafael implemented additional signage (R1-5, W11- 2, and W16-7P), advance yield pavement markings, and ladder crosswalk pavement marking to slow down vehicles at Mission Ave. These enhancements increase the likelihood that motor vehicles will notice crossing pedestrians.

Pedestrian Hybrid Beacons (PHBs)

Description

Pedestrian hybrid beacons are a pedestrian-activated overhead signal consisting of two red lenses above a single yellow lens. The lenses remain “dark” until a pedestrian pushes the call button to activate the beacon, which then initiates a yellow to red lighting sequence that directs motorists to slow and come to a stop. The pedestrian hybrid beacon accompanied with appropriate signs and pavement markings provides greater visibility for locations, where a crosswalk is not accompanied by a signal-controlled intersection.

Pedestrian Hybrid Beacon (FHWA)

Placement

Midblock crossings, school crossings, and other uncontrolled crosswalks/bike crossings across multi-lane (3+ lanes) roadways. The location should be identified with a pedestrian and bike need. This measure should only be installed at marked crosswalks and the criteria for placement should follow marked crosswalk placement criteria. Refer to CA MUTCD Chapter 4F

Functional Classification: Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: 9,000 ADT or more (FHWA). See Table 1 for more information on placement.

Posted Speed Limit: Varies. Refer to CA MUTCD Figure 4F-1 for posted speed limit less than or equal to 35 MPH. Refer to CA MUTCD Figure 4F-2 for posted speed limit greater than 35 MPH.

Performance

Speed Reduction: N/A (Driver compliance, drivers slowing down/stopping for pedestrians will increased significantly)

Impact on Emergency Response: Similar to other signalized crossings, where emergency response vehicles will need to slow down to verify pedestrian presence in the crossing if the beacon is activated.

Mobility Impacts: Nominal

Maintenance Considerations

- Keeping pedestrian indications red if beacons fail
- Activation method (button or sensor)
- Electrical and sign maintenance

Other Considerations

- Options such as improved lighting, advance or in-street warning signage, pavement markings, and geometric design elements can be combined to increase visibility of crosswalk. PHBs should only be installed with marked crosswalks and pedestrian countdown signals
- Community outreach should be performed if PHBs are not common within a community
- Consult with the District Pedestrians and Bicyclists Safety Engineer
- Adding signs to pole mast arms will require a wind load analysis from Structures Design and Geotechnical units
- Maintaining minimum sidewalk clear width in compliance with ADA if poles and foundations are placed within sidewalk. See DIB 82
- Right of way considerations if signal poles and foundations placed outside of right of way
- Signal pole foundations can impact existing utilities
- Consider the location of stop bars. Factors such as stopping sight distance to the stop bars and beacons should be verified. Consider adding transverse rumble strips in advance of stop bars

References

1. California MUTCD (Chapter 4F) - Caltrans
2. Design Information Bulletin 82 - Caltrans
3. Pedestrian Hybrid Beacon Tech Sheet - FHWA
4. Proven Safety Countermeasures - FHWA

Sample Project

State Route 168 and Edward St in Bishop, CA (Google Maps)

Project Description:

This project on State Route 168 was completed in November 2020 with the goal to enhance driver awareness of pedestrians at an uncontrolled crossing. Additional calming measures were incorporated, such as pedestrian crosswalk regulatory signs, pedestrian hybrid beacon, restriping with high-visibility markings, and upgrading the crosswalk to ADA standards.

Flashing Beacons

Description

Flashing beacons use repeating flashing lights to warn motorists. They are used to draw motorists' attention to a sign informing them of an upcoming change in the road conditions that could include unseen intersections, schools, curves, or applications discussed in the placement section below.

Flashing Beacons on US 50 EB to Business 80 Connector in Sacramento, CA (Google Maps)

Placement

CA MUTCD Chapter 4L lists the following typical applications:

- Signal ahead
- Stop signs
- Speed limit signs
- Other warning and regulatory signs
- Schools
- Fire stations
- Intersection control
- Freeway bus stops
- At Intersections, where a more visible warning is desired:
    - Obstructions in or immediately adjacent to the roadway
    - Supplemental to advance warning signs
    - At mid-block crosswalks
    - At intersections, where a warning is appropriate

Functional Classification: Principal Arterials, Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: Appropriate for all volume ranges

Maximum Posted Speed Limit: Appropriate for all posted speed limits, but it is best suited to situations where the difference between the posted and advisory speed is greater than 10 MPH under the posted speed limit.

Performance

Speed Reduction: The Crash Modification Factors (CMFs) show a significant reduction in crashes, which suggests the most extreme speeds were likely reduced (FHWA).

Volume Reduction: N/A (This was not well documented and is not generally a goal of this measure)

Impact on Emergency Response: None

Maintenance Considerations

SNOW

- Ice can reduce the visibility of the flashing beacons and damage lights

OTHER

- Power source. Use of solar-power panels can eliminate the need for a power source and save energy cost
- Visibility in inclement weather
- Foliage obstructing beacons

Other Considerations

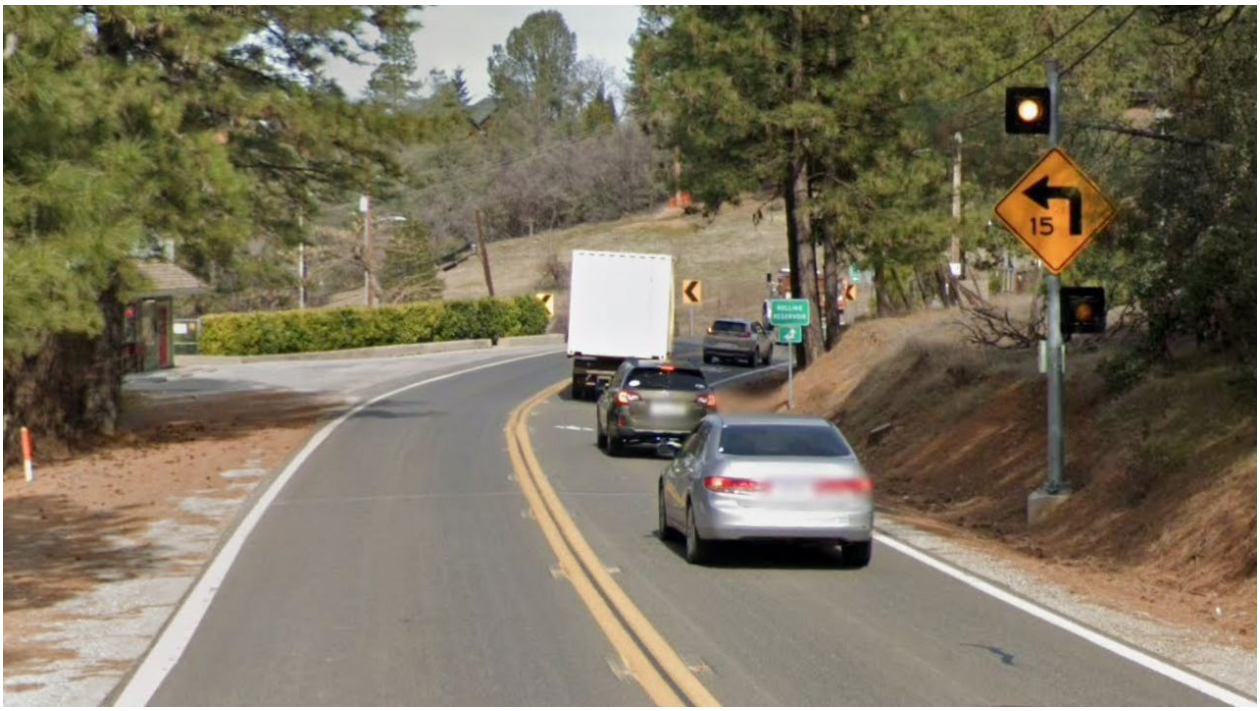
- Flashing beacons should be considered when warning signs have proven insufficient to gain driver attention
- The condition or regulation for justifying Warning Beacons should largely determine their placement. Warning Beacons should only operate during those periods or times when the condition or regulation exists
- Warning beacons shall be used only to supplement a warning or regulatory sign or marker
- Automatic dimming devices should be considered for night operations
- Beacon flash rate shall be between 50 and 60 times per minute
- Warning (yellow) beacons should not be used to emphasize Stop, Do Not Enter, Wrong Way, and Speed Limit signs
- Speed Limit Sign Beacon shall be used only to supplement a Speed Limit Sign.
- A Stop Beacon shall be used only to supplement a STOP sign, a Do NOT ENTER sign, or Wrong Way Sign.
- Beacons shall not be included in the border of a sign

- Edge of beacon signal housing should normally be no closer than 12” to the nearest edge of the sign
- 6” diameter lights
- Posts should be break-away and/or crash tested, otherwise will need to be shielded by guardrail, barrier or crash cushion

References

1. California MUTCD (Chapter 4L) - Caltrans
2. Low-Cost Treatments for Horizontal Curve Safety 2016 (Chapter 4) - FHWA

Sample Project



State Route 174 in Colfax, CA (Google Earth)

Project Description:

This project is located on State Route 174 in Placer County. A flashing beacon was implemented along with an advance warning sign in order to draw the attention of motorists to the upcoming curve in the roadway.

Category B. Physical Intersection Modifications

Roundabouts

Description

A roundabout is a form of circular intersection in which traffic travels counterclockwise around a central island and entering traffic must yield to the circulating traffic. They feature, among other things, a central island, a circulatory roadway, and splitter islands on each approach. Roundabout design has certain attributes that can reduce speed, such as geometric design of approach alignment and circular roadway of a roundabout. Modern roundabouts also have fewer conflict points, especially the high angle conflict points, which results in less severe crashes when compared to stop-controlled or signal-controlled intersections. Additionally, a roundabout also separates the conflict points which eases the ability of the driver, pedestrian, or bicyclist to identify a conflict and helps prevent conflicts from becoming crashes.

Roundabouts are included among FHWA's 28 Proven Safety Countermeasures due to their significant safety and operational benefits. Roundabouts are analyzed per Caltrans' Intersection Safety and Operational Assessment Process (ISOAP), which evaluates the various intersection control type designs on the State Highway System (SHS) to address intersection improvement project strategies. For more information about the ISOAP process, see, ISOAP Process Information Guide.

State Route (SR) 29 Napa Roundabout

Placement

Roundabouts can accommodate existing site constraints, such as intersections with skewed angles or other nontypical configurations. They are inherently flexible, which can lead to successful installations within or near main streets, schools, and railroads, among others.

Caltrans' roundabout guidance is provided in Highway Design Manual Index 405.10. See Figure 405.10A "Roundabout Geometric Elements" for nomenclature associated with roundabouts. Signs, striping and markings at roundabouts shall comply with the California Manual on Uniform Traffic Control Devices (CA MUTCD).

Roundabout intersections on the SHS must be developed and evaluated in accordance with the ISOAP memo. The FHWA Traffic Calming ePrimer Section 3.9 contains useful information on roundabouts as a traffic calming strategy.

Functional Classifications: Minor Arterial, Collectors, and Local Roads

Performance

Speed Reduction: Speed reduction is dependent on adequate advanced warning, vertical profile, driver familiarity or deflection of the travel path to slow vehicles. Speeds are approximately 40% lower in a roundabout than 350' away from the intersection (FHWA). Roundabouts should be designed so that the maximum entry speed for a single lane roundabout is 25 MPH and 30 MPH for a multilane roundabout. The entry speed should be verified by the fastest path performance check.

Volume Reduction: Negligible (FHWA)

Impact of Emergency Vehicle Access: Minimal – Roundabouts should be designed so that emergency vehicles can smoothly navigate through a roundabout without hitting a curb.

Mobility Impact: For any intersection alternative analysis, a transportation operational and safety analysis is needed to properly assess impacts either from the new or change in intersection control type to the project area and adjacent roadway network. Conformance to the ISOAP Memo and Process Information Guide is required for all projects that add new intersections or propose to change the existing intersection control configuration on the State Highway System.

Transportation analysis scope and methodology considerations include:

- Traffic control warrant analysis consistent with the CA MUTCD Section 4C may be needed when screening intersection alternatives. Note that there are no traffic control warrants for a roundabout
- Analysis of the project area and impacted parallel facilities
- Intersection analysis and modeling should be conducted to assess potential operational deficiencies

- Bicycle and Pedestrian analysis should be conducted consistent with Highway Capacity Manual (Chapters 4, 15, 24, and 35 and FHWA methodologies)
- Impacts to local freight and truck circulation should be considered. Truck turning templates used in the performance checks need to be validated and agreed by the District Truck Access Managers

For projects on the local road network, a transportation analysis that includes potential SHS impacts from diverted trips should be conducted through the Local Development Review (LDR) or Encroachment Permit process.

Maintenance Considerations

SNOW

- Consider snow storage in and around the roundabout and the shared use path
- Consider the difficulty in removing snow and provide mountable curbs and shared use paths widths to accommodate snow removal operations

OTHER

- Consider landscape maintenance
- Sweeping maintenance
- Striping and pavement marking maintenance
- If near a railroad, school or applied to a highly skewed intersection, additional parameters might need to be accommodated

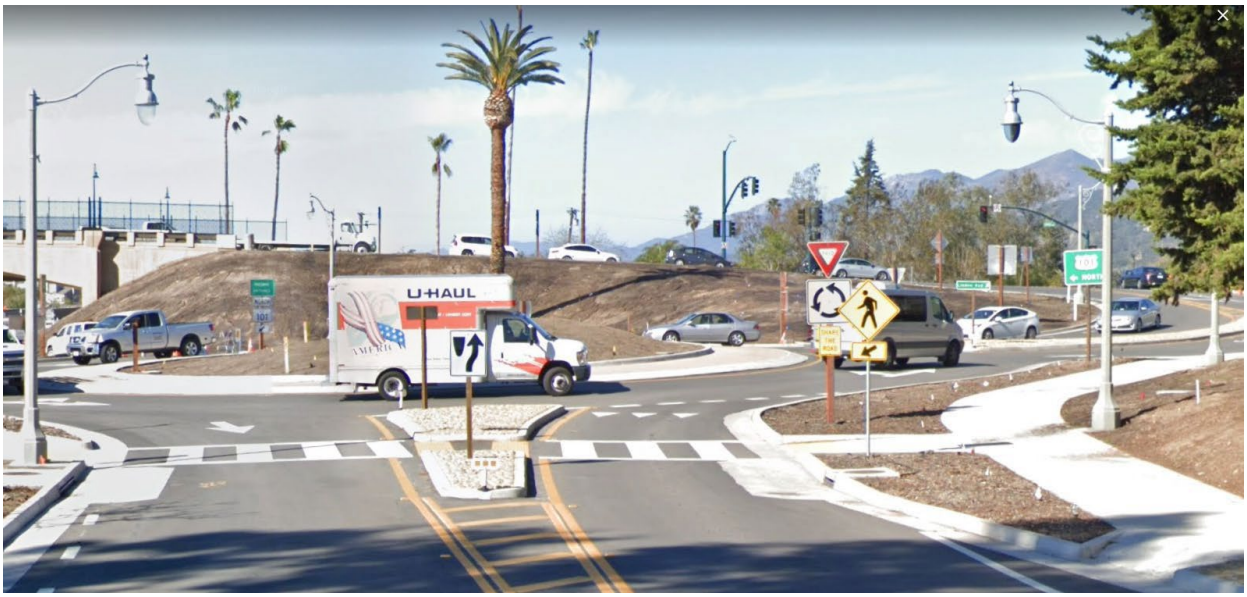
Other Considerations

- Roundabout design is an iterative process. The geometry is governed by performance check evaluations. Refer to NCHRP 672 Chapter 6, Section 6.7 for information regarding performance checks
- The sidewalk should be designed as a shared use path, since the path will serve both pedestrians and bicyclists, who are not comfortable taking the lane to proceed through the roundabout. Although the sidewalk is considered a shared use path, it does not need to meet the design standards in Index 1003, but it should meet the design standards within Index 405.10
- A landscape buffer/strip, detectable by cane and underfoot, between the sidewalk and the back of curb for the circular roadway of the roundabout should be a minimum of 2 feet wide
- Pedestrian activated push buttons should be considered for crossing more than one lane. If one leg of a roundabout has a crossing that includes crossing more than one lane, then consider providing push buttons for all crossings of that intersection. Refer to NCHRP 834
- Chicanes may be utilized at the approaches of the roundabout to reduce speeds prior to entering the roundabout
- Consult with the District Traffic Safety Engineer, District Traffic Operation Engineer, and District ISOAP Coordinator for guidance and recommendations

