Traffic Control Devices for Parking Lots

PAUL C. BOX AND NEIL S. KENIG

National guidelines for the application of traffic control devices (TCDs) in parking lots have yet to be developed. There are basic differences between needs on private property compared with those on public streets and highways—principally, much lower vehicular speeds in parking facilities. Although adherence to the *Manual of Uniform Traffic Control Devices* (MUTCD) is appropriate relative to the design of signs, there are conditions under which TCD applications in contradiction to the manual may be appropriate. The following are general principles of parking lot traffic control: (a) control need is largely related to facility size; (b) the unit most likely to best measure total conflict is the number of parking spaces; (c) standard TCD, as specified in the MUTCD, should be used where appropriate and logical, but not to the exclusion of other effective or less restrictive devices; (d) conditions under which the best TCD is not in the MUTCD may exist; and (e) reflective TCDs should be used on fixed-object hazards within parking lots except those behind curbing or not in a likely travel path. Findings from parking lot accident studies in several states are also reviewed.

Traffic control devices are standardized for application along public roads, including warrants for certain types (*1*). When they are installed on private property, the designs of signs and markings often follow the *Manual of Uniform Traffic Control Devices* (MUTCD) (*1*), but no guidelines for use appear in the MUTCD or the handbook (*2*).

The practice of traffic engineering can be defined as the planning, design, and operation of facilities for the reasonably safe and expeditious movement of persons and goods. The needs for safety and efficiency are in conflict: maximum safety is achieved only at zero vehicular movement, whereas maximum efficiency could generate unacceptable hazard. The traffic engineer tries to achieve a rational balance among the conflicts. This should apply to private and public property.

Traffic engineers (and others involved in planning, design, or operation of parking or loading facilities, such as planners, civil engineers, and architects) should apply to private property many of the principles used to control traffic on public roadways. However, most private property applications differ from those that may be most appropriate for streets and highways. The focus of this paper is to identify the similarities and the differences and to suggest the most appropriate applications, even if they are at variance with MUTCD.

GENERAL CONSIDERATIONS

The basic difference between parking facilities and streets is size. The shortest street is almost always longer than the length of a lot serving a drive-in restaurant or corner market. Up to a point distance relates to speed. The size of the area also relates to the magnitude of the conflict or the total number of vehicles in the area, which interact at intersections, for example.

Because parking facilities vary greatly in size, the magnitude of conflict, need for controls, and degree of likely enforcement differ greatly between a lot serving 10 or 20 parking spaces and another serving several thousand parking spaces. Thus, Principle 1 of parking lot traffic control is that the need for control is largely related to facility size.

A second principle follows—that the unit of size chosen should be related to the most appropriate measure of conflict. Ideally, this is the number of vehicles or pedestrians interacting at each point. Prediction of such conflicts is not practical other than where driveways connect to the public street system. Principle 2 is that the unit of size best representing a measure of total conflict is the number of parking spaces.

Because drivers are presumed already to be familiar with the typical traffic control devices found on the public streets and to be conditioned to at least some degree of compliance, it follows that standard devices generally should be used. Principle 3 is that standard traffic control devices should be used where appropriate and logical, but not to the total exclusion of other, potentially more effective, more reasonable, or less restrictive devices.

The type of control needed may vary from nothing [applicable to most parking access aisle/cross aisle intersections (Figure 1)] through Yield, Stop, and even traffic signals. Considering speed limits, it would be ludicrous to post speed limit signs on a cross aisle only 30 m (100 ft) long, but along the ring road of a regional shopping center or the main access road to an airport a reasonable speed zoning could be effective. Unfortunately, most such postings used today are so unrealistically low as to be meaningless.

In many of the larger parking lots the intersection of parking access aisles with interior cross-aisle connections results in cross-type intersections (Figure 2). A right-of-way assignment is usually needed (unless the parking aisles are extremely short). Several conditions may exist at a given moment, ranging from a completely vacant stall next to the aisle to one occupied by a van or larger pickup truck producing severe sight restrictions. No device in MUTCD can be used to effectively cover this range, running from no special need for unusual slowing down to the necessity of a full stop, depending on actual parking stall use. However, devices (nonstandard and not endorsed by the traffic engineering profession) that should be considered may be available. Principle 4 is that conditions under which the best control device is not contained in MUTCD may exist.

Fixed objects are common to most parking facilities, such as light, utility or sign poles, fire hydrants, structural columns, or walls. Principle 5 is that reflective signs or markings should be used on fixed object hazards within parking lots except those set behind curbing and not in a likely direct travel path.

ACCIDENTS

Although the need for guidance in the appropriate use of traffic control devices (TCDs) in parking facilities has yet to be met, some studies have addressed the ultimate measure of conflict—accidents.

Paul C. Box and Associates, Inc., 9933 Lawler Avenue, Skokie, Ill. 60077.

