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Traffic Calming Design

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I. Introduction

The Institute of Transportation Engineers (ITE), the international associates that represents traffic engineers, transportation planners and similar professionals who plan and design roads and neighborhoods, has defined traffic calming as “changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and or cut-through volumes, in the interest of street safety, livability, and other public purposes.”

Traffic calming may also be known as neighborhood traffic management, traffic abatement or neighborhood traffic control. Definitions of traffic calming vary, but they all share the goal of reducing vehicle speeds, improving safety and enhancing quality of life. Some include all three “E’s,” traffic education, enforcement and engineering.

- *Education* provides neighbors with information about how they as motorists can help to ease traffic impacts in their community through changes in behavior and attitudes, and informs them about neighborhood traffic management activities and opportunities.
- *Enforcement* enlists the assistance of the Police Department to focus enforcement efforts in key areas.
- *Engineering* encompasses both traditional traffic management measures as well as newer approaches, such as traffic calming.

All three are important components in dealing effectively with neighborhood and community-wide traffic issues.

Most definitions focus on engineering measures to change driver behavior. Some focus on engineering measures that compel drivers to slow down, excluding those that use barriers to divert traffic.

The general objectives of traffic calming include the following:

To encourage citizen involvement in the traffic calming process by incorporating the preferences and requirements of the citizens,

- To reduce vehicular speeds,
- To promote safe and pleasant conditions for motorists, bicyclists, pedestrians and residents

- To improve the environment and livability of neighborhood streets,
- To improve real and perceived safety for non-motorized users of the streets, and
- To discourage use of residential streets by non-resident cut through vehicular traffic.

Traffic calming can reduce accidents, collisions, noise, vibration, pollution and crime.

II. History

European traffic calming began in the 1960's when angry residents of the Dutch city of Delft fought cut through traffic by turning their streets into "woonerven," or "living yards." The streets were outfitted with tables, benches and parking bays jutting into the street. The effect was to turn the street into an obstacle course for motor vehicles and an extension of home for residents. Woonerven were officially endorsed by the Dutch government in 1976. The woonerf design was meant for streets with low traffic volumes.

In the late 1970's, Germany experimented with neighborhood traffic calming. This was the era when the term "verkehrsberuhigung" (translated as traffic calming) was coined. Individual traffic calming measures resulted in traffic diversion. The rerouted traffic was moved to already congested streets. A long-term demonstration was conducted in the 1980's in six German towns. A 20-mph speed limit was imposed over large areas. Speed tables, chicanes and center island narrowings were constructed on collectors and local streets. The results of the demonstration included no change in volumes, reduction in speeds and decrease in severity of accidents.

A 1963 British government document, "Traffic in Towns," is often credited with launching the modern traffic calming movement. The report was the first official document to recognize the growth of traffic threatened the quality of urban life. Neighborhoods were designed to close streets and use short one-way segments to prevent through trips. Volume control measures were emphasized over speed control measures.

In the 1980's, cities in Australia had full blown "local area traffic management" programs in place concentrating on neighborhood streets. There are almost 2,000 roundabouts found in the country. Australia has been a leader in the use of modern roundabouts for traffic calming and intersection control.

The European and Australian lessons show distinctive trends in traffic calming. The major trend includes a shift from volume control to speed control. There are also shifts from simple to diverse programs and from spot to area-wide treatments.

In the United States street closures and traffic diverters date back to the late 1940's and early 1950's. Berkeley, California was the first to establish a full-blown city-wide program of traffic calming in 1975. Seattle, Washington was the first to do area-wide planning in the early 1970's. Seattle has more experience implementing more traffic calming measures than any other

community in the U.S. Seattle's early success was largely due to funding. In 1968, a \$12 million bond was issued for neighborhood street improvements. The bond proceeds were then used to fund a series of traffic calming demonstrations to prove the benefits of traffic calming.

III. Statistics

In 2015 there were nearly 3 million people injured on the roads in the United States. There were 43,443 people killed on U.S. roads in 2015 alone. There is an average of 117 fatalities per day due to traffic incidents.

Road traffic crashes are the leading cause of death among young people (ages 10–24) in the world (30% of the people killed in traffic accidents each day are under 25). Each day, 400,000 people under age 25 die in traffic accidents, averaging more than 1,000 deaths a day. They are also the leading cause of death among children in the U.S.