References

1. Highway Design Manual (HDM) Chapter 400
2. California Manual on Uniform Traffic Control Devices (CA MUTCD)
3. Design Information Bulletin 94, Complete Streets
4. Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclist and Pedestrians
5. 28 Proven Safety Countermeasures
6. Traffic Operations Policy Directive (TOPD) #13-02
7. ISOAP Process Information Guide | Caltrans
8. NCHRP 672
9. NCHRP 834
10. Oversize Overweight Vehicles – District Truck Access Manger (DTAM) / District Truck Coordinator Contract
11. Highway Capacity Manual 7th Edition: A Guide for Multimodal Mobility Analysis |The National Academies Press
12. Traffic Calming ePrimer- FHWA
13. Roundabouts for bikes and peds FHWA
14. Pedestrian & Bicycle Safety | FHWA

Sample Projects



Via Real extension & Ogan Rd, Carpentaria, CA (Google Maps)

Project Description:

The new Ogan Road roundabout will connect to the Via Real extension and provide easier access onto northbound Highway 101 with a longer on-ramp. Additionally, improvements within the project includes, concrete splitter islands, shared use pedestrian path with buffered landscape strip, light poles for illumination, etc.

Full Closure

Description

Typical full closure implementation can help improve safety by reducing intersection conflict points and cut-through traffic. These applications can also be designed to accommodate safer bicycle and pedestrian movements. An analysis of the shift in vehicular trips anticipated from full closures should be conducted in order to assess whether travel demand and certain traffic movements can be accommodated within the project area roadway network. It should be noted that the full closure implementation, as a traffic calming tool, is not applicable for state routes. Local public agencies may close local roads intersecting a state route.

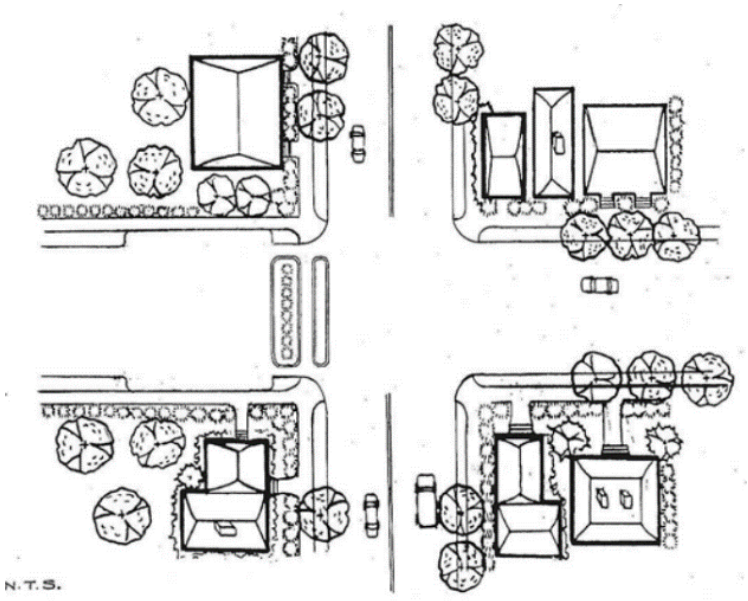


Image of Full-Street Closure (PennDOT)

Placement

At an intersecting through street, rather than the interior of a neighborhood (PennDOT)

Functional Classification: Local Roads

Place Type: Urban Area and Suburban Area, where there are near-by alternative routes. Only appropriate along a two-way roadway

Maximum Grade: N/A – However, adequate sight distance approaching the closure should be provided

Performance

Speed Reduction: Speed on the closed street will reduce to zero.

Volume Reduction: Reduction can be high but varies widely based on site specific conditions.

Impact on Emergency Response: Can Removes access – Not appropriate along a primary emergency access route or a street that provides access to a hospital/medical services. However, a 12' wide mountable curb (free of a barrier) can be installed if emergency vehicle access needs to be maintained (FHWA). This barrier should be clearly signed/marked for emergency use only (FHWA). Additionally, impacts to existing and potential future evacuation routes need to be considered in accordance with DIB 93. Project team should consult with Caltrans's Traffic Management, emergency response agencies, and law enforcement agencies for their input.

Mobility Impact: A transportation analysis may be needed to properly assess impacts of the capacity reduction associated with typical full closure projects within the project area and adjacent roadway network. Transportation analysis scope and methodology considerations include:

- Travel demand modeling to assess diversion impacts to other routes due to the reduction in capacity
- Analysis of the project area and impacted parallel facilities
- Intersection analysis and modeling should be conducted to assess potential operational deficiencies
- ISOAP and traffic control warrant analysis consistent with the California Manual on Uniform Traffic Control Devices (CA MUTCD) may be needed if there are major changes to travel demand
- Bicycle and Pedestrian analysis should be conducted consistent with HCM (Chapters 4, 15, 24, and 35) and FHWA methodologies
- Impacts of increased ADT due to diverted trips
- Impacts to local freight and truck circulation

For projects on the local road network, a transportation analysis that includes potential SHS impacts from diverted trips should be conducted through the Local Development Review (LDR) or Encroachment Permit process.

Maintenance Considerations

SNOW

- Provide adequate room for snowplows to turn around or navigate the road closure

OTHER

- Maintain landscaping

Other Considerations

- Eliminating parking on the approaches to the closure will assist u-turning traffic
- Diagonal diverter should have some type of barrier to physically prevent drivers from traversing it
- Drainage impacts
- Public engagement is recommended
- Impact to local businesses due to modified access
- Increase traffic to alternative parallel routes
- Impacts to existing utilities
- Impact to transit operator/user
- Advanced signing and appropriate notice need to be given for the closure
- Design cut-outs to accommodate bicycle, pedestrian, and wheelchair traffic
- Consider the consequences of an increase in traffic on alternative parallel routes

References

1. Design Information Bulletin (DIB) 93
2. Traffic Calming ePrimer - FHWA
3. Highway Capacity Manual 7th Edition - The National Academies Press
4. Pedestrian & Bicycle Safety - FHWA
5. Traffic Analysis and Intersection Considerations to Inform Bikeway Selection - FHWA

Sample Project

City of Stockton Traffic Calming Program

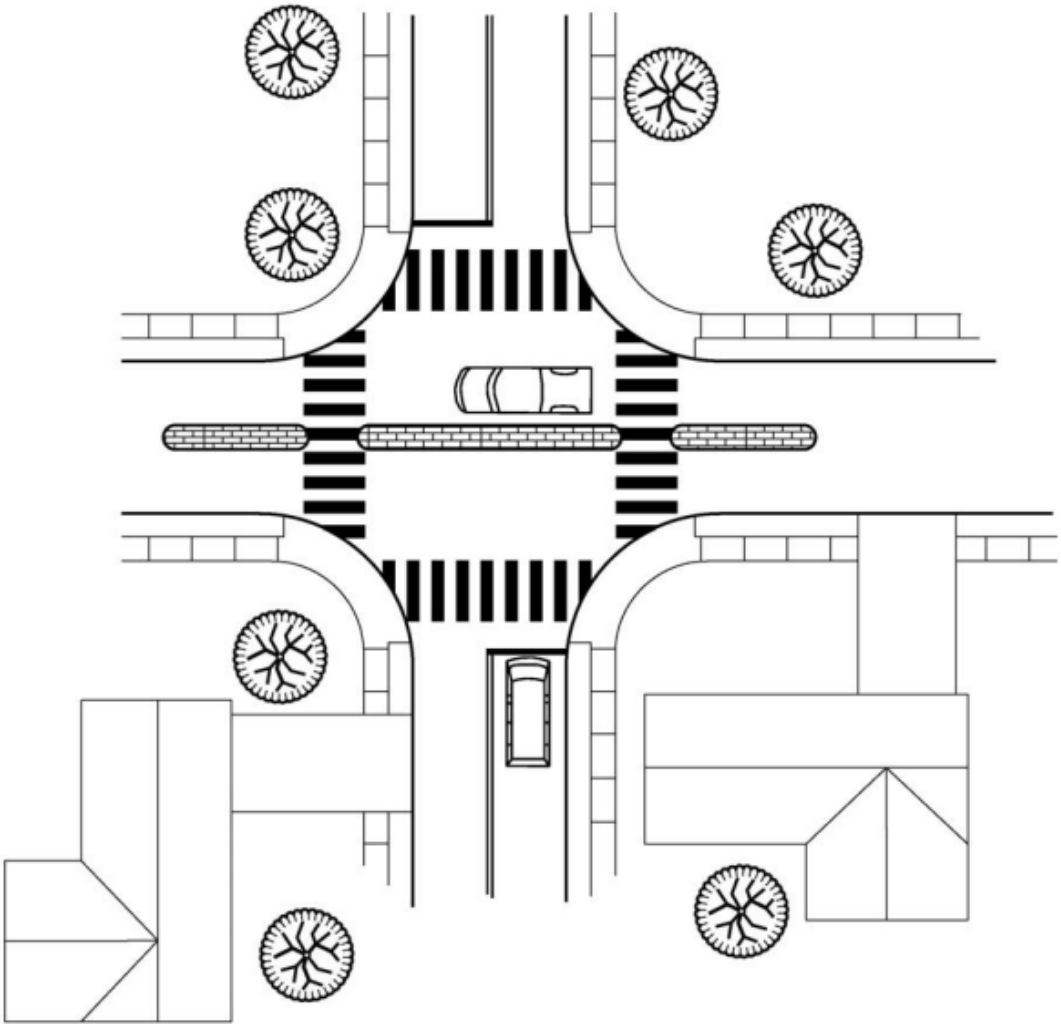
Project Description:

The City of Stockton implemented this full closure to help improve safety by reducing intersection conflict points and cut-through traffic.

Intersection Barrier

Description

A intersection barrier can be used to limit left-turn movements through an intersection. A fixed barrier such as a curb, raised island, or planter limits vehicle movements through the intersection, forcing drivers to reduce approach speeds. Advance warning signs and markings should clearly indicate limitations to movement, particularly in low visibility areas. Gaps in the barrier (commonly 8 feet) should be included to allow pedestrians and bicycles to pass through.



Intersection/Median Barrier (DelDOT)

Placement

Best suited for installation along minor arterials or collectors at their intersection with local (side) streets.

Functional Classification: Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: All ADTs (FHWA)

Maximum Posted Speed Limit: 25 MPH or less for local (side) streets (FHWA). Appropriate for speeds below 45 MPH on SHS.

Performance

Speed Reduction: Not expected to reduce speeds along side streets, since all vehicles will come to a stop in both the before and after conditions. The primary road will not see a reduction in speed.

Volume Reduction: Up to 70% on local (side) streets (PennDOT)

Impact on Emergency Response: May restrict access and is not recommended for placement along emergency access routes. Project team should consult emergency response agencies along with local and state law enforcement agencies.

Maintenance Considerations

SNOW

- Fixed object in the traveled way may impact snowplow operations
- Keeping pedestrian/cyclist/emergency vehicle gaps clear of snow and debris

OTHER

- If landscaped, need to consider maintenance and access
- Durability of mountable curbs
- Road maintenance access and sweeping activities

Other Considerations

- Impact on drainage and utilities
- Mountable curb and/or a larger barrier opening (at least 10 feet and clearly signed for emergency vehicles only) to allow for emergency access
- Appropriate signing and pavement markings on approaches
- Public Engagement is recommended
- Check if lane width reduction through use of an intersection barrier affects Design Vehicle swept path and tracking (HDM Topic 404 - Design Vehicles)
- Impact on existing traffic. Restricting left-turn movement and reducing lane width may negatively impact access for trucks and other larger vehicles. Consider if alternative routes are available. May increase traffic volume on adjacent parallel streets
- Extend the intersection barrier beyond the intersection, typically 15 to 25 feet, to discourage left turns from the main street

References

1. Highway Design Manual (HDM) Topic 404 - Caltrans
2. Traffic Calming Fact Sheets - ITE

Sample Project

Martin Luther King Jr Way and Addison St in Berkeley, CA (Google Earth)

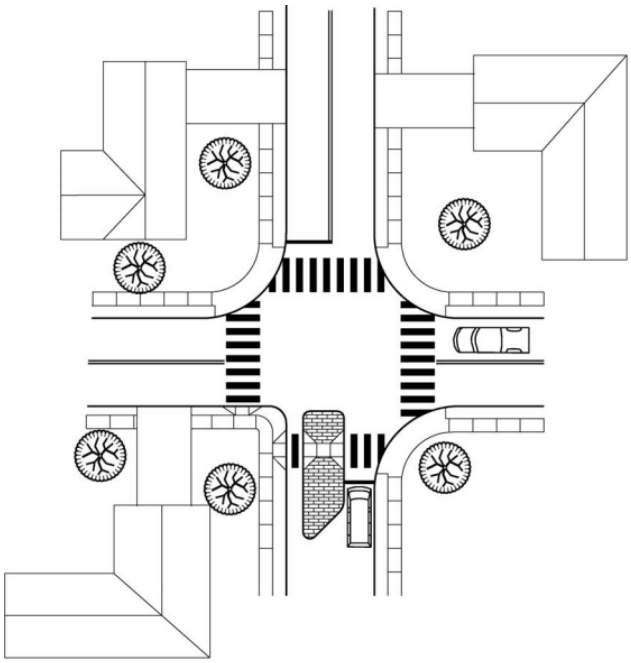
Project Description:

This intersection barrier provides a refuge for bicyclist and pedestrians, while allowing emergency vehicles to traverse its mountable curb. As a traffic diverter, the median restricts turning movements from Martin Luther King Jr Way, which eliminates a potential conflict point.

Partial Closure/Semi-Diverter

Description

Typical partial closure implementation can help improve safety by reducing intersection conflict points and cut-through traffic. These applications can also be designed to accommodate safer bicycle and pedestrian movements. An analysis of the shift in vehicular trips anticipated from partial closures should be conducted in order to assess whether travel demand as well as certain traffic movements can be accommodated within the project area roadway network.



