Two-Lane Loop Ramps: Operation and Design Considerations

ROSS J. WALKER

The literature on the operational, safety, and capacity aspects of existing two-lane loop ramps is reviewed, and an overview is provided. Using this information, design parameters are suggested until further research is available. Little research information is available on the operation and design of two-lane loop ramps. AASHTO covers single-lane loop ramps very well but does not mention two-lane loop ramps. A TRB literature search indicates that only Georgia has carried out research on two-lane loop ramps. The findings of the Georgia report are discussed along with observations of other two-lane loops in Toronto, Vancouver, and Florida. Generally, directional or semidirectional ramps are preferred for high-volume ramps. They provide more direct travel, easier operation, and higher capacity than loop ramps. However, where there is insufficient space, the two-lane loop ramp is a reasonable compromise. The observations show that two-lane loops operate well where they have good geometric properties. Entrance and exit transitions and ramp widths and curvature all have to be integrated to ensure safe and convenient operation.

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It appears that the first two-lane loop ramp was constructed on Highway 401 at Weston Road in Toronto in approximately 1966. This ramp has been in operation for 25 years. The high volumes that were first predicted have not materialized. It presently carries 1,100 vehicles in the peak hour, 10 percent of which are trucks.

EXISTING TWO-LANE LOOP RAMPS

Table 1 gives the dimensions of five two-lane loop ramps in operation today. Included are the pavement and shoulder width, radius of the controlling curve, and peak-hour volumes. These ramps are completely two lanes, including the exit and entrance terminals.

There are also many partial two-lane loops, where ramp metering and HOV and priority lanes are used. In these cases, the ramp proper becomes two lanes after a single-lane exit and continues as two lanes up to the ramp entrance where it tapers back to one lane. Table 1 indicates that there is little uniformity in the geometric dimensions of these ramps.

Delcan Corporation, National Engineering Technology Corporation, 16700 Valley View Avenue, Suite 260, La Mirada, Calif. 90638.

Highway 401 and Weston Road—Toronto

Figure 1 shows the configuration of the ramp that is part of a Parclo A interchange. It has spirals at each end leading into 20-degree curves, which are then compounded to a 38-degree controlling curve.

The pavement width is 24 ft with a 1.5-ft left shoulder and an 8-ft right shoulder. The peak volume is 1,100 vehicles per hour (vph). Pictures of this ramp are shown in Figures 2 through 4. Both lanes of the ramp are used, even at low volumes.

Figure 2 shows the two-lane exit on Weston Road where both lanes are dropped. There are signals immediately upstream from this picture, and the two lanes line up at the signalized intersection and continue through to the exit. The two-lane loop was designed to allow the exit to carry the 1,500+ volume forecast.

Figure 3 shows that both lanes of the ramp are used, and in this case the spacing between the vehicles seems to be adequate. However, as traffic continues around the loop, a W-beam guardrail is introduced 3 ft from the left edge of the pavement, just outside of view of Figure 2. This rail tends to restrict larger vehicles so that they crowd the right lane. The 24-ft pavement width is too narrow, and wider lanes would give better and safer operation.

Figure 4 shows the two-lane loop ramp entrance with the inside lane being carried on as the added lane to the freeway.

Highways 99 and 17—Vancouver, British Columbia

This ramp has a left shoulder width of 6 ft, a pavement width of 27 ft, and a right shoulder width of 6 ft. The controlling radius is 230 ft. The ramp has a uniform shape similar to Weston Road. Highway 17 has signals just east of the ramp exit, and therefore it operates as a Parclo A. The second lane is optional for ramp and through traffic on Highway 17. However, the optional lane is filled with ramp traffic during the peak hour. Highway 99 is a freeway.

This ramp operates well, as shown in Figures 5 through 8. The traffic is well spaced across the width of the ramp. During peak hour this ramp is subject to surge flows. Under these conditions the ramp carries 2,530 vph (15-min flows) and operates at 15 to 20 mph.

Florida Turnpike 821—Kendall Drive, Miami

This two-lane configuration has a good speed transition zone with 400-ft spirals and a controlling radius of 240 ft. It operates

TABLE 1 Geometry of Existing Two-Lane Loop Ramps

Location	Left Shoulder	Pavement Width	Right Shoulder	Radius	Peak Hour Volumes
	feet				vehicles p/h
Highway No. 401, Weston Road, Toronto	1.5	24.0	8.0	154	1,100
Highway 99, Highway 17, Vancouver, B.C.	6.0	27.0	6.0	230	2,530
Florida Turnpike 821, Kendall Drive, Miami	2.0	28.0	8.0	240	1,220
I-75N to I-285W, Atlanta	4.0	37.0	7.0	200	1,040
G 400 Holcomb Bridge, Atlanta	10.6	23.5	4.3	150	2,070