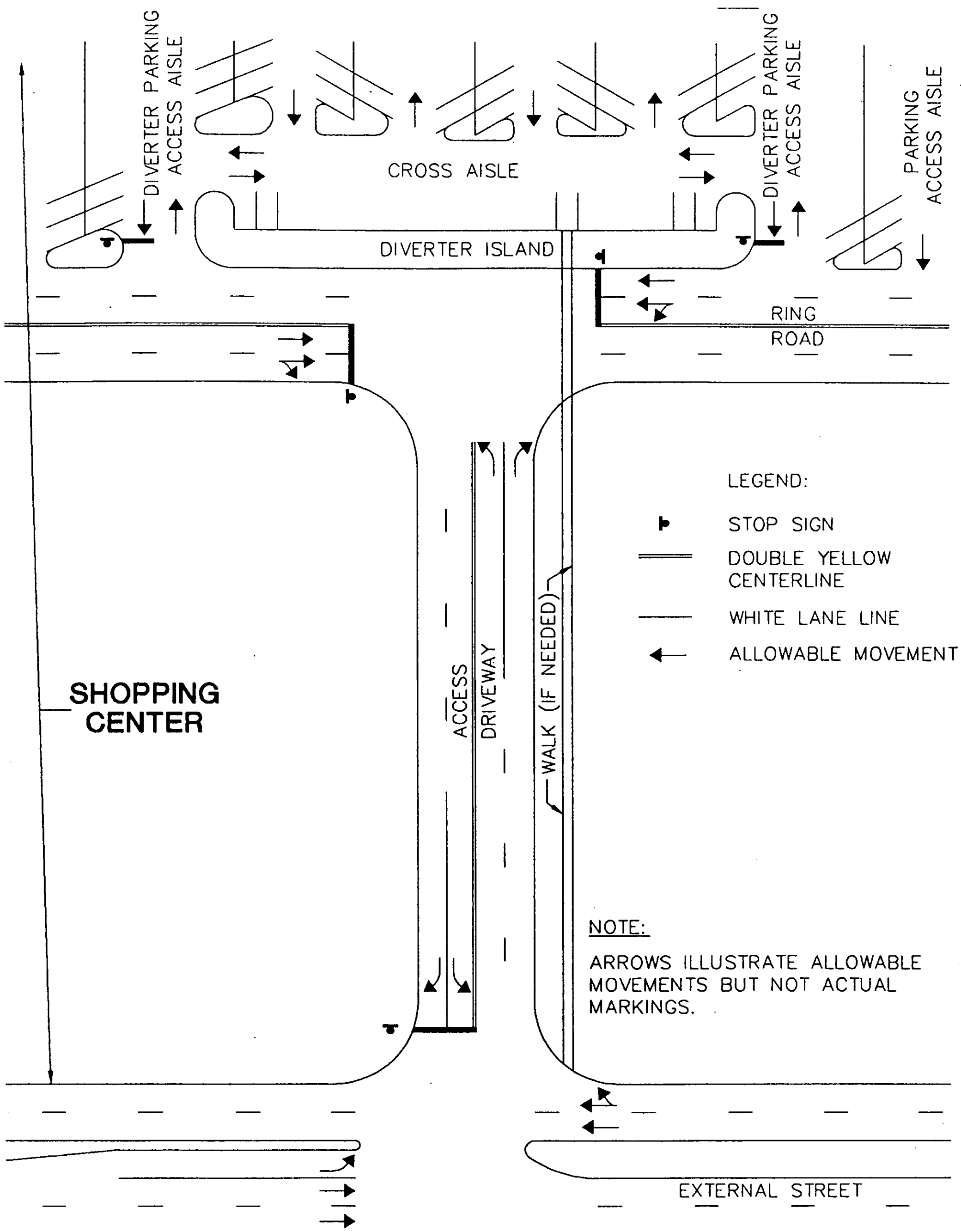

FIGURE 1 Ring road intersection types.

Lake (*3*) reported on general nontraffic accidents (those on private property) in data from Texas. For the period 1968 to 1975 he identified nearly 224,000 reported nontraffic accidents (Table 1).

Lake also found that about 5 percent of nontraffic accidents in Texas produced injuries. However, although only 1 percent of total accidents involved pedestrians, they suffered more than one-fifth of the injuries.

After allowances for nonreporting, Lake estimated that some 1.5 million nontraffic accidents occurred across the United States during 1975. With subsequent development the current number could approach 2 million.

This work can be compared with a smaller study by Box (*4*). He tabulated 3 years of private property accidents for the Chicago suburb of Naperville, Illinois, which had a population of 41,000 in 1979. That study also found that only 1 percent of these accidents involved pedestrians and that more than 20 percent of those injured were pedestrians. However, only 3 percent of the parking lot accidents involved injuries, versus Lake's 5 percent. This difference could be produced by higher reporting levels in Naperville.

Box found that about 20 percent of total (public street plus private property) accidents occurred on private property. Similar figures were found from two other suburbs—one larger and one