In 2015, traffic accidents killed an average of 4 children under that age of 14 each day and injured 556 daily. In total, 203,000 children were injured and 1,451 were killed. 53% of fatal head injuries in an eight-year study were to children who were playing in the street when injured. Two thirds of children who are hurt or killed traffic accidents are struck and injured within several blocks (0.25 miles) of their homes. Children who don't live within close proximity of a speed hump are twice as likely to be injured in a vehicle collision. Speed humps were associated with a 53-60% reduction in the odds of injury or death among children struck by an automobile in their neighborhoods. Traffic calming has proven far more effective in preventing child pedestrian injuries than road safety education, which has been “unable to exert meaningful changes in the behavior of children.”

Most pedestrian fatalities occur in urban areas (73%) at non-intersection locations (77%) in normal weather conditions (90%) and at night (67%). Speeding is the single most common traffic rule violation and contributes to one third of all road traffic crashes.

Traffic calming measures are a key intervention to road traffic crashes and deaths. If current trends continue, the number of people killed and injured on the world's roads will rise by more than 60% between 2000 and 2020. A study of 43 international traffic calming problems found that traffic calming solutions decreased traffic accidents by 8-100%.

IV. Types of Traffic Calming Measures

Traffic calming measure can be separated into four groups based on the main impact intended. Vertical control, horizontal control and roadway narrowings are intended to reduce speed and enhance the street environment for non-motorists. Closures are intended to reduce cut-through traffic by obstructing traffic movements in one or more directions. This can be achieved by blocking certain movements, thereby diverting traffic to streets better able to handle it. The distinction between the four types of measure is not as clear as their names suggest, since speed control measures frequently divert traffic to alternate routes, and volume control measures usually slow traffic.

A. Vertical Control

1. *Speed Humps*

Description:

Speed humps are rounded raised areas placed across the roadway. They are generally 10 to 14 feet long (in the direction of travel), making them distinct from the shorter “speed bumps” found in many parking lots and are 3 to 4 inches high. The profile of a speed hump can be sinusoidal, circular, parabolic or flat-topped. They are often tapered as they reach the curb on each end to allow unimpeded drainage and are often placed in series (typically spaced 00 to 600 feet apart). They are sometimes called road humps or undulations. The typical cost is approximately \$2,000.

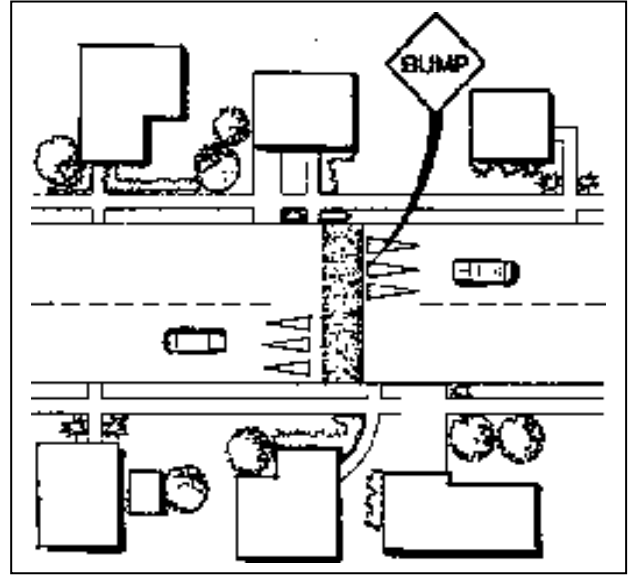
Applications:

- residential streets
- not typically used on major roads, bus routes or primary emergency response routes
- midblock placement, not at an intersection
- not on grades greater than 6 percent
- work well with curb extensions



Design/Installation Issues:

- typically, 12 to 14 feet in length
- speed hump shapes include sinusoidal, circular, parabolic and flat-topped
- hump heights range between 3 and 4 inches with trend toward 3 – 3 ½ inches maximum
- difficult to construct precisely
- often have signage (advance warning sign before first hump in series and warning sign or object marker at hump)
- typically have pavement marking (zigzag shark’s tooth, chevron, zebra)
- taper edge near curb to allow gap for drainage
- some have speed advisories
- bicyclists prefer it not cover or cross a bike lane



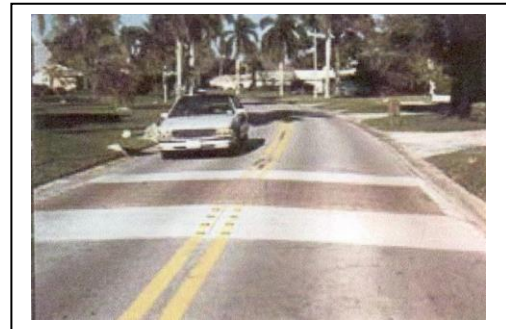
Advantages	Disadvantages
Inexpensive	Causes a “rough-ride” for all drivers
Relatively easy for bicycles to cross if designed appropriately	Forces large vehicles, such as emergency vehicles, to travel at slower speeds
Effective in slowing travel speeds	May increase noise and air pollution
	May have questionable aesthetics