Partial Closure/Semi-Diverter (DelDOT)

Placement

Best suited for installation along minor arterials or collectors at their intersection with a local road. Mid-block locations have a higher rate of violation (PennDOT). Extending the length of the semi-diverter can reduce violations.

Functional Classification: Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: All ADTs (FHWA)

Maximum Posted Speed Limit: ≤ 25 MPH on minor leg. No maximum posted speed limit on major leg (FHWA)

Grade: <6% (DelDOT)

Performance

Speed Reduction: 2-5MPH (PennDOT); Not expected to reduce speeds along side streets by much, since all vehicles will come to a stop in both the before and after conditions.

Volume Reduction: Up to 35-40% on local streets (DelDOT), 40-60% on local streets (PennDOT)

Impact on Emergency Response: Not recommended for placement along emergency access routes. Additionally, impacts to existing and potential future evacuation routes need to be considered in accordance with DIB 93. Project team should consult with Caltrans's Traffic Management, emergency response agencies and law enforcement agencies.

Mobility Impact: A transportation analysis may be needed to properly assess impacts from the throughput capacity reduction associated with typical partial closure projects within the project area and adjacent roadway network. Transportation analysis scope and methodology considerations include:

- Travel demand modeling to assess diversion impacts to other routes due to the reduction in capacity
- Analysis of the project area and impacted parallel facilities
- Intersection analysis and modeling should be conducted to assess potential operational deficiencies
- ISOAP and traffic control warrant analysis consistent with the California Manual on Uniform Traffic Control Devices (CA MUTCD) may be needed if there are major changes to travel demand
- Bicycle and Pedestrian analysis should be conducted consistent with HCM (Chapters 4, 15, 24, and 35) and FHWA methodologies
- Impacts of increased ADT due to diverted trips
- Impacts to local freight and truck circulation

For projects on the local road network, a transportation analysis that includes potential SHS impacts from diverted trips should be conducted through the Local Development Review (LDR) or Encroachment Permit process.

Maintenance Considerations

- Specialized equipment will be needed for snow plowing the bike cut-out
- Consider maintenance and access if landscaped
- Consider surface treatment upkeep and maintenance of flex posts

Other Considerations

- Low-laying shrubbery are preferred to maintain sight lines if landscaped
- Impacts to large design vehicle tracking and swept width lines
- Consider mountable curb to allow emergency access
- Impact to drainage
- Public engagement is recommended

References

1. Traffic Calming ePrimer - FHWA
2. Design Information Bulletin (DIB) 93 - Caltrans
3. Highway Capacity Manual 7th Edition - The National Academies Press
4. Pedestrian & Bicycle Safety - FHWA
5. Traffic Analysis and Intersection Considerations to Inform Bikeway Selection - FHWA

Sample Project

29th St and G St in Sacramento, CA (Google Earth)

Project Description:

The City of Sacramento implemented partial closure calming measure to reduce conflict points and cut-through traffic. This measure has the added benefit of accommodating safer bicycle and pedestrian movements through the street by restricting traffic.

Right-In, Right-Out

Description

Typical right-in, right-out implementation can help improve safety by reducing intersection conflict points, cut-through traffic, and restricting movements that have a higher likelihood of more severe injury crashes. These applications can also be designed to accommodate safer bicycle and pedestrian movements. An analysis of the shift in vehicular trips anticipated from right-in, right-out projects should be conducted to assess whether travel demand and certain traffic movements can be accommodated within the project area and roadway network.

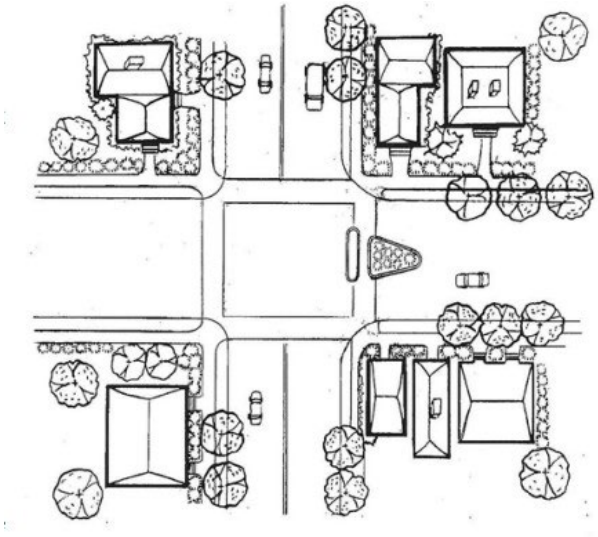


Image of Right-In, Right-Out (PennDOT)

Placement

At an intersection of a local road that intersects a collector or minor/ principal arterial in Urban Area or Suburban Area. Also recommended at intersections of local streets with major roadways that have a documented cut-through traffic issue or safety concerns with the left-turn movement.

Functional Classification: Local Roads

Appropriate Daily Volume Range: 500-7,500 ADT with >25% Non-Local Traffic (El Paso)

Maximum Posted Speed Limit: Generally, 25 MPH or less on local road (DelDOT)

Performance

Speed Reduction: Little to no impact on speed (PennDOT)

Volume Reduction: 20-60% along the local road (PennDOT)

Impact on Emergency Response Access: If along a primary emergency response route, the curb should be designed to allow emergency vehicles to make left-turns to/from the minor roadway. Additionally, impacts to existing and potential future evacuation routes need to be considered in accordance with DIB 93. Project team should consult with Caltrans's Traffic Management, emergency response agencies and law enforcement agencies.

Mobility Impact: A transportation analysis may be needed to properly assess impacts from the throughput capacity reduction associated with typical right-in, right-out projects within the project area and adjacent roadway network. Transportation analysis scope and methodology considerations include:

- Travel demand modeling to assess diversion impacts to other routes due to the reduction in capacity
- Analysis of the project area and impacted parallel facilities
- Intersection analysis and modeling should be conducted to assess potential operational deficiencies
- ISOAP and traffic control warrant analysis consistent with the California Manual on Uniform Traffic Control Devices (CA MUTCD) may be needed if there are major changes to travel demand
- Bicycle and Pedestrian analysis should be conducted consistent with HCM (Chapters 4, 15, 24, and 35) and FHWA methodologies.
- Impacts of increased ADT due to diverted trips
- Impacts to local freight and truck circulation

For projects on the local road network, a transportation analysis that includes potential SHS impacts from diverted trips should be conducted through the Local Development Review (LDR) or Encroachment Permit process.

Other Considerations

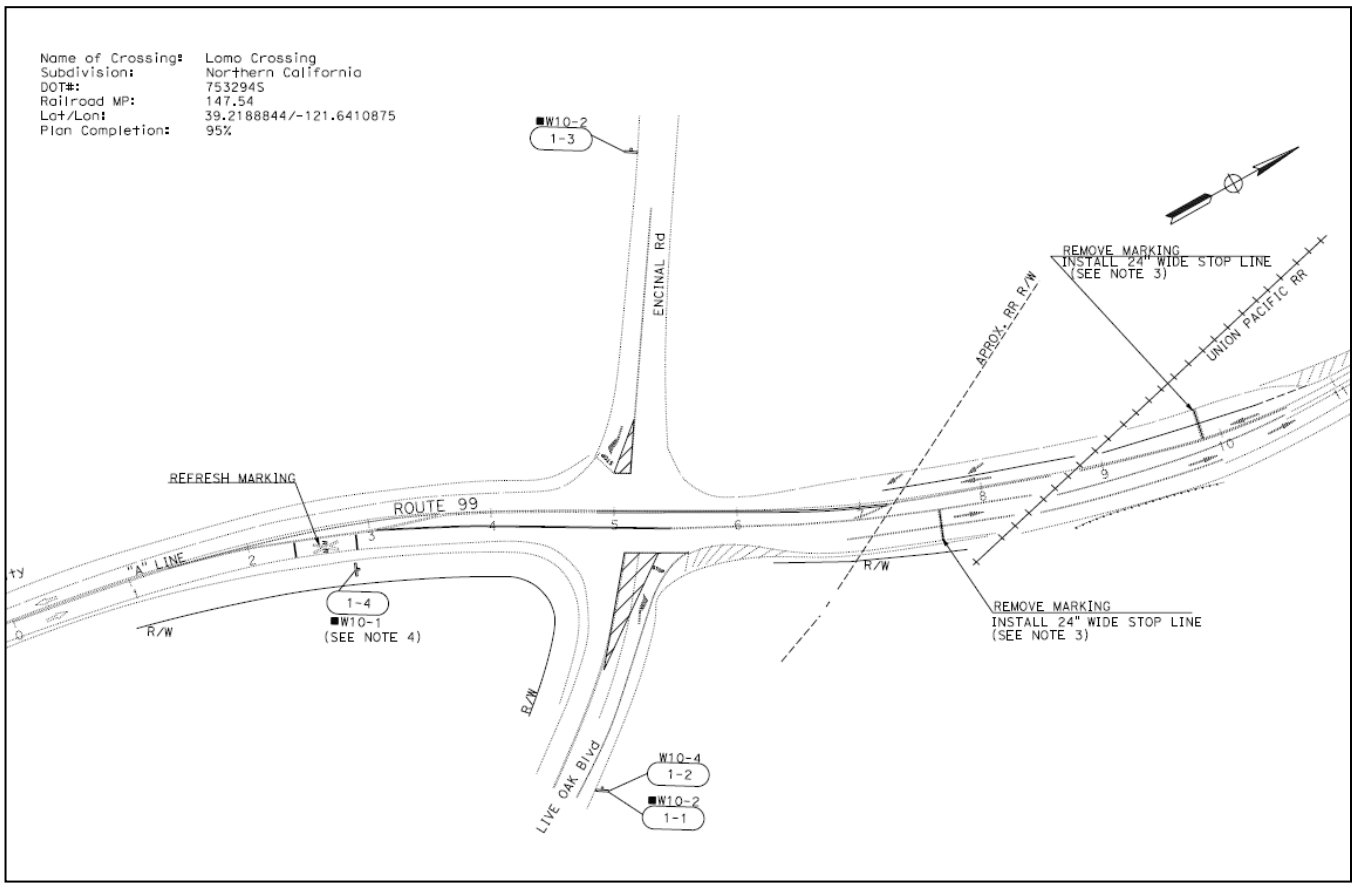
- Forced turn island can be designed with mountable curb to accommodate oversized vehicles. Refer to HDM Topic 404 Design Vehicles
- Force turn island can be designed as a pedestrian refuge if there is adequate roadway width
- Access for snow equipment
- May impact existing utilities

References

1. Design Information Bulletin (DIB) 93 - Caltrans
2. Traffic Calming ePrimer - FHWA
3. Traffic Calming Fact Sheets - ITE

4. Highway Capacity Manual 7th Edition
5. Pedestrian & Bicycle Safety - FHWA
6. Traffic Analysis and Intersection Considerations to Inform Bikeway Selection - FHWA

Sample Project



Lomo Crossing project on State Route 99 in Live Oak

Project Description:

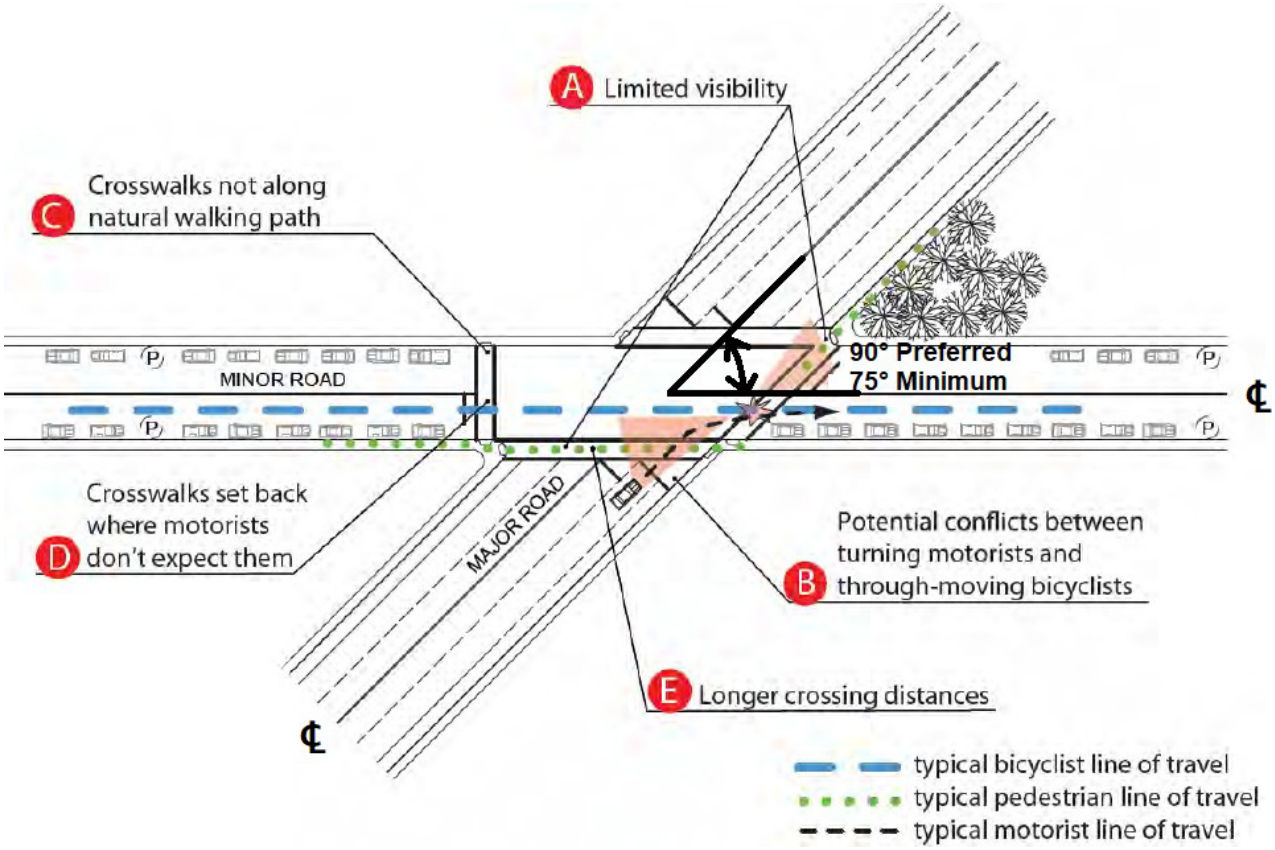
The Lomo Crossing project on State Route 99 in Live Oak, CA is proposing intersection improvements that include restricting through and left-turning movements with right-in, right-out implementation. The project will improve safety by reducing the likelihood of severe crashes, which occur from the minor street crossing movements. An interim temporary barrier was constructed to achieve right-in, right-out benefits before full project implementation.

Tee-up Intersection and Reduce Corner Radii

Description

Corner radii directly impacts vehicle turning speeds and pedestrian crossing distances. Minimizing the size of a corner radius is critical to creating compact intersections with safe turning speeds.