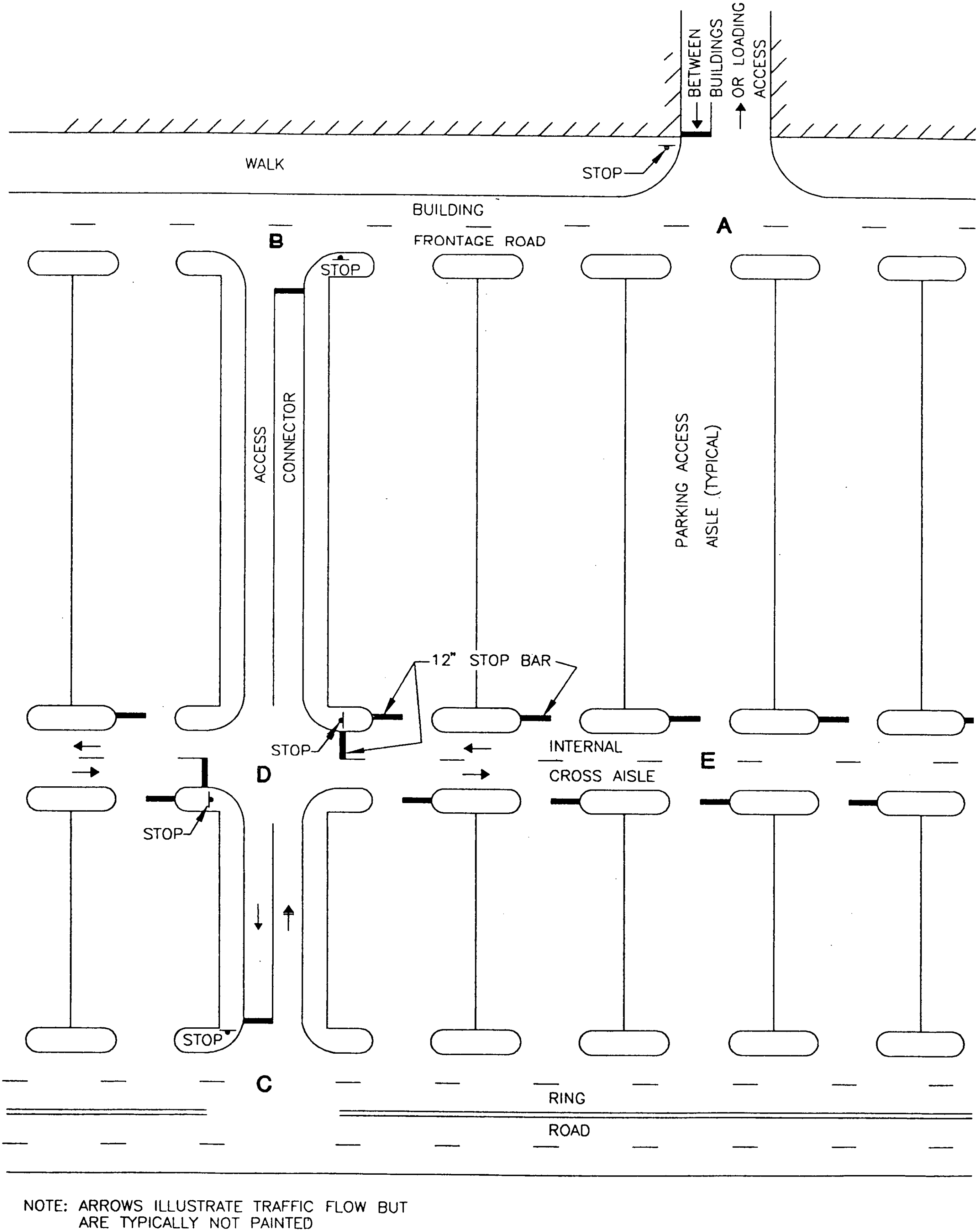

FIGURE 2 **Examples of interior road intersections.**

TABLE 1 Reported Motor Vehicle Nontraffic Accidents in Texas, 1968–1975 (3)

	Collisions Involving						
Location	Pedes-trian	Other MV	Parked MV	Fixed Object	Other All	Total	%
Shopping Center Lot	329	33,031	17,481	1,590	251	52,682	23%
School Parking Lot	198	9,389	6,508	389	118	16,602	7%
Government Lot	6	570	902	96	64	1,638	1%
Drive-in Lot	229	7,082	5,594	5,073	165	18,213	8%
Other Lots	1,265	52,720	67,058	10,435	822	132,300	56%
Shopping Center Ways	18	6,673	20	39	28	6,778	3%
Other Ways	91	3,569	551	548	667	5,426	2%
Totals	2,206	113,034	98,114	18,170	2,115	223,639	100%
Percentage	1%	48%	42%	8%	1%	100%	

smaller than Naperville. If this same proportion exists in urban areas nationwide, the projected number of such annual parking lot accidents would be 1,800,000 in 1989 (*5*).

Most Naperville parking lot accidents involved parked vehicles being struck (about two-thirds of the total). The next largest groups occurred in aisles, with a moving vehicle striking another moving vehicle (29 percent of the total). Fixed objects were struck in 6 percent of the cases.

Only 50 of the Naperville accidents involved moving vehicles at aisle intersections, as shown in Table 2. This represents 21 percent of moving vehicles, or 6 percent of total parking lot accidents, and suggests that the prevailing use of no control at these intersections is generally appropriate.

Box calculated accident rates per 1,000 parking spaces by assumed turnover, that is, the frequency of stall use as a function of land use served. The Low category included apartments, manufacturing, nursing homes, and commuter lots. The Medium category was principally offices, whereas the High category was retail, medical, and so on. Annual rates were about 5 for Low, 6 for Medium, and 26 for High turnover classes, for an average of 12.

A study of regional shopping centers in Atlanta, Georgia, addressed accidents during Christmas peaks at parking access aisle intersections with ring roads (Figures 1 and 2) as related to sight distance (*6*). The authors found that the accident frequency at one of the centers with no end islands (parking allowed up to the edge of the ring road) was some three times that at centers with end islands. This finding relates to large facilities (2,700 to 5,500 parking spaces) and does not imply that end islands are needed in much smaller parking lots.

That study also measured vehicle speeds along the ring roads. The 85th percentile ranged from 37 to 43 km/hr (23 to 27 mph). This compares with observations by others in which values of about 55 km/hr (35 mph) are not unusual during nonpeak times.

In a small parking lot with cross aisles of up to 60 to 90 m (200 to 300 ft) long, speeds will routinely be low, simply because such distances do not encourage significant accelerations.

INTERSECTIONS

Several distinct types of intersections are found in parking lots:

- Driveway/street (Figure 1),
- Ring road/access driveway (Figure 1);

TABLE 2 Moving Vehicles Striking Moving Vehicles in Aisles (4)

Category	PDO	Injury	Total	
Unparking vs Unparking				
Pulling OUT	2		2	(1%)
Backing OUT	30	2	32	(13%)
In parking access aisle				
One vehicle parking				
Pulling IN	2		2	(1%)
Backing IN	1		1	(0%)
One vehicle unparking				
Pulling OUT	4		4	(1%)
Backing OUT	104		104	(43%)
Both vehicles driving forward				
Sideswipe	20	2	22	(9%)
Head-on or rear end	19		19	(8%)
One vehicle cutting across parking rows	4	3	7	(3%)
At aisle intersections*	44	6	50	(21%)
Total	230	15	245	(100%)

*Most of tee type.

- Internal roads (Figure 2),
- Parking access aisle with
  –Building frontage (Figure 2),
  –Internal cross Aisle (Figure 2),
  –Ring road (Figure 2),
- Between building (Figure 2), and
- Loading access (Figure 2).

Traffic controls typically used at intersections are directly related to Principles 1 (control need is largely related to facility size) and 3 (standard traffic control devices should be used where appropriate and logical, but not to the total exclusion of other, potentially more effective, more reasonable, or less restrictive devices).