2. Speed Tables

Speed tables are flat-topped speed humps often constructed with brick or other textured materials on the flat section. Speed tables are typically long enough for the entire wheelbase of a passenger car to rest on the flat section. Their long flat fields give speed tables higher design speeds than speed humps. The brick or other textured materials improve the appearance of speed tables, draw attention to them and may enhance safety and speed reduction. They are sometimes called flat top speed humps, trapezoidal humps, speed platforms or raised crossings. Speed tables are good for locations where low speeds are desired but a somewhat smooth ride is needed for larger vehicles. The typical cost is approximately \$2,500 for asphalt tables (higher for brickwork, stamped asphalt or concrete ramps).

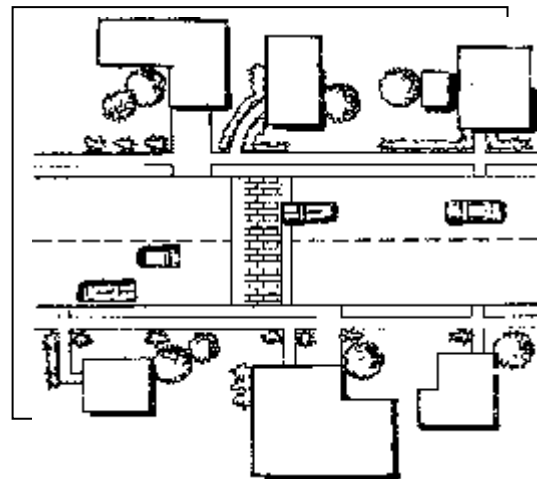
Applications:

- local and collector streets
- main roads through small communities
- work well in combination with textured crosswalks, curb extensions and curb radius reductions
- can include a crosswalk



Design/Installation Issues:

- typically, 22 feet in the direction of travel with 6 foot ramps on each end and a 10 foot flat section in the middle
- most common height is between 3 and 4 inches
- ramps are typically 6 feet long and are either parabolic or linear
- careful design is needed for drainage



Advantages	Disadvantages
Smoother on large vehicles (such as fire trucks)	Questionable aesthetics
Effective in reducing speeds	Textured, materials can be expensive
	May increase noise and air pollution

3. Raised Crosswalks

Raised crosswalks are speed tables outfitted with crosswalk markings and signage to channelize pedestrian crossings, providing pedestrians with a level of street crossing. Also, by raising the level of the crossing, pedestrians are more visible to approaching motorists.

Raised crosswalks are good for locations where pedestrian crossings occur at haphazard locations and vehicle speeds are excessive. The typical cost is approximately \$3,000.

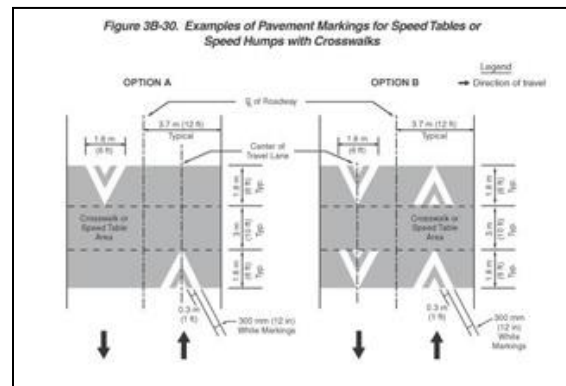
Applications:

- areas with high pedestrian crossing traffic (downtown)
- areas that need to draw more attention to the pedestrian crossing
- areas with a large group of handicap users since the crosswalk is at a nearly constant grade without curb ramps



Design/Installation Issues:

- may increase emergency vehicle response time
- careful design is needed for drainage



Advantages	Disadvantages
Improve safety for both pedestrians and vehicles	If textured, materials can be expensive
Aesthetic value if designed well	Impacts on drainage need to be considered
Effective in reducing speeds	May increase noise and air pollution

4. Raised Intersections

Raised intersections are flat raised areas covering an entire intersection, with ramps on all approaches and often with brick or other textured materials on the flat section. They usually raise the level of the sidewalk, or slightly below to provide a “lip” that is detectable by the visually impaired. By modifying the level of the intersection, the crosswalks are more readily perceived by motorists to be “pedestrian territory.” The cost is approximately \$15,000 to \$50,000 dependent upon the material used in construction.