The prevalence of speeding vehicles at skewed intersections can have a negative effect on all users of the intersection. If the State highway alignment has an angle or curve, a reconstructed intersection with right angles will induce slower speeds to negotiate the turning movements. This concept is especially useful at interchange ramp intersections with local roads. Common issues seen at skewed intersections are illustrated in the figure below.



Minor Leg Skewed to the Right

Placement

A right angle (90°) intersection provides the most favorable conditions for intersecting and turning traffic movements. Large deviations from right angles may decrease visibility, hamper certain turning operations, encourage high speed turns, and may reduce yielding to turning traffic. Furthermore, it will increase the size of intersection and therefore increase crossing

distances for bicyclist and pedestrian. Guidance for angle of intersections is contained in the HDM Index 403.3.

The guidance within HDM Index 405.8 discusses design elements that should be accounted for when adjusting City Street Returns and Corner Radii.

Functional Classification: Minor Arterial, Collector, and Local Roads

Appropriate Daily Volume Range: N/A

Performance

Speed Reduction: Turning speeds should be limited to 15 MPH or less when reducing corner radii. Minimizing turning speeds is crucial to pedestrian safety, as corners are where drivers are most likely to encounter pedestrian crossing in the crosswalk (NACTO).

Volume Reduction: This is not well documented and depends on the level of discomfort experienced by turning vehicles as well as the availability of alternative routes.

Impact of Emergency Response Routes: Minimal

Mobility Impact: Varying. An assessment of the potential mobility impacts may be needed for intersections with heavy travel demand or concentrated peak hour movements. If applied to ramp termini intersections, additional improvements may be needed to reduce potential mobility impacts. Refer to ISOAP Process Information Guide for more information. Truck turning movement impacts should be considered.

Other Considerations

- Consider additional intersection lighting
- Consider existing drainage impacts and utility relocation
- Consider including all modes of transportation
- Consider extending median curbs, where necessary to discourage wrong-way movements onto the mainline at interchanges
- Additional right of way acquisition maybe required
- Where right of way is constrained in an urban environment, consider evaluating other types of intersections such as roundabouts
- Design Vehicle swept path and tracking analysis should be performed when reducing corner radii
- Corner Sight Distance Analysis

References

1. Highway Design Manual Chapter 400
2. Design Information Bulletin 94, Complete Streets
3. Complete Intersections-Caltrans
4. Urban Street Design Guide- NACTO

Sample Project

Before (Google Earth)

After (Google Earth)

Project Description:

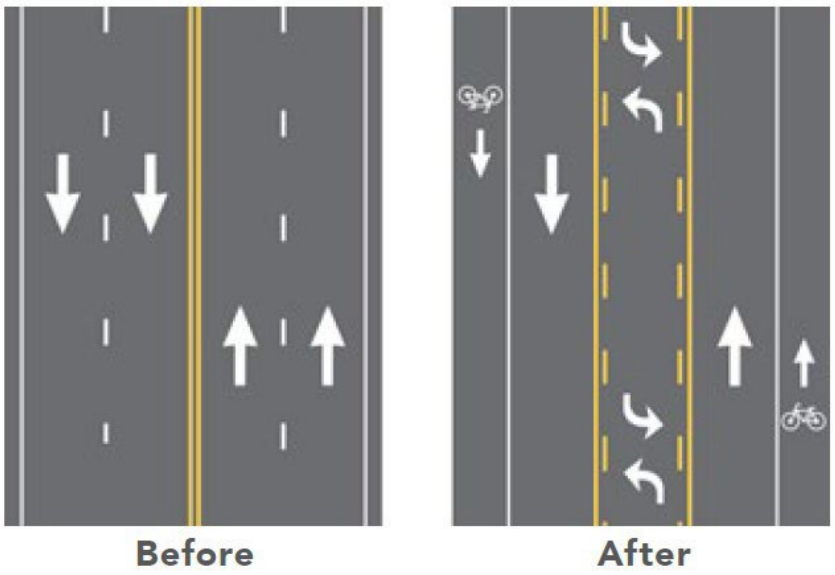
The project is located at Main Ave and Rio Linda Blvd in Sacramento County. Improvements include, tee-up intersection improvement, new bus stop, traffic signalization, dedicated bike lanes, turn pockets, crosswalk markings, etc.

Category C. Roadway Narrowing

Road Diet

Description

Typical road diets include roadway treatments that reduce the number of travel lanes and/or lane widths in order to address transportation deficiencies. Road diet in general allows reclaimed space to be allocated for other uses, such as bike lanes, sidewalks, bus islands and shelters, bus lanes, landscaping, pedestrian refuge islands, turn lanes, or parking. These modifications are intended to encourage slower operating speeds and provide new or enhanced facilities for bicycles, pedestrians, and transit users by reducing vehicular capacity. The reallocation of roadway space is intended to promote active transportation facilities as well as pedestrian and bicycle safety. A multi-modal transportation analysis is necessary to quantify mobility and safety impacts within the project area as well as adjacent roadway network.



Road Diet (FHWA)

Placement

See Table 1 for more information on placement.

Functional Classification: Principal and Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: 20,000 ADT or less or a peak hour volume below 1,000 after implementation (FHWA). Caltrans Traffic Management should be consulted for road diet projects with volume beyond 20,000 ADT.

Speed Limit: Most common urban speed limits (FHWA)

Performance

Speed Reduction: There is a wide range of road diet layouts that can result in various levels of speed reduction. Speed reduction is mainly due to an increase in congestion as well as driver discomfort due to narrower lane widths. Two field studies measured reductions of 1-2 MPH for the 85th percentile speed (FHWA).

Volume Reduction: Low, assuming that the road diet was applied to roadways with low demand, so that the proposed configuration can meet the capacity of the roadway. Road diet implementation can increase the use of other multi-modal facilities, which can reduce the volume of motorist. A traffic impact analysis may be needed for road diets, where the roadway cannot fully meet the demand of the new configuration.

Impact to Emergency Response: Nominal. If the project is on emergency access routes, road diets should be assessed for changes in response time and alternative emergency access routes. Impacts to existing and potential future evacuation routes will need to be considered in accordance with Design Information Bulletin (DIB) 93. Project team should consult with Caltrans's Traffic Management, emergency response agencies, and law enforcement agencies for their input.

Mobility Impact: A transportation analysis is needed to properly assess impacts from the throughput capacity reduction associated with typical road diet projects within the project area as well as adjacent roadway network. Transportation analysis scope and methodology considerations include:

- Travel demand modeling to assess diversion impacts to other routes due to the reduction in capacity
- Analysis of the project area and impacted parallel facilities
- Intersection analysis and modeling should be conducted to assess potential operational deficiencies
- Intersection Safety and Operational Assessment Process (ISOAP) and Highway Safety Manual (HSM) analysis may be needed if there are major physical changes or travel demand in the project area. Traffic control warrant analysis should be consistent with the California Manual on Uniform Traffic Control Devices (CA MUTCD)
- Bicycle and Pedestrian analysis should be conducted consistent with HCM (Chapters 4, 15, 24, and 35) and FHWA methodologies.
- Impact of ADT due to diverted trips.
- Impact to local freight and truck circulation.

For projects on the local road network, a transportation analysis that includes potential SHS impacts from diverted trips should be conducted through the Local Development Review (LDR) or Encroachment Permit process. In addition to the considerations above, the analysis should

include ramp queueing.

Maintenance Considerations

- Consider durability of markings and reflectivity
- Ensure traces of old markings are removed
- Recess pavement marking for locations with snow operations

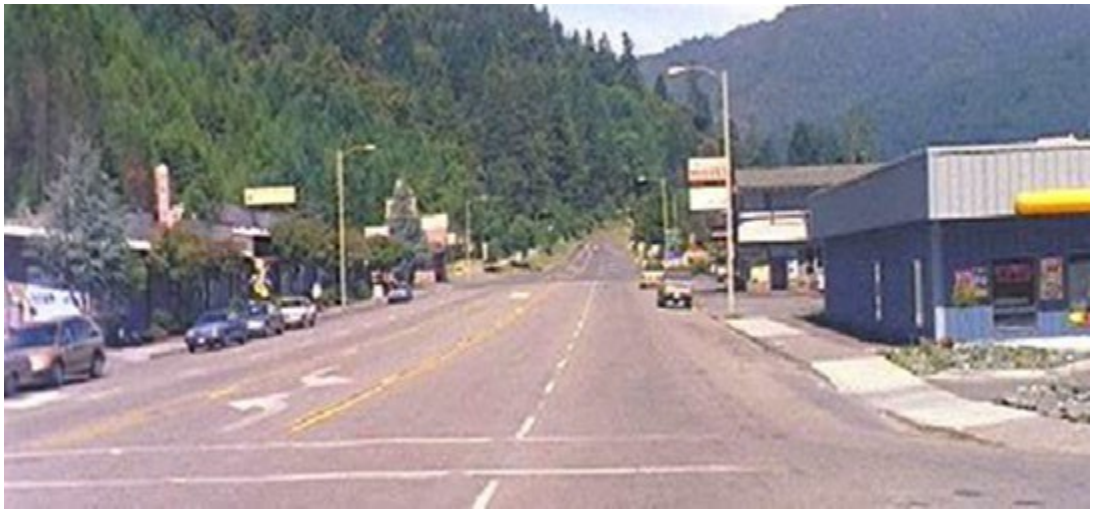
Other Considerations

- Provide consistency between adjacent roadway sections and provide transitions through intersections. Consider protected intersections for non-motorized users
- Project context and types of roadway users within a project segment can determine if road diets are appropriate to accommodate non-motorized users. See DIB 94 for low speed facilities in Urban Area, Suburban Area, and Rural Mainstreet
- Consider future plans for bus routes, bike facilities, pedestrian facilities, etc
- Signals may need to be modified with the implementation of a road diet, which can eliminate the number of lanes, turn pockets as well as providing a signal for bicycles
- Most common configuration: Reducing through lanes from four to two, while providing a center two-way left-turn lane (TWLTL)
- Can include bicycle lanes, transit lanes, bus turnouts, on-street parking, physical safety barriers (curb extensions, raised medians, pedestrian refuge islands, etc.), sidewalk widening, and/or wider shoulders (FHWA)
- Requirements from HDM Chapter 300 and the CA MUTCD should be considered depending on project scope
- Roadway narrowing with edge lines (creating 10.5 ft wide lanes) can reduce speeds 1 to 2 MPH. Reductions up to 5 MPH have been reported. Refer to DIB 94 for lane narrowing in Urban Area, Suburban Area, and Rural Mainstreet in low speed environment

References

1. Design Information Bulletin (DIB) 94
2. Highway Design Manual (HDM) Chapter 300 - Caltrans
3. California MUTCD - Caltrans
4. Traffic Calming ePrimer - FHWA
5. Road Diet Polices - FHWA
6. Proven Safety Countermeasures - FHWA

Sample Project



State Route 299 Willow Creek, CA (Before)

State Route 299 Willow Creek, CA (After)

Project Description:

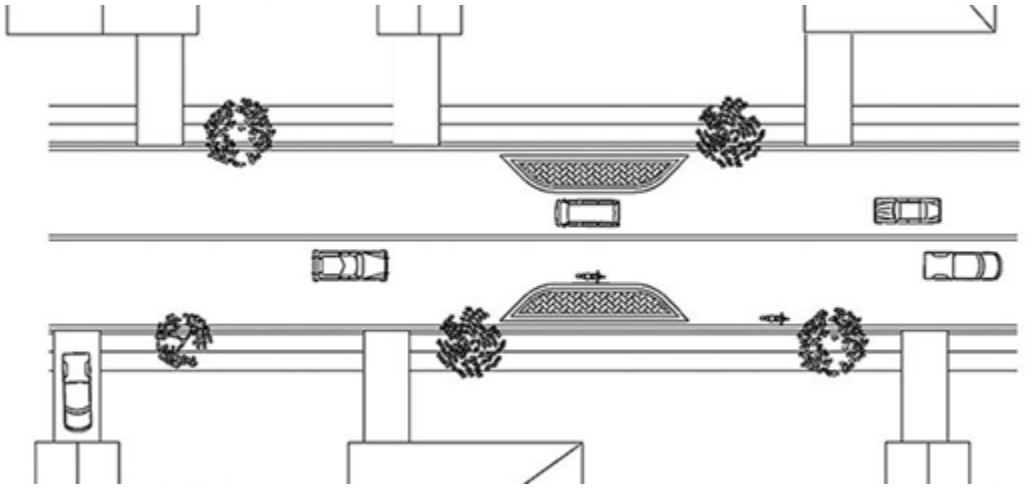
State Route 299 in downtown Willow Creek implemented a road diet treatment to convert an existing 4-lane roadway with two-way left turn lane (TWLTL) to a 2-lane roadway with TWLTL and a dedicated bike lane on each side. Some of the roadway cross-section was also reallocated to provide landscaping and street trees. These improvements lead to both a physical and perceived narrowing of the roadway. Refer to section F.1 for the traffic calming benefits of landscaping and street trees.

Neckdowns/Chokers

Description

A choker is a horizontal extension of the curb at a midblock on a street resulting in a narrower roadbed section.

Other terms for choker include: neckdown, midblock narrowing, midblock yield point, pinch point, constriction, or edge island. If the choker is a marked crosswalk, it is sometimes referred to as a safe cross.



Choker Schematic (Source: Delaware Department of Transportation)

Placement

Mid-block, along the shoulder on both sides of the street. The curb face of each choker should be setback a minimum of 2 feet from the class II bikeway or State Highway travel lane (HDM 303.4).

Functional Classification: Collectors and Local Roads (NOTE: Only local roads are suitable for neckdowns/chokers that reduce operations to one direction)

Appropriate Daily Volume Range: DelDOT: ≤ 20,000 ADT; El Paso: 500-7,500 ADT (NOTE: These daily traffic volumes refer to chokers that maintain two-way operations. Chokers that restrict travel to one direction at a time will require additional consideration to account for more complex operational impact.)

Speed Limit: 35 MPH or less (HDM 303.4)

Minimum Lane Width: The minimum lane width varies by ADT. For complete street contextual guidance, see DIB 94.

Maximum Grade: 5% (HDM 303.4)

Performance

Speed Reduction: 1-4 MPH reduction in 85th percentile speeds (FHWA); Up to 5 MPH (PennDOT)

Volume Reduction: Nominal impact (FHWA)

Impact to Emergency Response: Nominal. Determine whether your project is designated as an evacuation route. See DIB 93 for further guidance.

Mobility Impact: Nominal for vehicles. Vehicles are capable of passing each other without conflict within a choker. This narrowing is intended to discourage motorist from speeding and to reduce vehicle speeds in general. Bicycles may be impacted with the implementation of choker depending upon available shoulder/bike lane between vehicle lane and curb.