Driveways

For driveways connecting to public streets, the basic control is a Stop, typically mandated under law whether it is posted or not. In the smaller parking lots such as those with fewer than about 1,000 parking spaces and served by multiple driveways, it is unlikely to make any difference whether Stop signs are posted. For larger developments and greater volumes, the positive reminder to the rules of the road given by a Stop sign may be justified. However, no studies that specify the volume of driveway exit traffic for which posting becomes critically needed have been identified.

As volumes increase a traffic signal may be needed. This depends on the volumes and the numbers of lanes on the street being accessed as well as the proportion of traffic turning left out of the parking lot (*7*). Signals may be warranted at shopping centers as small as the large neighborhood shopping center with 5,000 to 5,500 m^2 (about 50,000 to 60,000 ft^2) of floor area, are often justified at one driveway of the larger community size shopping center, and are usually warranted at several driveways of regional shopping centers. Other large developments may have driveways with sufficient traffic to need signal control, hence the peak hour warrant in MUTCD (*1*).

Signal control at driveways should be based on MUTCD warrants. Multiway Stop signs are seldom applicable because of the intermittent nature of peak exit traffic from parking facilities. It is neither logical nor desirable to stop traffic on the public street when the development is closed or has low exit volumes.

Ring Road/Access Driveway

Figure 1 illustrates three types of common intersections at large shopping centers: (a) the driveway/street connection just discussed, (b) the ring road/access driveway, and (c) the parking access aisle/ring road. For the ring road/access driveway several methods of control are illustrated in Figure 3:

- Stop signs facing the ring road,
- Stop signs facing the access driveway,
- Multiway Stop signs, and
- Mixed Stop and Yield signs.

The intersections shown in Figure 3 are of the T-type. Cross-type intersections may occur within the lot. Preferential entry or four-way Stop Signs are the two most often used controls, although traffic signals can be considered and have been used.

The access driveway length from the street to the ring road represents the reservoir area for entry and exit. Usually, the left turn exit volume dictates the length of lane (and storage capacity) needed when an exclusive left turn lane is provided. Vehicles making right turns exit more readily because gaps are required in only one direction of travel on the major street or the ring road. With short reservoir areas the best control at the ring road is usually free-flow entry, with the ring road traffic stopped. Under heavy loadings, the multiway Stop sign or channelized control methods may be appropriate.

Internal Roads

Figure 2 shows several types of internal roads in larger developments. Because of restricted sight distance, the type indicated by point A in Figure 2 is usually controlled by a Stop sign, providing right-of-way to the building frontage road. The access connector is usually stopped at the building frontage road (Point B) and at the ring road (Point C), whereas it is given priority over internal cross aisles (Point D). Adequate sight distance at all intersections is desirable.

Parking Access Aisles

Aisles serving parking rows are the most common type. They intersect a building frontage road in most parking lots serving more than a few spaces. In slightly larger developments, even those with only a few hundred spaces, at least one additional cross aisle is usually found. At still larger developments an internal cross access aisle plus a ring road may exist.

Small developments typically have no need for end islands to open up sight distance. In large developments speeds on ring roads, internal cross-access aisles, and building frontage roads will be higher, and the need for end aisle sight triangles becomes increasingly important (*6*). This distance may be provided by islands that are painted, raised and curbed, or mixtures of the two. A 2-year study (unpublished) of a Texas shopping center found an annual accident rate of about 10 per 1,000 spaces, which compares closely with that found in the Naperville study (*4*). That super regional mall used alternating painted and curbed end islands.

Curbed islands often contain plantings other than grass. It is essential that clear sight lines exist in the zone between about 0.6 and 2 m (2 and 6 ft) above the pavement. Thus, only ground cover or bushes with a low mature height or trees without any lower foliage should be used. This same restraint applies along medial-type planting strips dividing opposing traffic streams or adjacent to access connectors (Figure 2).

With reasonable sight distances parking access aisles should need no regulatory traffic control at their intersections with building frontage or ring roads if these are of the T-type. Such designs result in exit drivers reducing their speed to the range of 15 to 25 km/hr (about 10 to 15 mph). Furthermore, drivers emerging from the stem of T-type intersections are accustomed to yielding right-of-way to cross traffic at public streets.

Parking access aisle intersections with internal cross access aisles are usually of the cross type (Point E in Figure 2). This perhaps represents the most difficult and controversial aspect of parking lot traffic control. As stated in Principle 4, conditions in which conventional devices are inappropriate may exist. This type of intersection is surely one of these because