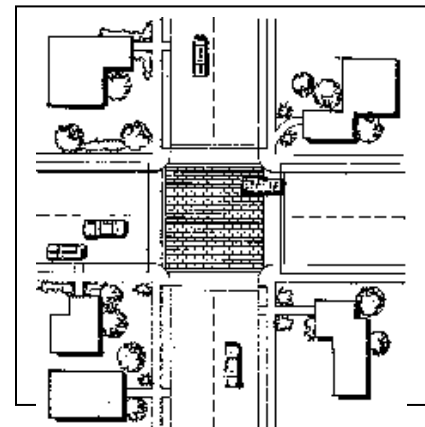
Applications:

- work well with curb extensions and textured crosswalks
- often part of an area wide traffic calming scheme involving both intersecting streets
- in densely developed urban areas where loss of parking would be unacceptable



Design/Installation Issues:

- typically rise to sidewalk level
- may require bollards to define edge of roadway
- storm drainage modifications are necessary



Advantages	Disadvantages
Improves safety for pedestrians and vehicles	If textured, materials may be expensive
Can have positive aesthetic value if designed well	Impacts on drainage needs to be considered
Can calm two streets at once	Less effective in reducing speeds

5. Textured Pavements

Textured and colored pavement includes the use of stamped pavement or alternate paving materials to create an uneven surface for vehicles to traverse. They may be used to emphasize the entire intersection or a pedestrian crossing, and are sometimes used along entire street blocks.

Textured pavements are good for “main street” areas where there is substantial pedestrian activity and noise is not a major concern. The cost varies greatly on the area to be covered and the type of textured pavement selected.

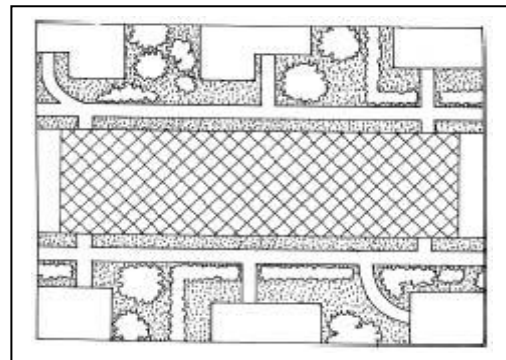
Applications:

- effective in alerting drivers to change in setting
- may slow driver speeds



Design/Installation Issues:

- may be difficult for bicyclists
- may be problematic for people with disabilities (blindness, handicap)
- may be expensive to maintain



Advantages	Disadvantages
Reduce vehicle speeds over and extended length	Materials may be expensive
Can have positive aesthetic value if designed well	If used on a crosswalk, they can make crossing more difficult for wheelchair users and the

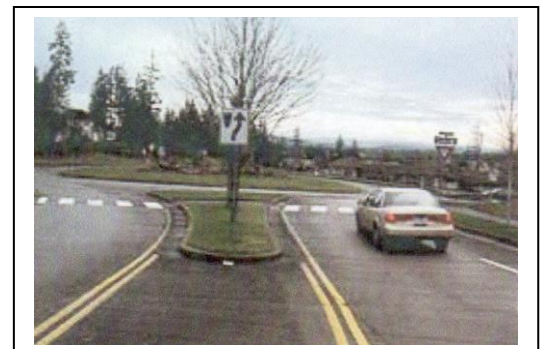
B. Horizontal Control

1. Neighborhood Traffic Circles

Neighborhood traffic circles require traffic to circulate counterclockwise around a center island. Unlike traffic circles, roundabouts are used on higher volume streets to allocate right-of-way between competing movements. Motorists must yield to motorists already in the intersection. They require drivers to slow to a speed that allows them to comfortably maneuver around them. They are sometimes called intersection islands. The typical cost is approximately \$15,000 (higher with landscaping).

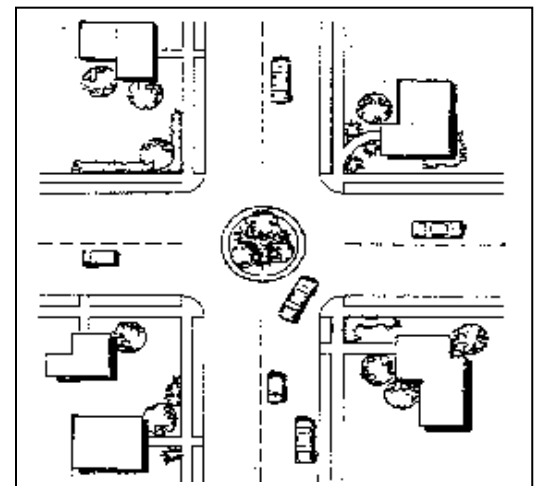
Applications:

- intersections of local or collector streets
- one lane each direction entering intersection
- not typically used at intersections with high volume of large trucks or buses



Design Considerations/Installation Issues:

- typically, circular in shape
- usually landscaped in their center islands
- often controlled by yield signs on all approaches
- key design features is the offset distance (distance between projection of street curb and center island), lane width for circling the circle, the circle diameter and height of mountable outer ring for large vehicles such as school buses and garbage trucks



Advantages	Disadvantages
Can moderate traffic speeds on an arterial	May be difficult for large vehicles (such as fire trucks) to circumnavigate
Generally, aesthetically pleasing if well landscaped	Must be designed so that the circulating lane does not encroach on the crosswalks
Enhanced safety compared to traffic signals	May require the elimination of some on-street parking
Can minimize queuing at the approaches to the intersection	Landscaping must be maintained, either by residents or by the municipality
Less expensive to operate than traffic signals	

2. Chicanes

Chicanes are curb extensions that alternate from one side of the street to the other, forming S-shaped curves. Chicanes can also be created by alternating the on-street parking, either diagonal or parallel, between one side of the street and the other. Each parking can be created either by restriping the roadway or by installing raised, landscaping islands at the ends of each parking bay. They are also called deviations, serpentine, reversing curves, twists and staggerings. The cost is approximately \$5,000 to \$15,000 depending on the ornate landscaping.

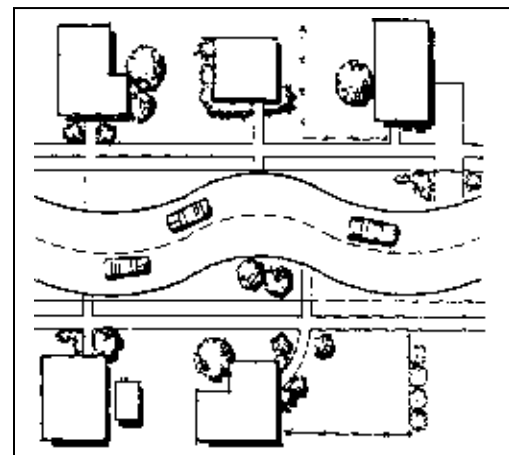
Applications:

- appropriate for midblock locations only
- most effective with equivalent volumes on both approaches
- typically, is a series of at least three curb extensions
- can use on-street parking to create chicane



Design/Installation Issues:

- unless well-designed, chicanes may still permit speeding by drivers cutting straight paths across the center line
- recommend shifts in alignment of at least one lane width, deflection angles of at least 45 degrees and



center islands to prevent drivers from taking a straight line through the chicane

Advantages	Disadvantages
Discourage high speeds by forcing horizontal deflection	Must be designed carefully to discourage drivers from deviating out of the appropriate
Easily negotiable by large vehicles (such as fire trucks) except under heavy traffic conditions	Curb realignment and landscaping can be costly, especially if there are drainage issues
	May require the elimination of some on-street parking

3. Realigned Intersections

Realigned intersections are changes in alignment that convert T-intersections with straight approaches into curving streets that meet at right-angles. A former “straight-through” movement along the top of the T becomes a turning movement. While not commonly used, they are one of the few traffic calming measures for T-intersections, because the straight top of the T makes deflection difficult to achieve, as needed for traffic circles. The cost can vary if right-of-way acquisition is required.

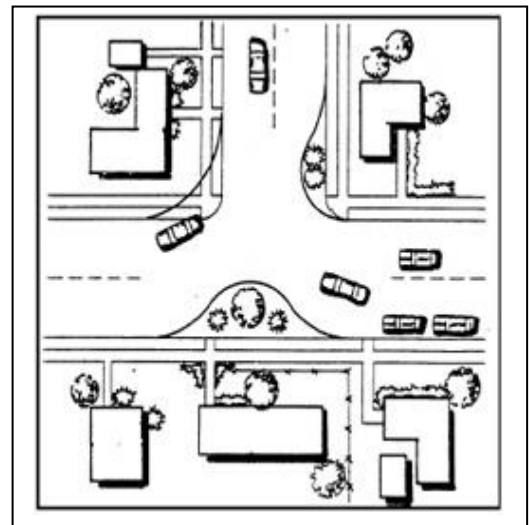
Applications:

- effective in reducing speeds
- improves safety at a T-intersection that is commonly ignored by motorists



Design/Installation Issues:

- curb realignment can be expensive
- may require additional right-of-way to cut the corner



Advantages	Disadvantages
Can be effective reducing speeds and improving safety at a T-intersection that is commonly ignored by motorists	Curb realignment can be costly
	May require some additional right-of-way to cut the corner