Maintenance Considerations

SNOW

- Design choker to accommodate snow storage
- Design choker to accommodate width of snowplow
- Consider signage or other devices to alert snowplow operators

OTHER

- Consider impact on drainage to gutter
- Consider maintenance and irrigation if landscaping is provided

Other Considerations

- Chokers can be created by either curb extensions or roadside islands. Roadside islands are less appealing aesthetically but leave existing drainage channels open. They also make it possible to provide a bicycle bypass lane on streets without curbside parking. If motor vehicle volumes are large, chokers can be challenging to bicyclists, who may need to navigate through traffic congestion. Bicycle bypass lanes should be considered in such cases
- Consider bicyclists during the design process. The probability of vehicles and bicycles meeting at a choker is low and require no special accommodation for bicycles when streets have little bicycle traffic and/or low motor vehicle volumes. Provide sharrow markings in advance of choker to alert vehicles of the need to share the space with bicyclists where no bicycle bypass lane is provided. Consider providing a bypass lane for bicycles that are separated from the travel lanes by the curb extension on wider streets with higher volumes

- The length of a choker can vary depending on the location of driveways and curbside parking but should be a minimum of 20 feet long (DelDOT)
- A choker may be a good location to place a midblock crosswalk and can be leveled with the roadbed or as a raised crosswalk. Chokers shorten the crossing distance as well as increasing the visibility of pedestrians, while providing protection with curbs
- To comply with the International Fire Code that has been adopted by emergency services, the minimum street width between the choker islands shall be 20 feet
- A midblock location near a streetlight is preferred for a choker
- May require relocation of drainage features and utilities
- Edge line tapers should conform to the CA MUTCD taper formulas and accommodate street sweeping equipment
- Curb extensions that create choker (narrowing) should include signs that are compliant with the CA MUTCD. Landscaping features can also enhance this calming measure by drawing motorist attention the chokers. The preference for landscaping are low-lying, slow growing shrubs or herbaceous perennial plants to maintain adequate sight lines and to minimize maintenance costs
- See HDM Topic 303 for selection of curb type
- See CA MUTCD for painting of curb adjacent to choker

References

1. Highway Design Manual (HDM) Index 303.4(1) - Caltrans
2. California MUTCD - Caltrans
3. Traffic Calming ePrimer - FHWA
4. Design Information Bulletin (DIB) 94 - Caltrans
5. Design Information Bulletin (DIB) 93 - Caltrans

Sample Project

Two-lane chokers in Stockton, CA

Project Description:

The City of Stockton implemented chokers on their two-lane roadway to slow vehicles within this corridor. Chokers can act as a transition between commercial and residential area. These chokers provide an added buffer for signage and planting that otherwise would restrict the existing pedestrian path.

Curb Extension/Bulbouts

Description

Bulbouts are a type of curb extension used for the benefit of pedestrians because it shortens the crossing distance and provides more area and visibility for pedestrians. Bulbouts have a traffic calming effect because it requires more attention from the driver, while inducing a speed reduction due to larger turning maneuvers.

Esparto Improvement project on State Route 16 in Esparto, CA

Placement

Bulbouts should comply with the HDM Figures 303.4A and B, while also considering site specific conditions. Bulbouts should be placed at all corners of an intersection. When used at mid-block crossing locations, bulbouts should be used on both sides of the street. The curb face of the bulbout should be setback a minimum of 2 feet from either the traveled lane or class II bikeway. For full details of the standards, refer to HDM 303.4.

Functional Classification: Minor Arterial, Collectors, and Local Roadways

Maximum Posted Speed Limit: Most appropriate for posted speeds 35 miles per hour or less. Refer to HDM 303.4

Minimum Lane Width: Varies based on ADT and other project site condition. For complete street contextual guidance, see DIB 94

Performance

Speed Reduction: 1 to 3 MPH reduction in 85th percentile speeds of through vehicles (FHWA). Turning speeds will be reduced more significantly

Volume Reduction: Nominal, but some turning volumes might decrease depending on the level of driver discomfort as well as the availability of alternative routes

Impact on Emergency Response: Nominal but turning radius of emergency vehicles should be considered if located along an emergency response route. See DIB 93 for further guidance

Mobility Impact: Nominal

Maintenance Considerations

SNOW

- Need to alert snowplow operators
- Consider snow storage

OTHER

- Consider impact to drainage and underground utilities
- Consider accommodations for commercial vehicles off-tracking (e.g., truck aprons)

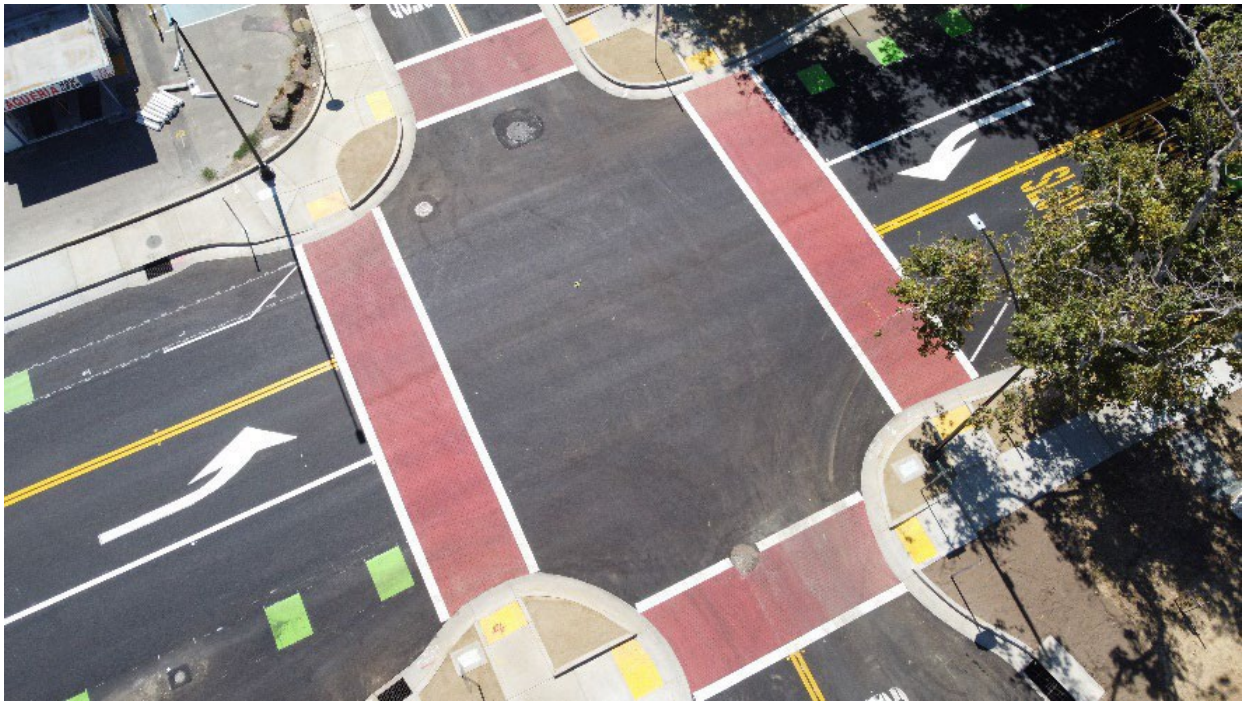
Other Considerations

- Drainage and existing utility relocation
- Should not extend into bicycle lanes
- Consult with the District Pedestrians and Bicyclists Safety Engineer
- Opportunities to provide green infrastructure
- Tracking and swept widths for Design Vehicles
- Bulbouts work well in situations where on-street parking is present. On-street parking may provide separation from errant vehicles
- Bulbouts may be designed to include protected crossings for bicycles
- Coordinate with the District Truck Access Manager to ascertain the oversize/overweight vehicles accommodation and as any additional vehicle requirements
- For added pedestrian visibility at mid-block crossings, consider crosswalk enhancement features discussed in “Category A, Signings and Markings”

References

1. Highway Design Manual (HDM) Index 303.4 - Caltrans
2. Highway Design Manual (HDM) Index 404.4 - Caltrans
3. Design Information Bulletin (DIB) 94 - Complete Streets
4. Design Information Bulletin (DIB) 93 – Evacuation Route Design Guidance
5. FHWA Traffic Calming ePrimer Section 3.16
6. NACTO Don't Give Up at the Intersection

Sample Project



Route 16 in Yolo County, CA

Project Description:

The project is located in Yolo County on State Route 16 from Orleans Street to County Road 21A. Pedestrian improvements include crosswalks, sidewalks, curb bulbouts, upgraded curb ramps, improved lighting, green bicycle lane treatment, pavement rehabilitation, parking, etc.

On-Street Parking

Description

On-street parking can assist in achieving lower operating speeds by constricting driver experience with increased side friction. On-street parking may also be used as bikeway separation from the traveled lane, which enhances bicyclist comfort by providing physical separation from motor vehicles as well as providing traffic calming. On-street parking can either be parallel or angled, parallel parking provides more potential for speed reductions. Typical applications can include parking on both sides of the roadway, either side, or alternating from one side to the other for a chicane effect. On-street parking can be combined with other traffic calming measures.

Back-Angled Street Parking (SR99 in Live Oak, CA)

Placement

Appropriate at midblock location or near an intersection. Parking should be prohibited within close proximity to an intersection to allow for adequate corner sight distance. Curb extension can be implemented to allow for on-street parking, while offering a shorter crossing distance for pedestrians

Functional Classification: Principal Arterials, Minor Arterials, Collectors, and Local Roads

Maximum Posted Speed Limit:Appropriate for common urban speed limit. Consider providing

shy distance between parked vehicles and the through lanes (FHWA)

Performance

Speed Reduction: 1-5 MPH reduction, with 2-3 MPH being the most common (FHWA)

Volume Reduction: Little to no impact

Impact on Emergency Response: Nominal

Mobility Impact: Analysis of impacts to the project area or roadway network that is consistent with HCM (Chapters 15, 16, 18, 29, and 30) methodologies should be conducted

Maintenance Considerations

- Consider impact on-street sweeping or snow plowing operations

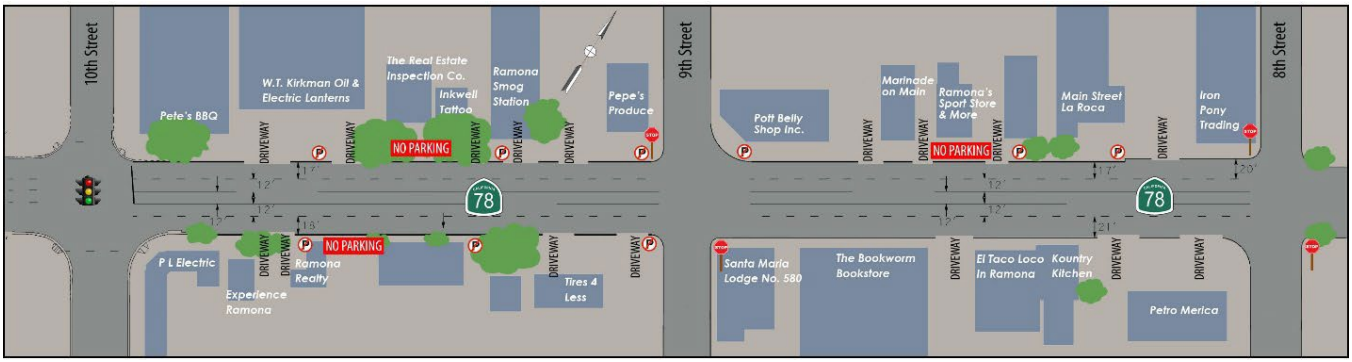
Other Considerations

- Requires local agency enforcement of no parking regulatory signage during plowing or sweeping operations
- Coordination with local agencies may be necessary to remove, change, or enforce parking
- May impact road user visibility and sight distance at driveways, alleys, and intersections
- If paired with bike lane, consider bike lane buffer and/or wider bike lane to protect cyclists from car doors
- Reduces effective width of roadway if more than half of a block-face is occupied
- Can be paired with curb extensions or bulb-outs to protect parking
- Parallel parking preferred for speed reduction
- Consider parking demand and back-in angle street parking
- Provides protective buffer between pedestrians and moving traffic
- Requirements from HDM Chapter 300 should be considered depending on project scope
- ADA-compliant spaces may be necessary depending on context. Refer to DIB 82
- Consult with the District Traffic Safety Engineer and/or the District Bicyclist and Pedestrian Safety Engineer for the implementation of this measure

References

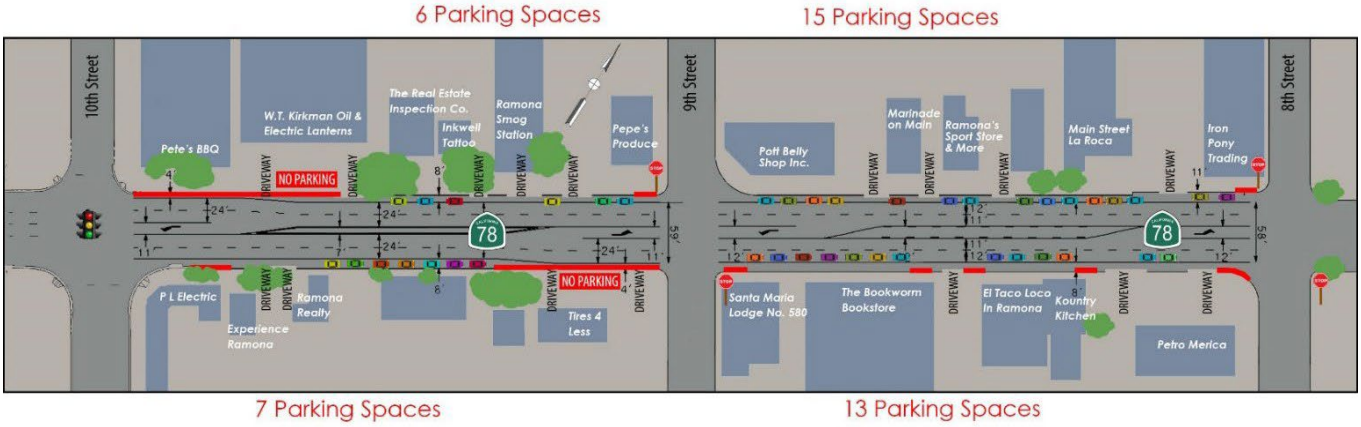
1. Highway Design Manual (HDM) - Chapter 300
2. Traffic Calming ePrimer - FHWA
3. Traffic Calming Fact Sheet - ITE
4. Highway Safety Manual - AASHTO
5. Highway Capacity Manual 7th Edition - The National Academies Press
6. California MUTCD - Caltrans

Sample Project



Before Project

- NO PARKING allowed on both sides of the street between 9th and 10th
- NO PARKING allowed on the westbound side of the street between 8th and 9th



After Project

- Parallel parking spaces for 21 vehicles on the westbound side and 20 on the eastbound side provided

Project Description:

41 additional parking spaces have been provided that were previously designated as no parking areas along State Route 78 in Ramona, California. This feature was implemented in addition to road diet implementation that narrowed the roadway to reduce vehicle speeds.

Raised Median Island/Traffic Island

Description

Traffic Islands are typically used for channelization but could also be used for traffic calming, since it introduces a curb adjacent to vehicles and has the effect of slowing vehicles. Pedestrian refuge islands and raised median islands are commonly used together. Landscaping the raised median island contributes to community livability and environmental sustainability. The proposed landscaping should not impair sight distances.

State Route 131 in Tiburon, CA (Google Earth)

Placement

For guidance on design and delineation of traffic islands / raised medians island, see the HDM Index 405.4. Table 405.4 provides information regarding commonly used parabolic curb flares. The California MUTCD should be referenced when considering the placement of traffic islands at signalized and unsignalized intersections. The HDM index 405.4 also provides additional information on pedestrian refuge. All traffic islands placed in the path of a pedestrian crossing must comply with DIB 82.