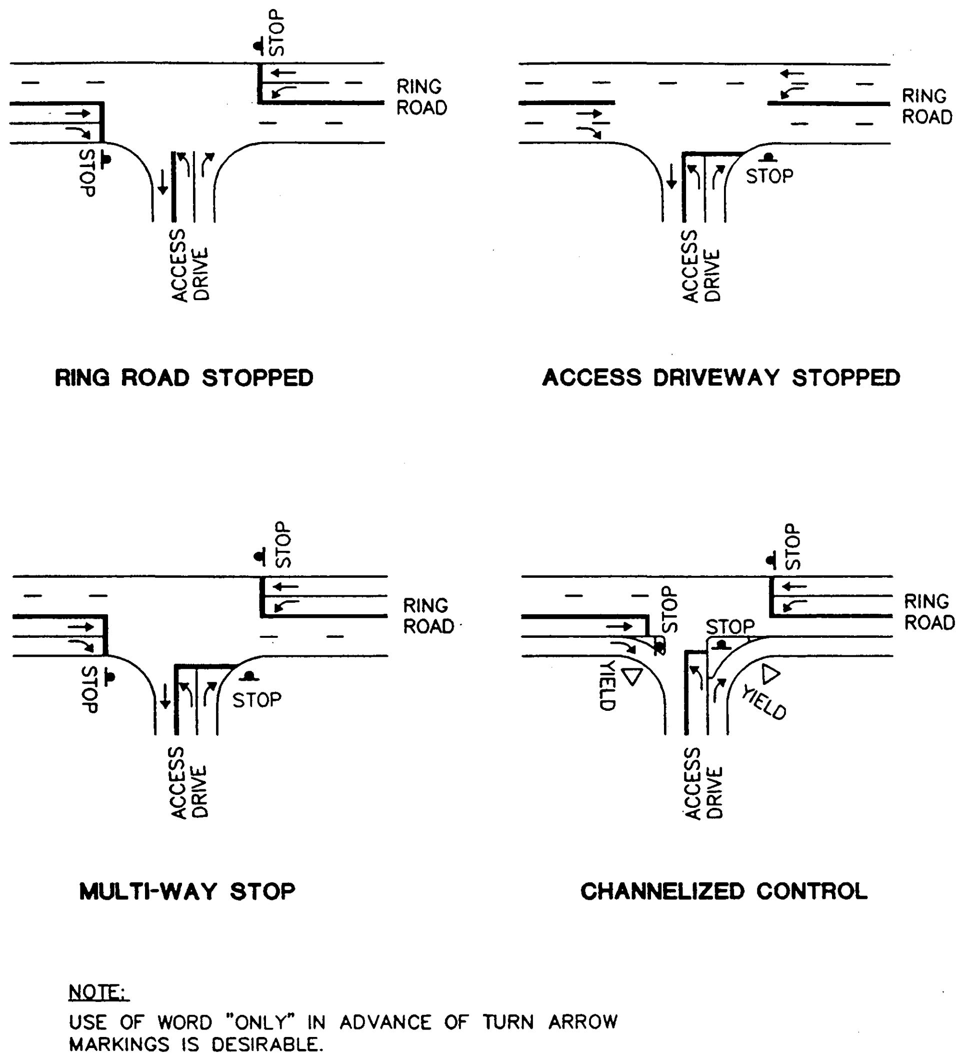

FIGURE 3 Types of ring road/access driveway control.

1. If no vehicles are parked next to or near the cross aisle, the intersection should safely operate with no control;
2. If sight distance is mildly restricted by parked cars, a yield may be required of a driver emerging from the parking access aisle; or
3. If a van-type vehicle is parked in the end stall, a full stop may be required for safety.

There is no official traffic control that allows a driver to roll through or that requires a yield or stop, depending on actual conditions. Even if such a sign existed there often would be no place to post it, because all parking access aisles do not require end islands. When an end island exists proper design calls for a length of about 4 m (13 ft), which is shorter than the adjacent stall depth (*8–10*). A posted sign would be blocked from view by vans.

Operators of many large parking facilities from New York to Hawaii have treated parking access aisle intersections with interior cross aisles by painting the word *Stop* or a white stop bar on the pavement. Others have painted the word *Stop* in red within the area of a widened stop bar. In the absence of a posted sign, this installation would be considered unenforceable by most agencies. It directly violates MUTCD (*1*). It can be obscured by snow and requires periodic repainting (as do parking stall lines). Nonetheless, a painted word *Stop* fulfills most of the accepted requirements of a traffic control, with no penalty for violation. It alerts the driver of possible conflict and informs drivers who is to yield or stop. It does not legally obligate a driver to do either—an important point for locations where a physical stop is seldom required.

Until a practical alternative is developed, painted Stop signs may represent a good compromise in the search for a reasonable and effective device for this type of intersection control. Observations at many locations have found appropriate driver behavior with such markings. Additional specialized research that uses conflict measurement techniques may be warranted.

When employee, outlot, or overflow parking exists on the outside of ring roads of large developments, cross-type intersections also may be produced. For both of the latter conditions, a positive type of regulatory control may be required even when ample end islands are in place.

PEDESTRIANS

A very small proportion of total parking lot accidents involves pedestrians. Only 3 to 5 percent involve injuries, and about 20 percent of the injuries are to pedestrians. Evidently, pedestrian accidents are not a major problem. Several explanations appear to be plausible.

1. Drivers expect pedestrians to be almost anywhere in the lot because they themselves have either just finished being a pedestrian or are about to become one, and
2. Speeds in parking lots are low compared with those on streets and highways.

Walks Parallel to Rows

In a few older lots pedestrian sidewalks have been constructed as medial-type islands parallel to the parking rows. Such islands reduce lot efficiency and are typically a waste of space, aside from any landscaping, because vehicle occupants typically use the parking access aisles when walking to and from their cars.

Building Front Walks

When pedestrians have reached the building frontage they usually must then travel varying distances to an entrance. Except for the smallest facility, a building front walk is appropriate. Widths of 1.2 to 2.4 m (4 to 8 ft) are typically used, depending on whether parking abuts the walk (with bumper overhang) and whether merchandise is displayed for sale or other equipment is located on the walk.

The building front walk should usually be raised 13 to 15 cm (about 5 to 6 in.), with the curb face painted yellow. Because access to the walk is typically along its entire length, there may be little or no need for any crosswalk markings on the building front road.

Crosswalk Locations

When pedestrian concentrations occur and there is movement across interior roads, painted crosswalks should be considered. This generally applies to larger facilities or cases in which very frequent crossings occur, such as at a supermarket. In a regional shopping center crosswalks on the ring road are desirable at all points where internal walks or paths connect with the public street system, especially when residential streets radiate toward the shopping center.

The primary access driveways may represent logical pedestrian entry routes, even if they are not aligned with a public street to form a cross-type intersection, when nearby developments are residential. In such cases a sidewalk running the length of the reservoir area should be provided adjacent to the driveway of a shopping center (Figure 1). With significant numbers of pedestrians, attention must be given to the crosswalk at the ring road. This intersection may carry heavy vehicular volumes, most of which are turning movements. This adds conflict and pedestrian hazard, and it may require use of multiway Stop signs. If there is a diverter island (Figure 1), a walk may be needed to cross the island. Sometimes, a continuous pedestrian route to the nearest building front sidewalk is appropriate. This system could involve a walk within a curbed area parallel to a parking row (Figure 2).

Other pedestrian crosswalks on ring roads may be needed if a theater is located as an outlot on one side of the ring road, and most of its parking is on the other side. Because a crosswalk at such a location would not be near a major intersection, it likely should be treated as a midblock-type crosswalk with advance warning signs. Yellow flashers may be justified if the location is on or near a severe curve on the ring road that restricts sight distance.