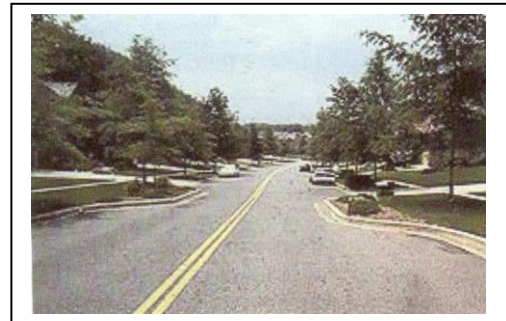
C. Roadway Narrowings

1. Chokers

Chokers are curb extensions at midblock locations that narrow a street by widening the sidewalk or planting strip. If marked as crosswalks, they are also known as safe crosses. Two-lane chokers leave the street cross section with two lanes that are narrower than the normal cross section. One-lane chokers narrow the width to allow travel in only one direction at a time, operating similarly to one-lane bridges. They are good for areas with substantial speed problems and no on-street parking shortage. The typical cost is approximately \$2,000.

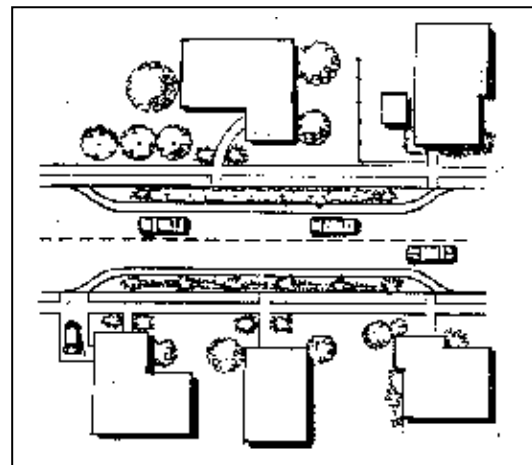
Applications:

- local and collector streets
- pedestrian crossings
- main roads through small communities
- work well with speed humps, speed tables and raised intersections



Design/Installation Issues:

- some applications use an island which allows drainage and bicyclists to continue between the choker and the original curb line
- typically designed to narrow road to 20 feet for two-way traffic
- adequate drainage is a key consideration
- provides opportunity for landscaping



Advantages	Disadvantages
Easily negotiable by large vehicles (such as fire trucks)	Effect on vehicle speeds is limited by the absence of any vertical or horizontal deflection
Can have positive aesthetic value if designed well	May require bicyclists to briefly merge with vehicular traffic
Reduce both speeds and volumes	May require the elimination of some on-street parking

2. Center Island Narrowings

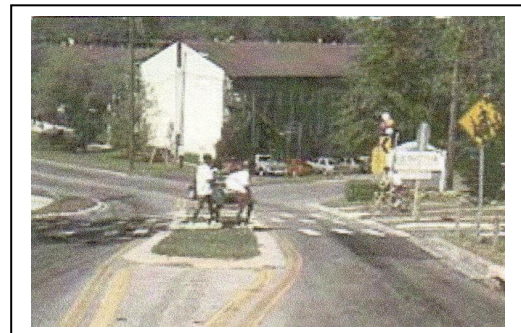
A center island narrowing is a raised island located along the centerline of a street that narrows the travel lanes at that location. Center island narrowings are often landscaped to provide a visual amenity. They are sometimes called gateways, midblock medians, median slow points or median chokers.

Center island narrows are good for entrances to residential areas and wide streets where pedestrians need to cross. The typical cost is approximately \$3,000.

Advantages	Disadvantages
Increases pedestrian safety	May require elimination of some on-street parking
Can have positive aesthetic value if designed well	Speed-reduction effect is somewhat limited by the absence of any vertical or horizontal deflection
Reduces traffic volumes	

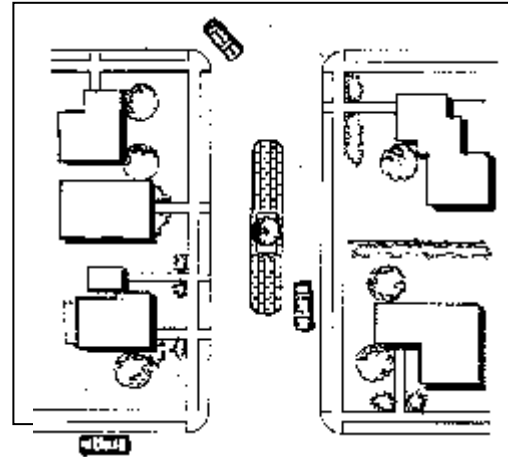
Applications:

- often combined with textured pavement
- must be fitted with a gap to allow pedestrians to walk through a crosswalk
- are often landscaped to increase aesthetics



Design/Installation Issues:

- potential loss of on-street parking and driveway access
- may limit visibility of pedestrian crossing



3. Neckdowns

Neckdowns are curb extensions at intersections that reduce the roadway width from curb to curb. The “pedestrinize” intersections by shortening crossing distances for pedestrians and drawing attention to pedestrians via raised peninsulas. They also tighten the curb radii at the corners, reducing the speeds of turning vehicles.