The guidance in the HDM Topic 904 applies if landscaping is provided within the island. The FHWA Traffic Calming ePrimer Section 3.18 contains useful information on Raised Median Islands/Traffic Islands.

Functional Classification: Minor Arterials, Collectors, and Local Roads

Maximum Posted Speed Limit: Appropriate for roadways under 35 MPH posted speed limit

Minimum Lane Width: Varies by ADT and other project specific site condition. For complete street contextual guidance, see DIB 94

Performance

Speed Reduction: 1-8 MPH Reduction of 85th percentile speed depending on the degree of lane narrowing and the volume of traffic (FHWA)

Volume Reduction: Negligible

Impact on Emergency Response: Nominal. Raised Median Islands and Traffic Islands can affect the ability to move large volumes of people and vehicles into and out of communities within designated evacuation routes. Refer to DIB 93, Evacuation Route Design Guidance.

Mobility Impact: Nominal

Maintenance Considerations

SNOW

- Need signage to alert snowplow operators

OTHER

- If landscaped, need to consider maintenance and access
- Need to consider impact on drainage and existing utilities, which may require relocation
- Consider effectiveness of mountable curbs

Other Considerations

- May impede with large vehicle turning movements
- Consider impact of blocking left turns from driveways.

References

1. Highway Design Manual (HDM) Index 405.4 - Caltrans
2. Highway Design Manual (HDM) Topic 904 - Caltrans
3. Traffic Calming ePrimer (Section 3.18) - FHWA
4. Design Information Bulletin (DIB) 82 - Caltrans
5. Design Information Bulletin (DIB) 94 - Caltrans
6. Design Information Bulletin (DIB) 93 - Caltrans

Sample Project

Live Oak Complete Streets on State Route 99 in Live Oak, CA

Project Description:

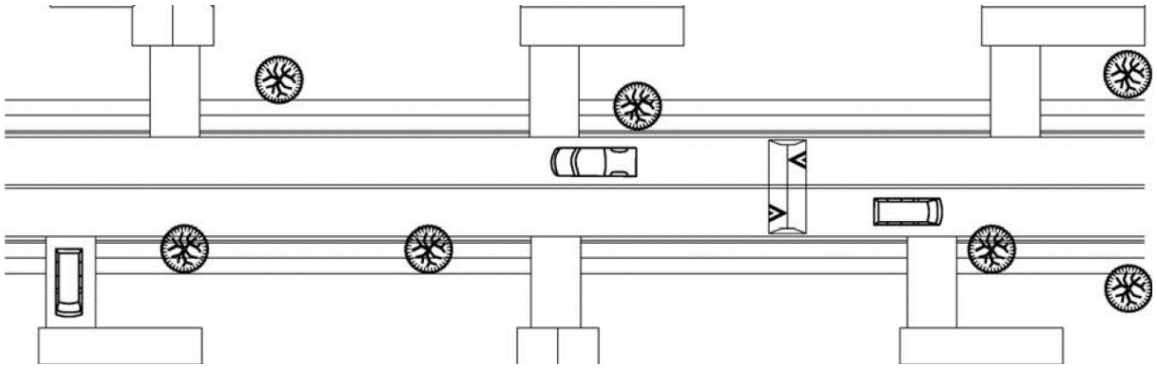
The project is located along SR 99, south of Coleman Ave and extends to the north of Nevada Street within the City of Live Oak in Sutter County. Improvements within this project include, rehabilitating pavement life, upgrading drainage systems, constructing new continuous sidewalks, improving traffic signals, providing parking, upgrading curb ramps, constructing raised median island, etc.

Category D. Vertical Roadway Elements

Speed Hump

Description

A speed hump is an elongated mound in the roadway pavement surface extending across the traveled way at a right angle to the traffic flow. A speed hump is typically 12 feet in length (in the direction of travel) and 3 to 4 inches in height. The purpose of a speed hump is to discourage speeding by producing sufficient discomfort to a motorist while driving through it. A speed hump is also referred to as a road hump or undulation.



Speed Hump Schematic (DelDOT)

Placement

Mid-block, not near an intersection. Should not be placed on a sharp curve.

Functional Classification: Local Roads

Appropriate Daily Volume Range: 3,500 ADT (PennDOT). Consider only if no more than 5% of the overall traffic flow consists of long-wheelbase vehicles (ITE)

Maximum Posted Speed Limit: 30 MPH (ITE)

Performance

Speed Reduction: A single speed hump reduces vehicle speeds to a range of 15 to 20 MPH when crossing the hump. To keep 85th percentile operating speed between 25 MPH to 30 MPH, a series of speed humps at spacing between 260’ to 500’ is recommended (ITE)

Volume Reduction: 20% (DelDOT) - The reduction will depend on the impact to travel time and the availability of an alternative route.

Impact to Emergency Route Access: Typically, delay for a fire truck is in the 3 to 5 seconds range. Delay can be as much as 10 seconds for an ambulance with a patient. Consider using a speed cushion or an offset speed table to help mitigate delay. See DIB 93 for further guidance.

Mobility Impact: Moderate

Maintenance Considerations

SNOW

- Signing to alert snowplows to avoid damage to approach ramps
- Consider snowplow design when choosing approach ramp shape (straight, sinusoidal, or parabolic)

OTHER

- Visibility of warning sign
- May impact street sweeping operations
- Pavement marking upkeep due to constant traffic wear

Other Considerations

- The SPEED HUMP (W17-1) sign should be used to give warning of a vertical deflection in the roadway that is designed to limit the speed of traffic. The SPEED HUMP sign should be supplemented by an Advisory Speed plaque. See CA MUTCD Section 2C.29 for additional information on Speed Hump Sign
- If speed hump markings are used, they shall be a series of white markings placed on a speed hump to identify its location. See CA MUTCD Section 3B.25 for additional information on Speed Hump Markings
- Speed humps may present a potential obstacle to all vehicles including bicyclists, motorcyclists, and emergency vehicles
- Speed humps implementation will result in an increase in vehicle noise
- Traffic may diverge from roads to adjoining parallel roads where speed humps are installed. Drivers may swerve to avoid speed humps
- Consult with regional transit, emergency services, and fire departments prior to the installation of speed humps
- May impact drainage on roadways where drainage gutter or flow of water is in the center of roadway
- Consider street lighting near speed humps
- Speed humps should not be installed in front of driveways or other significant access areas

References

1. California MUTCD - Caltrans
2. Design Information Bulletin (DIB) 93 - Caltrans
3. Traffic Calming ePrimer - FHWA
4. Updated Guidelines for the Design and Application of Speed Humps - ITE

Sample Project

Speed Hump in Stockton, CA

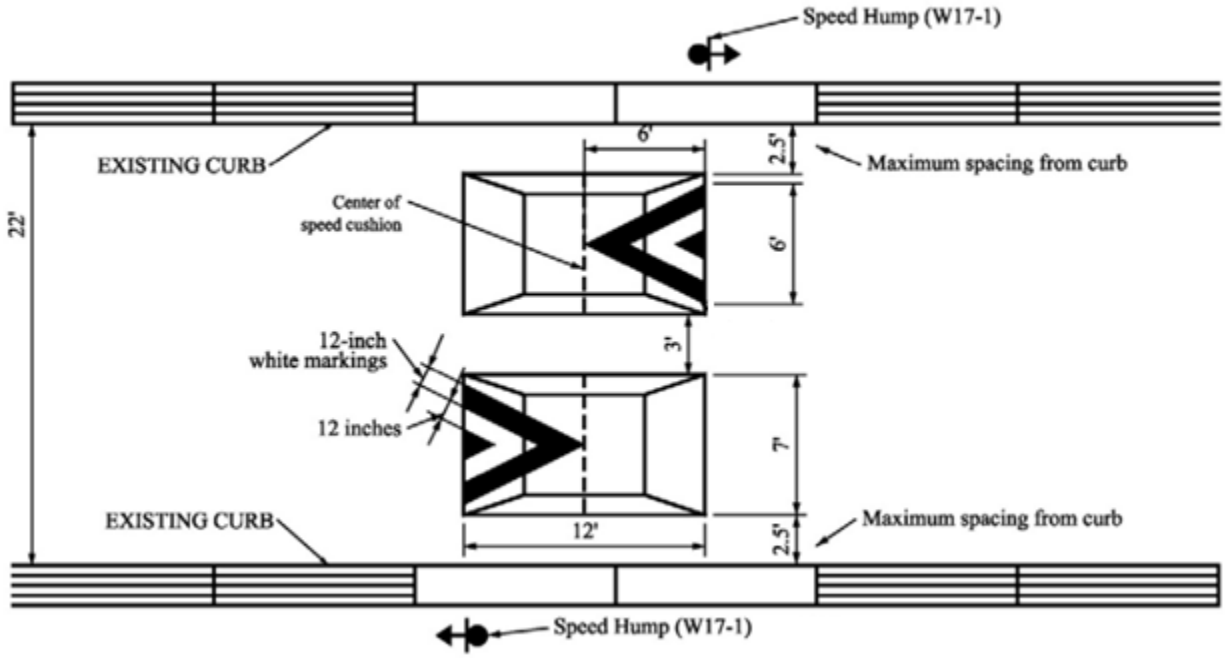
Project Description:

The City of Stockton implemented speed humps within residential area to discourage speeding.

Speed Cushion

Description

A speed cushion consists of two or more raised mounds placed laterally across a roadbed. The height and length of the raised mounds are comparable to the dimensions of a speed hump. The primary difference is that a speed cushion has gaps (often referred to as "cutouts") between the raised mounds to enable a vehicle with a wide track (e.g., a large emergency vehicle, some trucks, some buses) to pass through the feature without any vertical deflection. Another difference between a speed cushion and a speed hump is that the top of the speed cushion is usually levelled. Speed cushions can be more accommodating for users on two-wheeled modes such as cyclists and motorcyclists when compared to speed humps due to the gaps provided. A speed cushion is often the preferred alternative to a speed hump on a primary emergency response route, a transit route with frequent service, or when higher truck volumes are anticipated. A speed cushion is also known as a speed lump, speed slot, and speed pillow.



Speed Cushion Schematic with Median (DelDOT)

Placement

Appropriate at midblock, not near an intersection. Should not be placed on a sharp curve.

Functional Classification: Local Roads

Appropriate Daily Volume Range: 3,500 ADT (PennDOT)

Maximum Posted Speed Limit: 30 MPH (ITE)

Performance

Speed Reduction: Single speed cushion reduces vehicle speeds to a range of 15 to 20 MPH when crossing the hump. To keep 85th percentile operating speed between 25 MPH to 30 MPH, a series of speed humps spaced between 260' to 500' is recommended (ITE). Average speeds are typically higher when compared to a speed hump because speed cushion allows a motorist to pass over the cushion with one wheel on the cushion and one wheel off

Volume Reduction: Minimal as a single installation, but around 20% when installed in a series (PennDOT)

Impact on Emergency Vehicle Access: Negligible – Emergency vehicles can pass over the speed cushions at or near the speed limit.

Mobility Impact: Moderate

Maintenance Considerations

SNOW

- Signing to alert snowplows to avoid damaging approach ramps
- Consider snowplow design when choosing approach ramp shape (straight, sinusoidal, or parabolic)

OTHER

- Visibility of warning sign
- Pavement marking upkeep due to constant traffic wear
- Impacts to street sweeping operations

Other Consideration

- Pavement markings (e.g., striping, arrows) and signage for a speed cushion should replicate those for a speed hump. See CA MUTCD Section 2C.29 and Section 3B.25 for additional information
- Speed cushions implementation will result in an increase in vehicle noise
- Traffic may diverge to adjoining parallel roads from roads where speed cushions are installed. Drivers may swerve to avoid speed cushions
- Consult with regional transit, emergency services, and fire departments prior to the installation of speed cushions
- Consider placing street lighting near speed cushions

- The cushion width should be wide enough to slow personal passenger vehicles and yet narrow enough to permit fire trucks and transit vehicles to pass easily without overloading the rear axles of those heavier vehicles

References

1. California MUTCD - Caltrans
2. Design Information Bulletin (DIB) 93 - Caltrans
3. Traffic Calming ePrimer - FHWA
4. Updated Guidelines for the Design and Application of Speed Humps - ITE

Sample Project

Pamplico Dr in Santa Clarita, CA (Google Maps)

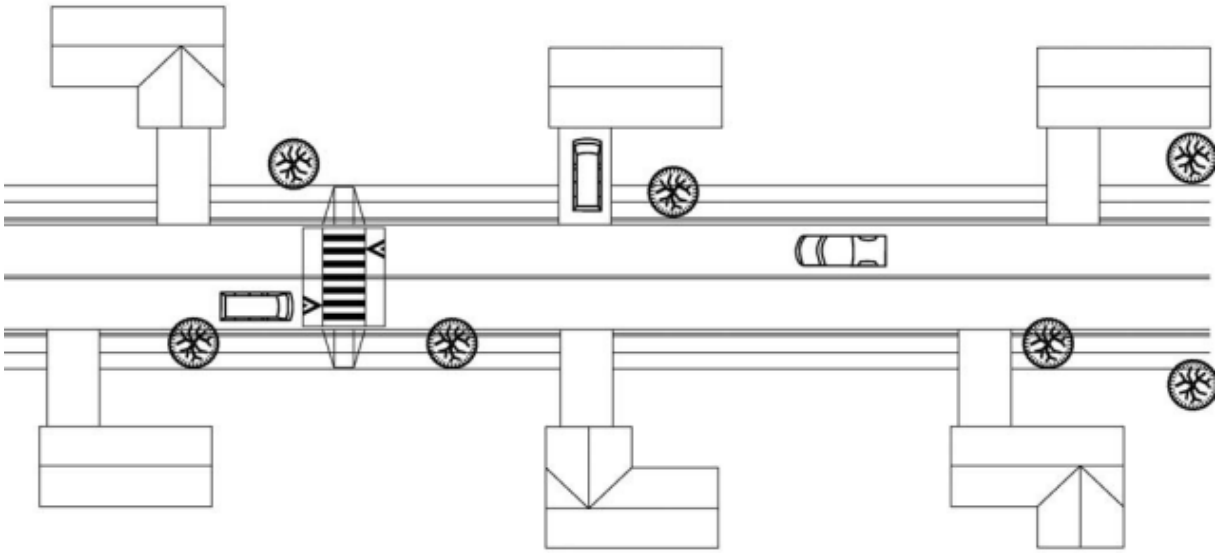
Project Description:

The City of Santa Clarita implemented speed cushions to discourage speeding within residential area. Emergency vehicles with wide tracks can pass through this calming measure without any vertical deflection.

Speed Table/Raised Crosswalk

Description

A speed table is a vertical traffic calming device, similar to a speed hump that runs transverse to the direction of traffic. The speed table is longer than a speed hump, typically having a ramp up of approximately 6 feet followed by a 10 feet minimum flat section, then a ramp down of 6 feet for a total width of 22 feet. The roadway transition will not exceed 5% grade relative to the roadway profile. The flat section may have a marked crosswalk placed on the flat section, which provides more visibility to the crosswalk and crossing pedestrians.