Bicycles

Many provisions for pedestrians also have application for bicycle access. Bicyclists may cross roads in or adjacent to crosswalks and in general tend to follow the internal system for pedestrians. Normally, no special control or guidance is needed, but management may prohibit use of bicycles (and skateboards or roller blades) on building front sidewalks.

SPEED CONTROL

In smaller parking facilities it is unlikely that speed limit posting is needed or would be of significant value if one were installed. In large facilities, such as airports, office or industrial parks, and regional shopping centers, sensible speed limits should be considered. Limits of less than 50 km/hr (about 30 mph) are unlikely to be justified or obeyed under most conditions. On routes similar to ring roads such postings may be appropriate, even though the actual 85th percentile operating speeds are closer to 55 km/hr (about 35 mph). All speed limits should be in multiples of 10 km/hr (or 5 mph), not with signs such as 43 km/hr or 27 mph.

Speed control often is achieved by curves and roadway discontinuities. Ring road curves should not be severe. A 50-km/hr (30-mph) minimum design speed should be considered. Discontinuous roads may not be particularly desirable if circulation suffers. Use of Stop signs for the sole purpose of attempting to control speeds is not recommended. Studies have shown very high violation rates when these are used, except at marked crosswalks connecting generators such as supermarkets to their parking lots.

Speed bumps are not recommended. They can cause loss of control and injury to bystanders (*4*).

MARKINGS

Pavement markings may be divided into two broad categories: those intended to guide, control, or warn traffic, which should be reflectorized, and those used solely for delineating parking stalls (Figure 4).

Guidance

Guidance markings include centerlines and lane lines, should be installed in accordance with MUTCD (*1*), and should have widths of 10 to 15 cm (4 to 6 in.). Centerlines for two-lane roadways use skip-dash yellow, with segments of 1.5 to 3 m (5 to 10 ft) and gaps of 5 to 10 m (about 15 to 30 ft). For three- or five-lane roads with two-way left turn lanes, the standard solid yellow line outside and dashed yellow line inside should be used with white turn arrows.

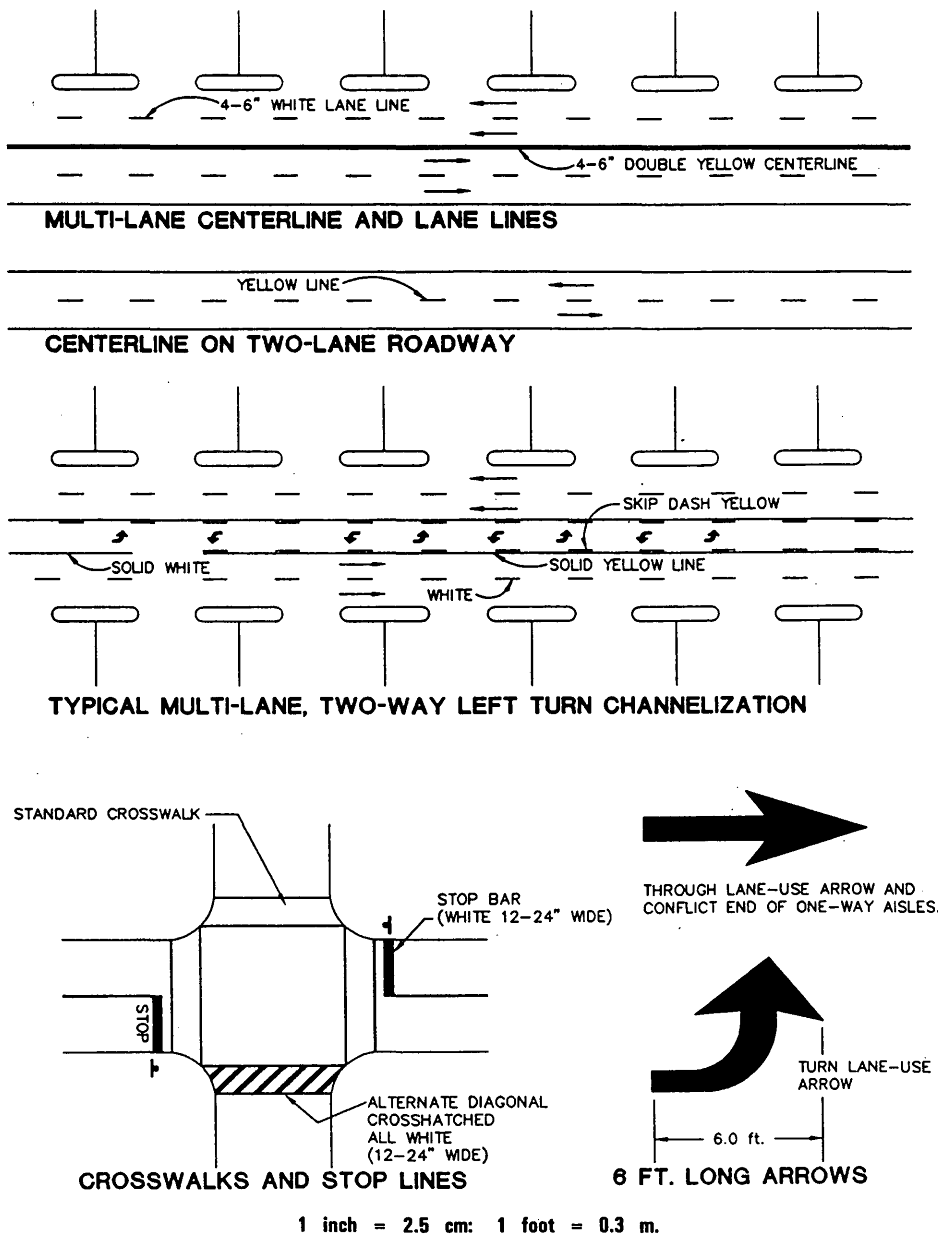

FIGURE 4 Typical markings.