They are good for intersections with substantial pedestrian activity and areas where vertical traffic calming measure would be unacceptable because of noise considerations. The cost is approximately \$2,000.

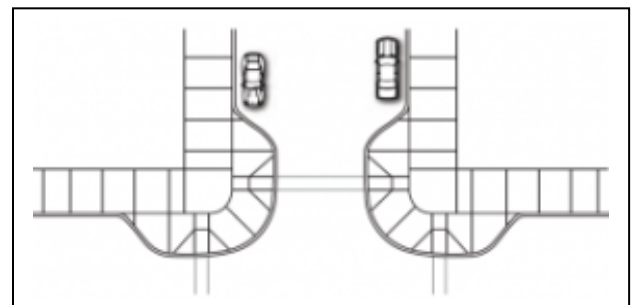
Applications:

- used to force drivers to slow down when they turn the corner, making it safer for the pedestrian
- increases pedestrian visibility of drivers



Design/Installation Issues:

- must be careful with drainage design
- may lose on-street parking



Advantages	Disadvantages
Improves pedestrian circulation and space	Effectiveness is limited by the absence of vertical or horizontal deflection
Through and left-turn movements are easily negotiable by large vehicles	May slow right-turning emergency vehicles
Create protected on-street parking bays	May require the elimination of some on-street parking near the intersection
Reduces speeds, especially for right-turning vehicles	May require bicyclists to briefly merge with vehicular traffic

D. Closures

Street closures are barriers placed across a street to completely close the street to through traffic, usually leave only sidewalks open. They are good for locations with extreme traffic volume problems where several other measures have been unsuccessful. Closures have been used as a crime prevention tool. The cost can range between \$2,000 for a simple half-closure to \$35,000 for a highly landscaped diagonal diverter.

Applications:

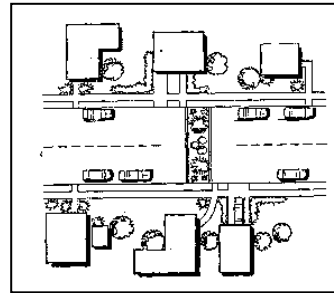
- closures are typically applied only after other measure have failed or been determined to be inappropriate
- for all types of closure, provisions are available to make diverters passable for pedestrians and bicyclists
- often used in sets to make travel through neighborhoods more circuitous

Design/Installation Issues:

- there may be legal issues associated with closing a public street
- can be placed at an intersection or midblock
- barriers may consist of landscaped islands, walls, gates, side-by-side bollards or any other obstruction that leave an opening smaller than the width of a passenger car

1. Full Closures:

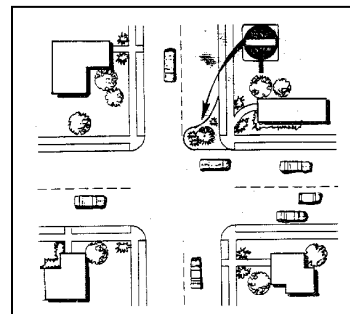
Full closures are barriers placed across a street to completely close the street to through-traffic, usually leaving only sidewalks open. They are sometimes called cul-de-sacs or dead-ends. The typical cost is approximately \$120,000.



Advantages	Disadvantages
Able to maintain pedestrian and bicycle access	Require legal procedures for street closures
Very effective in reducing traffic volume	Cause circuitous routes for local residents and emergency services
	May be expensive
	May limit access to businesses

2. Half Closures

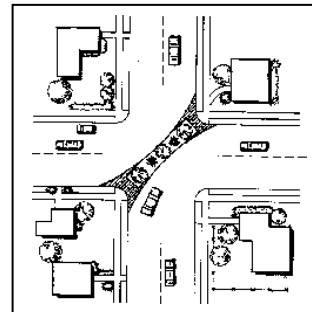
Half closures are barriers that block travel in one direction for a short distance on otherwise two-way streets. They are good for locations with extreme traffic volume problems where non-restrictive measures have been unsuccessful. They are sometimes called partial closure, entrance barriers or one-way closures. The typical cost is approximately \$40,000.