Speed Table / Raised Crosswalk (DelDOT)

Placement

Recommended for single-lane one-way or two-lane two-way roadways, where a crosswalk exist or if a crosswalk is warranted. Should not be placed on a sharp curve.

Speed tables can enhance marked crosswalk visibility, while having the added benefit of reducing vehicular operating speed at the crossing location. There are two types of speed tables: flush with the curb and open at the edges.

When speed tables are constructed flush with the curb, an ADA curb ramp is not required. However, detectable warning surfaces are needed at the sidewalk curbs. Drainage flow must be considered along the gutter line.

When speed tables are constructed with open ends, the crosswalk will taper to the pavement prior to the gutter, and an ADA curb ramp must be provided. The edge taper should meet ADA design requirements and can also conform prior to the bike lane to avoid impeding bicyclist

operation.

Functional Classification: Collectors and Local Roads

Appropriate Daily Volume Range: 9,000 ADT or less. Refer to Table 1 for more information on placement.

Maximum Posted Speed Limit: 30 MPH or less

Performance

Speed Reduction: 7-8 MPH reduction in 85th percentile operating speeds (FHWA)

Volume Reduction: Low, but more significant diversion can be achieved by combining this measure with other traffic calming measures.

Impact on Emergency Vehicle Access: Generally, not appropriate for a primary emergency vehicle route or on a street that provides access to a hospital or emergency medical services. See DIB 93 for further guidance.

Maintenance Considerations

SNOW

- Signing to alert snowplows to avoid damaging approach ramps
- Consider snowplow design when choosing approach ramp shape (straight, sinusoidal, or parabolic)

OTHER

- Visibility of warning sign
- Pavement markings require upkeep due to constant traffic wear
- Impacts to street sweeping operations

Other Considerations

- Pavement markings (e.g., striping, arrows) and signage for a speed table/raised crosswalk should replicate those for a speed hump. See CA MUTCD Section 2C.29 and Section 3B.25 for additional information
- Consult with the District Pedestrians and Bicyclists Safety Engineer
- Speed tables may present potential obstacle to all vehicles including bicyclists and motorcyclists
- Speed tables implementation will result in an increase in vehicle noise
- Speed Tables are typically 3” to 6” high
- Traffic may diverge to adjoining parallel roads from roads where speed tables are installed
- Consult with regional transit, emergency services, and fire departments prior to the

installation of speed cushions

- Requires Advanced Warning Signs
- Proximity of nearest intersection
- Impact to drainage, street parking, and existing utilities
- May require street lighting
- ADA compliance
- Flat top long enough (typically 10 feet) for the entire wheelbase of a passenger car to rest on top (FHWA)

References

1. Design Information Bulletin (DIB) 93 - Caltrans
2. Design Information Bulletin (DIB) 82 - Caltrans
3. California MUTCD (Section 3B.18) - Caltrans
4. Traffic Calming ePrimer - FHWA
5. Traffic Calming Fact Sheets - ITE
6. Urban Street Design Guide - NACTO

Sample Project

66th St in Emeryville, CA (Google Maps)

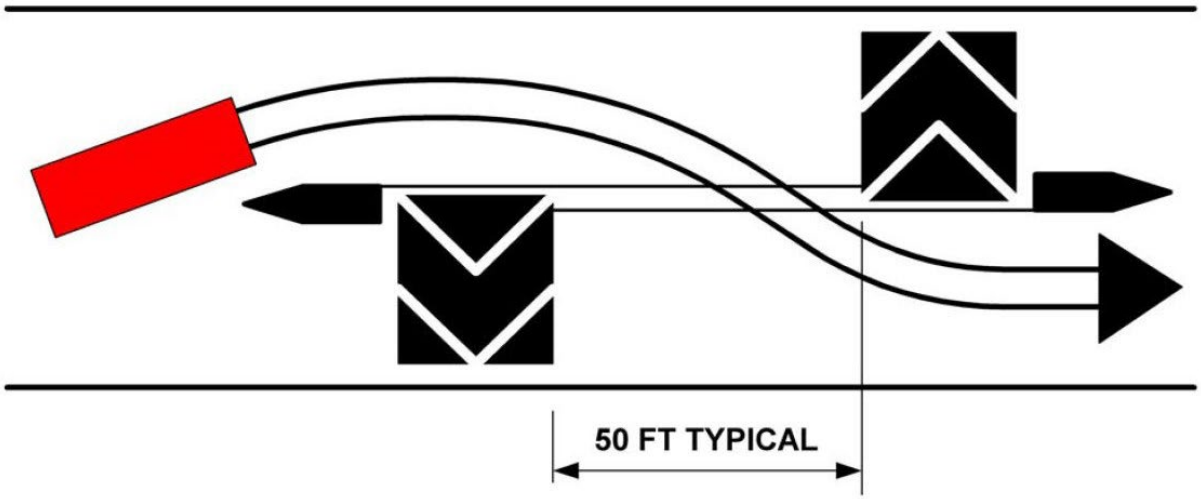
Project Description:

The City of Emeryville implemented a speed table/raised crosswalk. Additional crosswalk enhancements include RRFB signing, In-street Pedestrian Crossing signs, and pavement markings at the 66th St pedestrian crossing. These calming measures were implemented to help reduce vehicle speeds, improve driver awareness of the pedestrian crossing, and encourage motorists to yield to pedestrians.

Offset Speed Table

Description

An offset speed table provides the calming benefits of a speed table, while allowing emergency vehicles to pass through with minimal delay. An offset speed table is a speed table split in half down the street centerline with longitudinal separation between the two halves. This geometry allows for emergency vehicles to avoid the vertical device by weaving through the two halves of the speed table. An offset speed table is typically 3 to 4 inches in height with a 6 feet ramp up section, a 10 feet flat section, followed by a 6 feet ramp down section for a total width of 22 feet. A minimum separation distance between humps of 40 feet is necessary to allow emergency vehicles to bypass the speed table.



Offset Speed Table (NACTO, ITE)

Placement

Mid-block along a corridor that is suited to a speed hump but requires minimal impact for emergency response vehicle delay. Not recommended on a sharp curve.

Functional Classification: Local Roads

Appropriate Daily Volume Range: 9,000 ADT or less

Maximum Posted Speed Limit: 30 MPH

Performance

Speed Reduction: 7-8 MPH reduction in 85th percentile speeds

Volume Reduction: Low, but more significant diversion can be achieved by combining this measure with other traffic calming measures.

Impact of Emergency Response Access: Minimal. This countermeasure is specifically designed to minimize emergency vehicle delays, while still providing the speed reduction benefits of speed humps.

Mobility Impact: Nominal

Maintenance Considerations

SNOW

- Signing to help snowplows avoid damaging approach ramps
- Consider snowplows when choosing approach ramp shape (straight, sinusoidal, or parabolic)

OTHER

- Warning sign visibility
- Pavement marking upkeep due to constant traffic wear

Other Considerations

- Driver circumnavigation can be minimized by providing small median islands leading up to each table with a double-centerline and raised pavement markers
- Pavement markings (e.g., striping, arrows) and signage for an offset speed table should replicate those for a speed hump. See CA MUTCD Section 2C.29 and Section 3B.25 for additional information
- Offset speed tables may present a potential obstacle to all vehicles including bicycles and motorcycles
- Offset speed tables implementation will result in an increase in vehicle noise
- Traffic may diverge to adjoining parallel roads from where offset speed tables are installed. Drivers may swerve to avoid offset speed tables
- Consult with regional transit, emergency response services, and law enforcements.
- Emergency vehicles swerving to avoid the offset speed table may confuse opposing traffic. Consider proper signing
- Impact to drainage and street parking
- May require street lighting

References

1. California MUTCD (Chapters 2C and 3B) - Caltrans
2. Traffic Calming Fact Sheets - ITE
3. Traffic Calming ePrimer - FHWA
4. Offset Speed Tables for Reduced Emergency Response Delay – NACTO, ITE

Sample Project

SW 87th Ave in Beaverton, OR (Scott Batson)

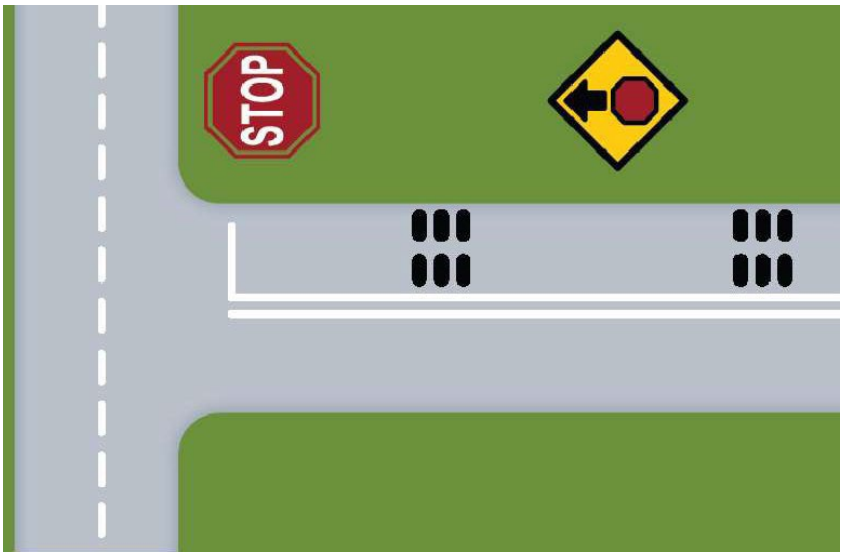
Project Description:

The City of Beaverton installed offset speed tables along SW 87th Ave. Offset speed tables were chosen due to the designation of the street for emergency response. The city saw a reduction in speed along this residential neighborhood. The City of Beaverton also added raised pavement makers with inset reflectors to deter vehicles from crossing the centerline.

Transverse Rumble Strips

Description

Transverse rumble strips are raised or grooved patterns installed perpendicular to the direction of travel in the roadway travel lane. Typically installed on rural roadways that have low volume and with infrequent traffic control devices. Transverse rumble strips provide an audible and tactile warning downstream of a decision point. They are different from center line and edge line rumble strips, which are located off the travel lane.



Transverse Rumble Strips (MNDOT)

Placement

On the approach of an unexpected roadway condition such as a stop condition or at a location that has a significant reduction in the speed limit. Examples include intersections, toll plazas, horizontal curves, end of highway/freeway, and work zones.

Functional Classification: Principal Arterials, Minor Arterials, Collectors, and Local Roads

Performance

Speed Reduction: 1-2 MPH on rural highways (FHWA)

Volume Reduction: Low

Impact on Emergency Response Vehicles: None. Emergency vehicles should be able to transverse the measure at or above the speed limit.

Mobility Impact: Nominal

Maintenance Considerations

SNOW

- Need signage to alert snowplow operators to avoid damaging the transverse rumble strips
- Using grooved rumble strips to avoid damage by snowplows

OTHER

- Need to be replaced or repaired frequently. The raised portions wear down rapidly due to constant traffic on them, which reduces their effectiveness

Other Considerations

- Noise pollution from rumble strips may impact surrounding land uses
- Will impact motorcyclists and bicyclists. Consider providing a center gap
- Raised or grooved options can be used for intersection approaches
- Grooved are generally 0.5” deep
- Raised are no more than 0.5” tall (multiple layers of thermoplastic for desired height)
- Can be used in combination of different length thermoplastics for more aggressive effect

References

1. Factors Influencing Operating Speeds and Safety on Rural and Suburban Roads - FHWA
2. California MUTCD (Section 3J.02) - Caltrans

Sample Project

Birch Ave and John St in Princeton, NJ (Google Earth)

Project Description

Transverse rumble strips were installed in a residential neighborhood in New Jersey. This calming measure was implemented to heighten motorist awareness of the pedestrian crossings and stop-controlled intersection ahead.

Raised Intersection

Description

A raised intersection is a vertical traffic calming device that raises the entirety of an intersection by 3 to 4 inches. The ramp sections of the intersection are approximately 6 feet in length with no greater than a 5% slope. Alternative paving methods such as colored asphalt, concrete, or pavers can be used to mark the intersection. A raised intersection provides many of the same benefits as other vertical traffic calming devices such as reducing vehicle speeds and increasing driver awareness of pedestrians and bicycles.

Raised Intersection (NACTO)

Placement

At the intersection of two local roadways with posted speeds less than 35 MPH. Commonly implemented in commercial areas with high pedestrian volumes

Functional Classification: Collectors and Local Roads

Maximum Grade: 8% or less

Performance

Speed Reduction: Speed should be reduced on all approaches, especially on un-controlled approaches (DelDOT)

Volume Reduction: Low

Impact on Emergency Response Access: Not recommended for use along primary emergency response routes, as it can add 4 to 6 seconds of delay.

Maintenance Considerations

SNOW

- Signage to help snowplows avoid damaging approach ramps
- Consider snowplow operations when choosing approach ramp shape (straight, sinusoidal, or parabolic)

OTHER

- Drainage impacts
- Crosswalks require tactile pavement for visually impaired pedestrians.
- Visibility of warning sign
- Upkeep of pavement markings due to constant traffic wear

Other Considerations

- Major impacts to drainage
- Changes to the existing drainage could impact existing utilities
- Detectable warning surface and/or color contrasts must be incorporated to differentiate roadway and sidewalk
- Pattern or tactile raised pavement

References

1. Traffic Calming ePrimer - FHWA
2. Design Information Bulletin (DIB) 82 - Caltrans
3. Traffic Calming Fact Sheets - ITE
4. Urban Street Design Guide - NACTO

Sample Project

Butte St and Market Pine Alley in Redding, CA (Google Maps)

Project Description:

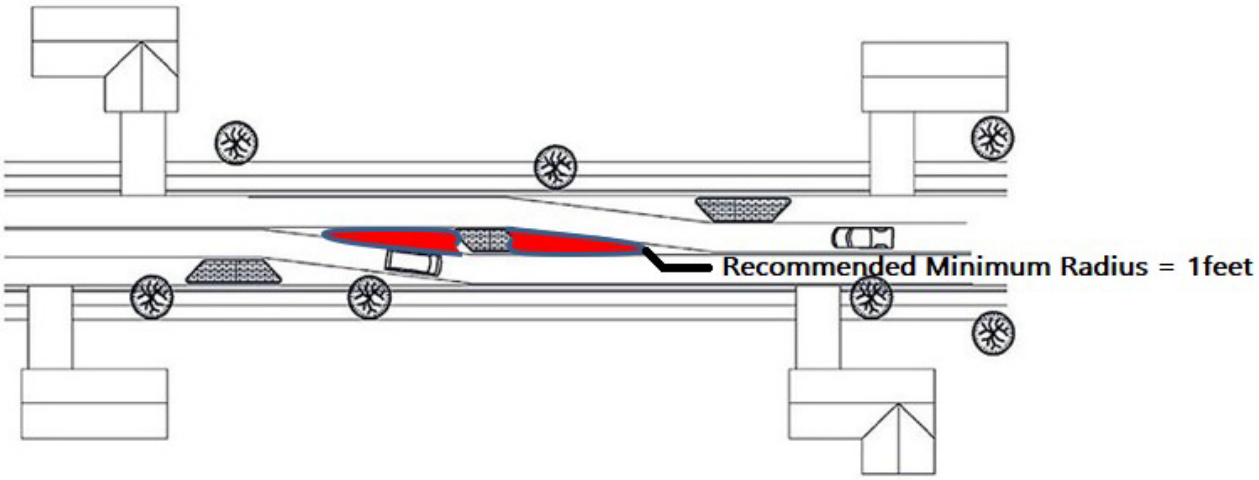
A raised intersection was implemented at Butte St and Market Pine Alley in Redding, CA. This calming measure was implemented to improve safety and accessibility at an intersection with high volumes of vehicles and pedestrians. The raised intersection improves pedestrian visibility, slows vehicle speeds, and provides a level pathway across the intersection.