For four-lane roads a double yellow centerline is recommended. It should not be broken at intersecting parking access aisles. It should be broken at access driveways (Figures 1 and 2).

Lane lines are always white, and typically skip-dashed with segments of 3 to 5 m (10 to 15 ft) and gaps of 5 to 8 m (15 to 25 ft). For about 30 m (100 ft) approaching a Stop sign or traffic signal, the lines may be solid. Adjacent to an exclusive turn lane the line should be solid.

Edge lines may have application along ring roads or any road without curbs. Their widths are typically 8 to 10 cm (3 to 4 in.), with white used for the right side and yellow used for the left side if it is next to a median strip or one-way road.

Crosswalk lines should be at least 15 cm (6 in.) wide and may also contain cross-hatching lines 60 cm (24 in.) wide.

Paint reflectorization uses premix (reflective beads mixed in) plus hand- or machine-spread beads dropped onto the wet paint. The surface sprinkle gives initial reflectivity, whereas the wearing of the paint exposes the mixed-in beads.

Thermoplastic markings can be used. Although they are more expensive, a much longer useful life is obtained.

Control

Traffic control markings are white and include turn lane arrows, one-way aisle directional arrows, stop bars, crosswalks, and the word *stop* when a word is used. A small 1.8-m (6-ft) standard arrow and the word *only* for turn lanes is usually adequate.

With angle parking and one-way aisles an arrow should be placed in the aisle with the point even with the intersecting crossroad at the conflict end that is subject to wrong-way entry (Figure 1). The word *only* is not required for this condition.

Stop bars may be used at Stop signs or traffic signals. If crosswalks are at stop or signal control points, a stop bar (Figure 4) is desirable.

If the word *stop* is painted at the intersection of a parking access aisle with a priority crossroad, white is the preferred color. However, red has been used for stop within the boundaries of a white stop bar of 30 to 40 cm (about a 12 to 15 in.).

Warning

Two general types of warning markings exist: those used on lineal objects such as curbs and cross-hatching (as within an end island or on approach to a median). Yellow is used, with lines of 10 to 15 cm (4 to 6 in.) in end islands and lines of 20 to 30 cm (8 to 12 in.) for cross hatching on approaches to obstructions (Figure 5).

When curbs are painted the marking typically extends over the top of the curb. Along a raised sidewalk, paint should wrap around on top for 15 cm (about 5 in.). A special condition exists when portions of the walk have been depressed for handicap access. Here the adjacent tapers, from full height to depressed, can present a slip-and-fall hazard. This can be reduced first by using a proper cross slope (*11*) of about 12:1 and second by painting the triangular depression slope yellow with a skid-resistant paint mixed with fine sand. It is desirable to use skid-resistant paint on the tops of all curbs abutting sidewalks or wraparound edge painting.

Another warning marking concerns vertical objects such as light, utility, or sign poles and fire hydrants. Yellow is the preferred hazard color for most applications. Several methods are available:

1. Paint extending at least 0.6 m (2 ft) up from the surface,
2. Reflective tape bands mounted 0.6 to 1.2 m (2 to 4 ft) above the surface,
3. Vertical panels, and
4. Circular reflectors.

The 3M Company makes a reflective liquid (Scotchlite 7200 Series) in white and yellow nighttime colors. These can be brushed or sprayed onto the lower parts of poles, concrete bases, or fire hydrants. Liquids used for round objects typically cover the full circumference facing all directions of approach.

Tape bands are used on poles to face all approach directions.

Only one reflective face of vertical panels [object markers; Type 3 in MUTCD (*1*)] is exposed. They usually are not suitable for marking poles because three or four panels would be needed. They are used to warn of hazards immediately adjacent to the roadway, such as walls, or are used on columns in the center of a roadway, although the Keep Right sign may be preferred.

Circular markers (MUTCD Types 1 and 2) can be used for one direction of an approach. Even 8-cm (3-in.) bicycle reflectors can be nailed to the four sides of a wooden utility pole or sign post exposed in a parking lot. A serious injury accident occurred within a parking lot where on a rainy night a truck struck a utility pole placed in the direct path of travel (*12*). A bicycle reflector or reflective band likely could have prevented the accident.

Parking Stalls

The standard and desirable color for painting stall lines is white (*8,10*). Yellow is reserved for uses where the attention-gathering power of this color is needed, such as in cross hatching of end islands and curbs. In at least one slip-and-fall injury case, it is claimed that the widespread use of yellow paint for parking stalls, arrows, and curbs depreciated the effect of this color at a walk's edge.

There are two general types of stall marking: the single and the double (hairpin). Some engineers and users are of the opinion that the latter type aids drivers in centering their vehicles within the stalls. However, research by Box (*4*) found no centering differences between single and double lines.

MISCELLANEOUS SIGNS

Several regulatory signs in the MUTCD may have application. They should be used in conformity with the standards and the application guidelines of Manual (*1*). These include

- No Parking Fire Lane,
- No Parking at Any Time,
- Keep Right (left),
- Do Not Enter,
- One-Way,
- No Left (right) Turn,
- Traffic from Right (left) Does Not Stop,
- Stop,
- Yield,
- Dead End, and
- Large arrows.

Parking signs are available in two sizes: 30 × 45 cm (12 × 18 in.) and 45 × 60 cm (18 × 24 in.). Those of the smaller size should be spaced not more than 50 m (about 150 ft) apart when they are used in series, whereas those of the larger size can be set up to about 75 m (250 ft) apart.

Most Stop signs will be adequate if they are of the 60-cm (24-in.) size. However, for short viewing distances such as those that occur when a vehicle is emerging from truck docks or between buildings (see Point A on Figure 2), the 45-cm (18-in.) size may be used. It is sometimes necessary to bracket mount the sign to the wall, and the reduced size minimizes the projection.

Other signs are fabricated for specific uses, such as Exit to _____ Street and Added Parking in Rear.