Advantages	Disadvantages
Able to maintain two-way bicycle access	Cause circuitous routes for local residents and emergency services
Effective in reducing traffic volumes	May limit access to businesses
	Drivers may be able to circumvent the barrier, depending on the design

3. Diagonal Diverters

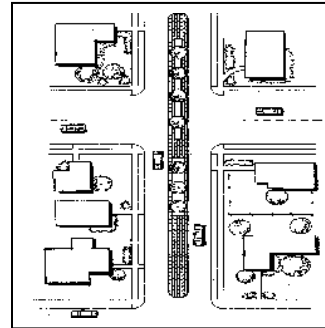
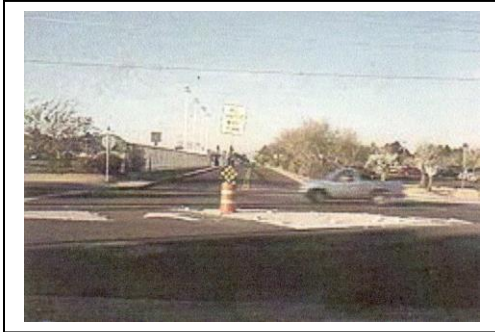
Diagonal Diverters are barriers placed diagonally across an intersection, blocking through movements and creating two separate, L-shaped streets. Like half closures, diagonal diverters are often staggered to create circuitous routes through the neighborhood as a whole, discouraging non-local traffic while maintaining access for local residents. They are good for inner-neighborhood locations with non-local traffic volume problems. They are sometimes called full diverters or diagonal road closures. The typical cost is approximately \$85,000.



Advantages	Disadvantages
Do not require a closure per se, only a redirection of existing streets	Cause circuitous routes for local residents and emergency services
Able to maintain full pedestrian and bicycle	May be expensive
Reduce traffic volumes	May require reconstruction of corner curbs

4. Median Barriers

Median barriers are islands located along the centerline of a street and continuing through an intersection so as to block through movement at a cross street. They are good for local street connections to main street where through traffic along the continuing local street is a problem. They are also good for main streets where left-turns to and/or from the side street are unsafe. The typical cost is approximately \$15,000 to \$20,000.



Advantages	Disadvantages
Can improve safety at an intersection of a local street and a major street by prohibiting dangerous turning movements	Require available street width on the major street
Can reduce traffic volumes on a cut-through route that crosses a major street	Limit turns to and from the side street for local residents and emergency services

The various types of traffic calming measures vary greatly in the reduction of crashes and approximate cost. The following table compares the effectiveness and approximate cost estimates for the traffic calming measures.

Type of Traffic Calming	Effectiveness			Approx. Cost Estimate
	Reduction in Accidents	Decrease in 85 th percentile speed	Decrease in Volume	
Speed Humps	For 12' hump, 11% (2.7 to 2.4 accidents/yr); For 14' hump, 41% (4.4 to 2.6 accidents/yr.)	For 12' hump, 22% (35.0 to 27.4 mph); For 14' hump, 23% (33.3 to 25.6 mph)		\$2,000
Speed Tables	45% (6.7 to 3.7 accidents/yr)	18% (36.7 to 30.1 mph)		\$2,000
Raised Crosswalks		1% (34.6 to 34.3 mph)		\$4,000
Raised Intersection	No Data			\$15,000-50,000
Textured Pavements	No Data			Varies
Traffic Circles	29% (5.9 to 4.2 accidents/yr)	11% (34.1 to 30.2 mph)		\$15,000
Chicanes			No Data	\$14,000
Realigned Intersections			No Data	Varies
Chokers		% (from 34.9 to 32.3 mph)		\$2,000
Center Island Narrowings		% (from 34.9 to 32.3 mph)		\$8,000-15,000
Neckdowns		7% (from 34.9 to 32.3 mph)		\$40,000-80,000
Full Closures			44%	\$120,000
Half Closures			42%	\$40,000
Diagonal Diverters			35%	\$85,000
Median Barriers			31%	\$15,000-20,000

V. Summary

ITE defines traffic calming as “changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and or cut-through volumes, in the interest of street safety, livability, and other public purposes.”

The objectives of traffic calming include reducing speeds, promoting safe conditions, improving the environment, improving real and perceived safety, and discouraging use of residential streets by cut through traffic. Traffic calming can reduce accidents, collisions, noise, vibration, pollution and crime.

European traffic calming began as a grassroots movement in the late 1960’s. Angry residents of the Dutch city of Delft fought cut through traffic by tuning their streets in to woonerven, or “living yards.” This was followed by the development of European slow streets (designed for 20 mph) in the late 1970’s.

In the U.S., a version of traffic calming was practiced as early as the late 1960’s and early 1970’s in such places as Berkeley, California and Seattle, Washington.

There are a variety of traffic calming measures available that can provide speed and/or volume control for collector and local streets. The cost of these measures varies dependent upon the amount of construction required for implementation.

This course should have provided the engineer traffic calming techniques for the planning and design of roadways.