Category E. Physical Roadway Segment Modifications

Lateral Shifts

Description

A lateral shift is a realignment of an otherwise straight street that causes travel lanes to shift. The primary purpose of a lateral shift is to reduce motor vehicle speed along the street. A typical lateral shift separates opposing traffic through the shift with the aid of a median island. Without the island, a motorist could cross the centerline and take the straightest path possible, thereby reducing effectiveness of the lateral shift. Additionally, a median island reduces the likelihood of a motorist veering into the path of opposing traffic. A chicane is a variation of a lateral shift except a chicane shifts alignment more than once.



Lateral Shift Schematic (DelDOT)

Placement

Along streets with a documented speeding problem, where more substantial measures (such as a chicane) are not appropriate; two-lane minor arterial.

Functional Classification: Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: All volumes (FHWA)

Speed Limit: 35 MPH or less

Performance

Speed Reduction: 5 MPH (DelDOT)

Volume Reduction: Nominal impact

Impact to Emergency Response: Minimal

Maintenance Considerations

- Design lateral shift to accommodate snowplow operations and snow storage
- If the median island is landscaped, consider maintenance and irrigation

Other Considerations

- Lateral Shifts should follow the guidance in CA MUTCD Section 6C.08
- Applicable only at mid-block locations, preferably near a streetlight
- For locations with bicycle facilities, the preference is to separate bicycles from motor vehicle lanes
- Less effective in reducing vehicle speed when the volume of traffic is significantly higher in one direction than the other or when volumes are so low that the likelihood of a motorist encountering an opposing motorist within the lateral shift zone is low
- May require removal of some on-street parking to implement lateral shift, therefore slightly reducing the accessibility of adjacent properties
- Physical features can also be used as a landscaping opportunity
- A lateral shift can be created by means of either curb extension or edge island. A curb extension offers better opportunity for aesthetic enhancement through landscaping. An edge island can leave an existing drainage channel open and tends to be less costly to construct
- The curb extension or edge island should have 45-degree tapers to reinforce the edge lines
- A curb extension or edge island that forms a lateral shift should have a vertical element (e.g., signs, landscaping, a reflector, or some other measure to draw attention to it)
- Either a barrier or mountable curb can be used on an island that forms a lateral shift. The use of a mountable curb is more forgiving to motorists and is acceptable where the island is expected to serve as a pedestrian refuge
- Taper should comply with the HDM for taper angle and length
- Check if the lateral shifts affect the Design Vehicle swept path and tracking (HDM 404)
- May require drainage relocation. Impacts to existing utilities should be avoided
- Can provide a location for pedestrian crossings with a median refuge
- May reduce roadway space available for bicyclists depending on design

References

1. Design Information Bulletin (DIB) 93 - Caltrans
2. California MUTCD (Section 6C.08) – Caltrans
3. Traffic Calming ePrimer - FHWA
4. Traffic Calming Fact Sheets - ITE

Sample Project

Keystone Ave in Reno, NV (Google Earth)

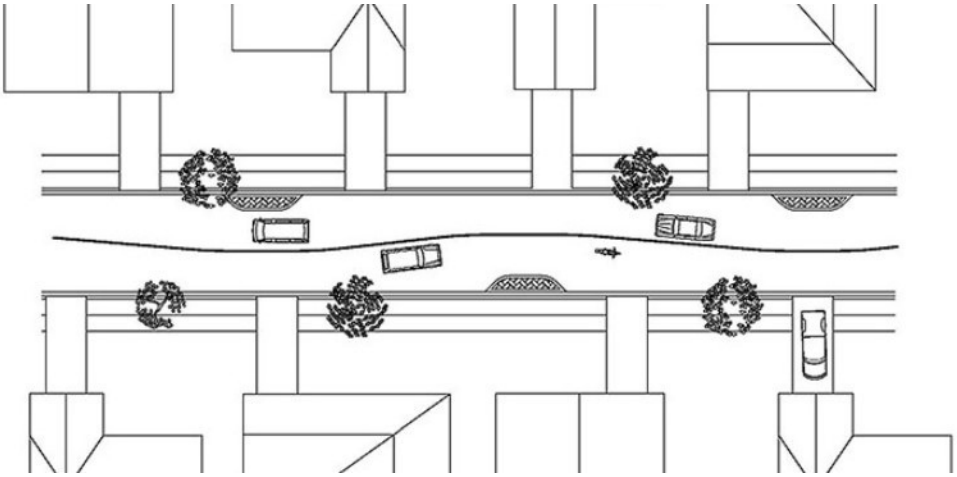
Project Description:

The City of Reno implemented a lateral shift within this residential neighborhood to reduce motor vehicle speeds along the street.

Chicanes

Description

Chicanes are a series of narrowing or curb extensions that alternate from one side of the street to the other, forming an S-shaped, curvilinear roadway alignment. They are also referred to as deviations, serpentines, or reversing curves. The purpose of a chicane is to introduce horizontal curvature to the road, breaking up the “runway effect” of wide and straight streets.



Chicanes (DelDOT)

Placement

Best suited to mid-block locations along local road where there are balanced traffic volumes in both directions to discourage drivers from crossing the center line. Adequate distance is needed between driveways and intersections.

Functional Classification: Collectors with low volume and Local Roads

Maximum Posted Speed Limit: 35 MPH or lower

Minimum /Maximum Number of Lanes: One-lane one-way or two-lane two-way roadways

Maximum Grade: Varies - 10% (El Paso, TX), 8% (PennDOT), 6% (DelDOT)

Performance

Speed Reduction: 3-9 MPH. 5-13 MPH within the chicane

Volume Reduction: Up to 20% (PennDOT). Traffic diversion is heavily dependent on the impact the chicane has on travel time and the availability of a nearby faster route.

Impact on Emergency Response: Minimal. When located along primary emergency response routes, the impact can be nominalized by designing the curb extensions to be mountable by emergency response vehicles.

Mobility Impacts: Nominal

Maintenance Considerations

- Design chicanes to accommodate snowplow operations
- Upkeep of reflective pavement markers if used

Other Considerations

- Check if the lateral shifts affect the Design Vehicle swept path and tracking (HDM 404)
- Changes to the existing drainage and lighting could impact existing utilities
- Optional reflective pavement markers
- Signage on bulbouts
- Object marker for 2-way traffic
- Driveway access maintained

References

1. Highway Design Manual (HDM) Topic 404 - Caltrans
2. Highway Design Manual (HDM) Index 303.4 - Caltrans
3. Traffic Calming ePrimer (3.4) - FHWA
4. Traffic Calming Fact Sheets – ITE

Sample Project

NW 56th St and 2nd Ave NW in Seattle, WA (Google Earth)

Project Description:

Chicanes were implemented in Seattle within a residential neighborhood to lower vehicles speeds by forcing vehicles to shift from one side of the road to the other. This calming measure was paired with appropriate signage to warn drivers of the upcoming lateral shift in lanes.

Category F. Others

Street Trees and Landscaping

Description

Street trees and landscaping have long been shown to improve comfort and livability, but recent research indicates that they can also contribute to a reduction in the rate of crashes. This effect is often attributed to a perceived narrowing of the roadway, a sense of rhythm and human scale created by framing the street, and the perception that the driver is in a place where they are more likely to encounter pedestrians, bicyclists, and cross-traffic. Trees and landscaping can also support the shift to more space-efficient modes such as walking and biking by making those modes more comfortable.

Mature trees line State Route 16 in Esparto, CA

Placement

Street trees are ideally placed behind curbs in sidewalk buffer zones and medians of Urban Area, Suburban Area, and Rural Main Streets where posted speeds are 35 mph or less. In Transitional Area (between high speed rural highways and low speed town centers), landscaping may be used alone or in combination with gateway monuments to indicate drivers of a changed environment. Large trees are not appropriate within the clear recovery zone of rural conventional highways, freeways, and expressways. Provide minimum clearances, clear recovery zones, and appropriate sight distance, per the HDM.

Functional Classification: Principal Arterials, Minor Arterials, Collectors, and Local Roads

Maximum Posted Speed Limit: Refer to HDM Table 904.5 and local codes

Performance

Speed Reduction: The quantitative impact is not well documented, but one study showed an average decrease in cruising speed of about 3 MPH. At gateway treatments combining landscaping with other elements, 3-10 MPH speed reductions have been documented.

Volume Reduction: N/A. Reduced volumes are not generally a goal of this measure.

Impact on Emergency Response: Nominal

Maintenance Considerations

SNOW

- Need to consider downed tree limbs during inclement weather
- Consider impact of landscaping on snow storage spaces

OTHER

- Consider maintenance access and worker safety
- Provide for plant establishment period and consult with Landscape Architecture and Maintenance regarding permanent irrigation
- Select plant material and design planting area to minimize impact of root systems on underground utilities and sidewalks
- Need to consider risk of run-off-road crashes when placing trees, particularly at intersections and conflict points
- Consider upkeep needs, climate-adapted species, and horticultural requirements of different plants
- Street trees and landscaping may be maintained via a maintenance agreement with local agencies

Other Considerations

- Consider sight distance and safety setbacks for street trees at intersections and conflict points
- Consider clear views of traffic control devices and street and pedestrian lighting requirements. See HDM Index 904.5 for information on locating trees, HDM Index 405.1 for Sight Distance, HDM Index 309.1(2) for Clear Recovery Zone, and DIB 82 for clear width for sidewalks
- Consider placement relative to on-street utility equipment to minimize potential conflicts

- Refer to utility providers for minimum utility offsets and maximum tree height under overhead utilities
- Consider locating street trees or landscaping between motor vehicle traffic lanes and bikeways or pedestrian facilities for pedestrian and bicyclist comfort
- In Transitional Area and at community gateways, consider varying landscape composition, spacing, and formality. Consider maintaining consistent landscaping throughout an urbanized area or main street corridor
- Solicit community engagement to inform landscape aesthetics and design
- Consult the District Landscape Architecture and Maintenance for design development

References

1. Highway Design Manual (HDM) Index 901.2 Landscape Architecture Design Standards Caltrans
2. Highway Design Manual (HDM) Index 904.3 Plant Selection - Caltrans
3. Highway Design Manual (HDM) Index 904.5 Locating Trees - Caltrans
4. Highway Design Manual (HDM) Topic 201 Sight Distance - Caltrans
5. Highway Design Manual (HDM) Index 309.1(2) Clear Recovery Zone (CRZ) - Caltrans
6. Highway Design Manual (HDM) Index 405.1(2) Corner Sight Distance - Caltrans
7. Encroachment Permits Manual (Section 506) – Caltrans
8. Design Information Bulletin (DIB) 82 – Caltrans
9. Speed Management ePrimer - FHWA
10. NCHRP Report 737 – Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways

Sample Project

Existing Entrance to the City of Rio Vista on EB SR 12

Proposed Design with Street Trees, Landscaping, and Gateway Monument

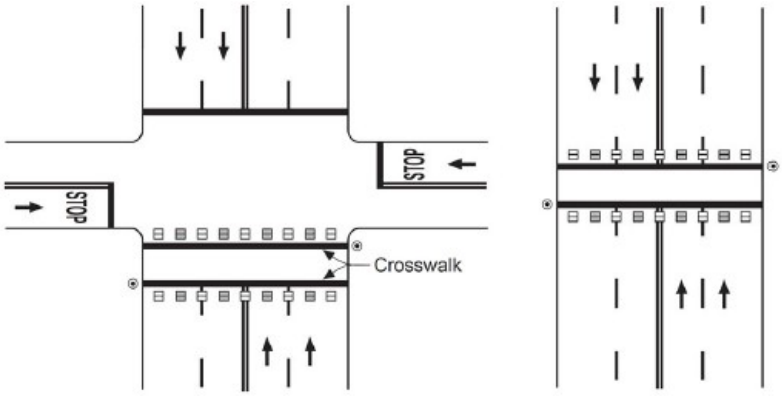
Project Description:

State Route 12 in Rio Vista is undergoing redesign as a Complete Street. The community felt it was important to alert drivers on this busy trucking route that they are entering the City of Rio Vista. Caltrans landscape architecture developed this sketch to illustrate how landscaping could be combined with a gateway monument to visually indicate the entrance and extent of the Rural Main Street. Several complete streets elements in this view contributes to the visual narrowing of the roadway, but the verticality of the proposed street trees plays a critical role in visually defining the corridor.

In-Roadway Light

Description

In-Roadway Lights (IRWLs) are a special type of highway traffic signal installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway. They may draw drivers' attention to features that might not be readily apparent, so that drivers can slow down or come to a stop. IRWLs are actuated devices with flashing indications that provide real-time warning of a specific condition. See CA MUTCD Chapter 4N for additional guidance on IRWLs' application, IRWLs at crosswalks, and maintenance considerations.



In-Roadway Lights Schematic for crosswalk at an intersection and midblock crosswalk (CA MUTCD)

Placement

Marked midblock crosswalk, marked school crosswalk, marked crosswalks on uncontrolled approaches, crosswalks / bike crossings with higher pedestrian collision rates at night, and other roadway situations involving pedestrian crossings. This measure should only be installed at marked crosswalks, so the criteria for placement should follow marked crosswalk placement criteria.

Functional Classification: Minor Arterials, Collectors, and Local Roads

Appropriate Daily Volume Range: 5,000-30,000 ADT(MDOT)

Performance

Volume Reduction: Low

Impact on Emergency Response: None

Mobility Impacts: Nominal

Maintenance Considerations

SNOW

- Consider durability due to moisture buildup
- Minimize conflict with snowplow operations

OTHER

- These systems can be easily damaged and difficult to repair due to in-pavement installation and proprietary nature of these systems
- Replacement of these devices may be more frequent on heavy truck routes
- Lights are most effective when kept clean because they can collect debris rapidly

Other Considerations

- Do not place lights in the center of bike lanes or within the traveled way of Class III bikeway
- Consider using in-roadway light along with other overhead devices such as pedestrian hybrid beacons. In-roadway lights can sometimes be visible only to the first vehicle in line and not for the rest
- Consider vehicle wheel paths when locating devices
- Consider how lights can be activated (button or pedestrian sensor)

References

1. California MUTCD - Caltrans
2. Traffic Calming ePrimer – FHWA

Sample Project

Route 1 at Mountain Road in Laguna Beach, CA (Google Earth)

Project Description:

This project on State Route (SR) 1 at Mountain Road in Laguna Beach includes the installation of intersection lighting, high visibility crosswalks, in-roadway warning lights, mast arm mounted pedestrian crossing sign with warning beacons, etc.