Signs are most effective if standard color combinations are used, such as black on white for information and green on white for guidance. Principles of basic legibility should be followed, and the desired readability distance should be determined. A rule of thumb is 6m/cm (50 ft/in.) of letter height for broad-stroke letters and numerals. At least 3 sec at likely driving speed should be available for reaction and response time. For example, an assumed speed of 55 km/hr (35 mph) is about 15 m (50 ft) per sec, which requires an 8-cm (3-in.) letter height. In practice larger sizes are preferable.

Most signs intended to be read by drivers, except the parking series, should have reflectorization or direct illumination.

ENFORCEMENT

The *Model Traffic Ordinance* (*13*) contains provisions pertaining to police enforcement of traffic regulations on private property recommended for adoption by local governments. Two methods are used: routine police patrol and on call by management. Enforcement should be limited to standard devices identified in the state MUTCD. They should be properly displayed and maintained to be reasonably visible to the driver.

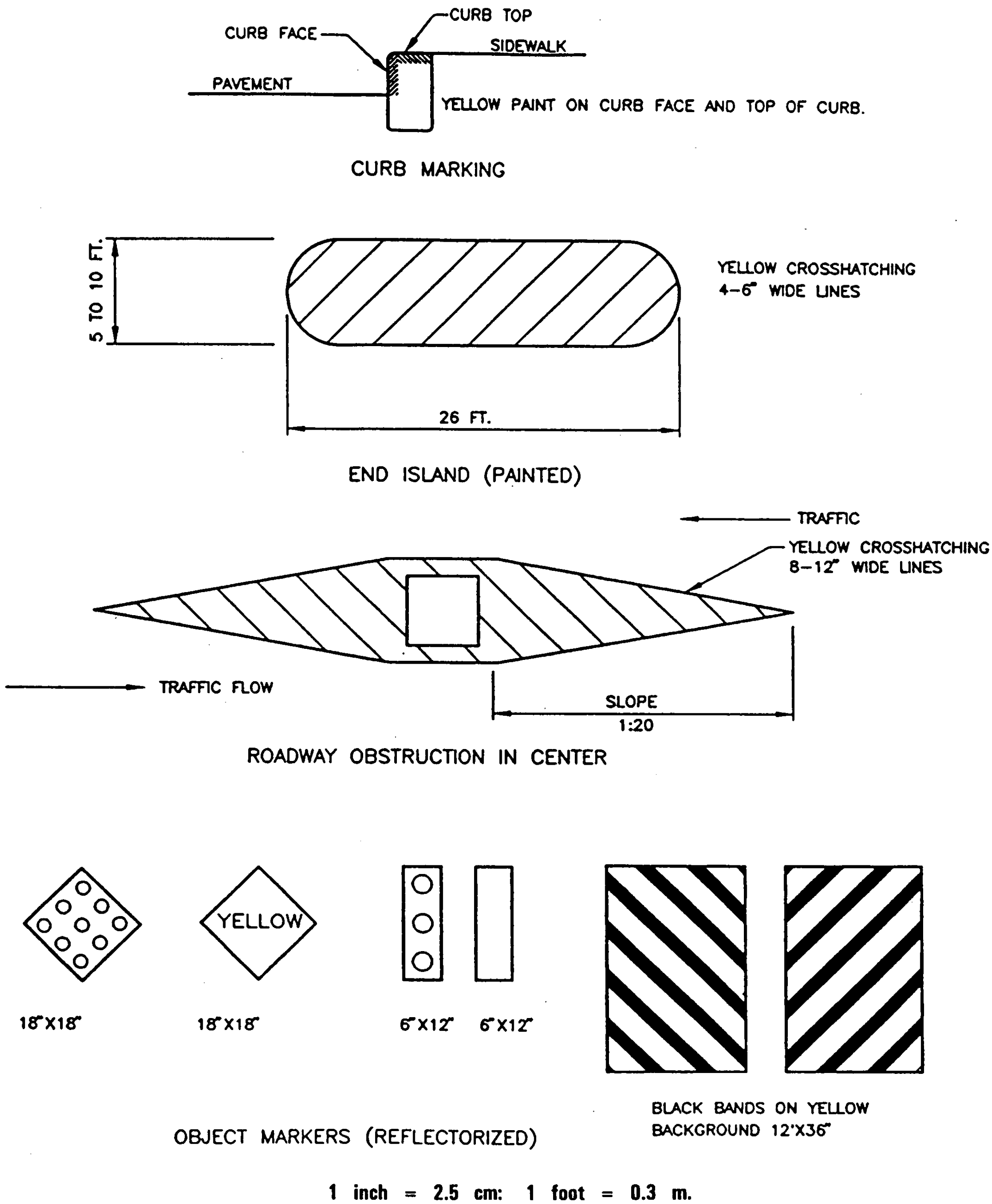

FIGURE 5 Marking used for warning.

There is an exception for speed limit and Stop signs. Unless the speed posting is set by 85th percentile engineering studies of actual driver behavior, it is not a legal limit in many states. The *Uniform Vehicle Code* (*14*) statutory urban limit of 50 km/hr (30 mph) as legislated in progressive states would not be expected to apply unless it was posted and warranted by engineering studies. Therefore, enforcement of speed limits is usually impractical.

The multiway Stop sign installations have specific warrants in MUTCD. Unless they are installed as a result of an engineering study that found the warrants to be met, issuance of a traffic ticket for violation of any Stop sign in a multiway set is likely to be improper on private property.

In large developments a security force and patrol of the premises are common. Although they cannot issue conventional traffic or parking tickets, warning tickets can be given or they can summon the local police.

CONCLUSIONS

Traffic control devices in parking facilities should be based on engineering judgment and rational application. Research on driver behavior at intersection controls consisting solely of white stop lines, the word *stop,* or combinations of the two is needed to determine the effectiveness of this type of control. Additional studies of accidents of the types performed in Illinois and Atlanta would be desirable. In particular, the size of the parking facility needs to be determined, where end islands may become significantly effective. Also, accidents involving vehicles exiting from driveways onto access streets need to be studied in relation to the size of the parking facility to determine where Stop signs should be installed to supplement the rules of the road.

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