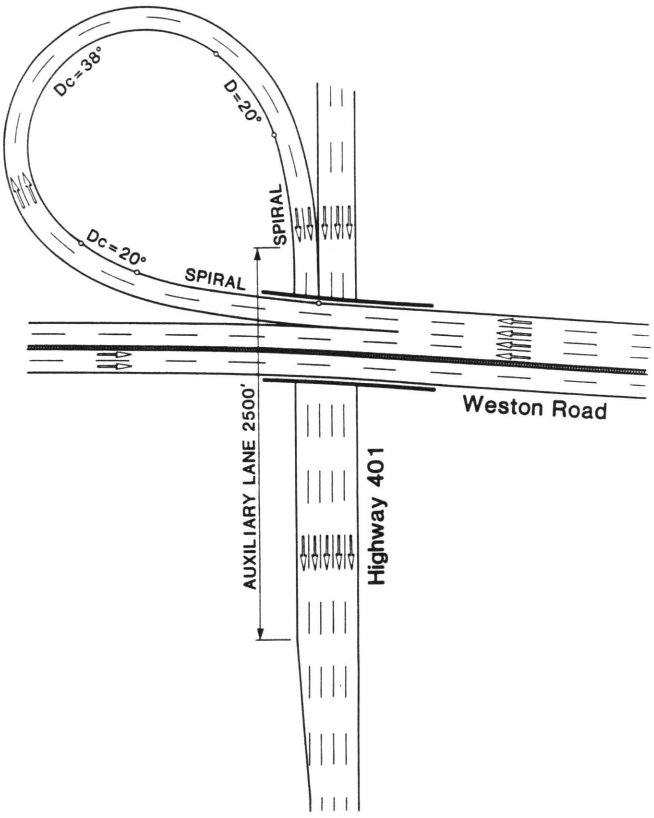


FIGURE 1 Highway 401 and Weston Road ramp.

FIGURE 2 Two arterial lanes approach exit to loop ramp (Toronto).

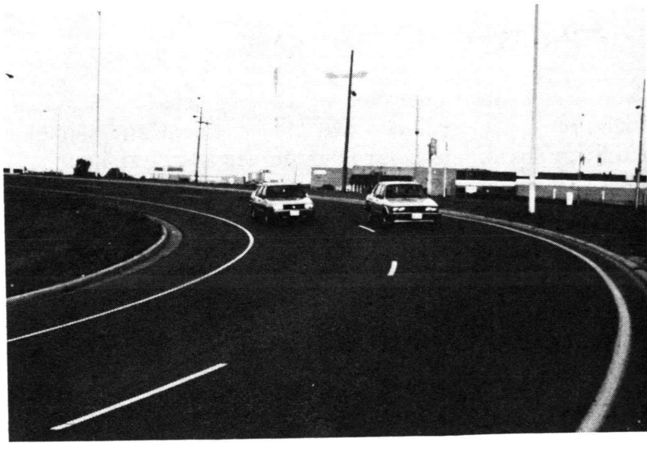


FIGURE 3 Spacing of vehicles on two-lane loop under low-volume conditions (Toronto).

as a Parclo B with a single exit off Kendall Drive before the structure as shown in Figure 9. The pavement width is 28 ft, the right shoulder width is 8 ft, and the left shoulder width is 2 ft. Present off-peak volumes are low because the ramp has only recently been opened to traffic. Even in low-volume periods, both lanes are being used.

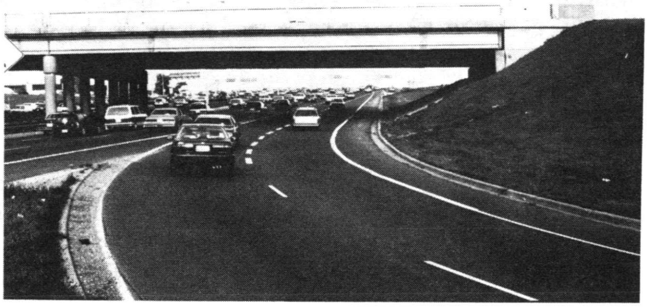


FIGURE 4 Two-lane entrance to freeway from loop ramp (Toronto).

FIGURE 5 Traffic exiting highway 17 to two-lane loop ramp (Vancouver).

FIGURE 6 Vehicle spacing on two-lane loop ramp (Vancouver).

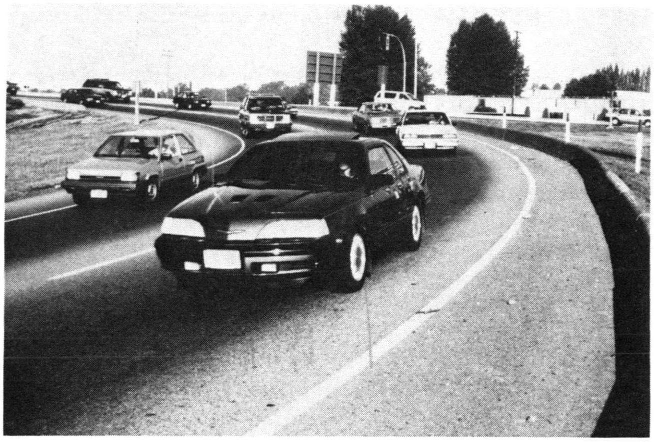


FIGURE 7 Vehicle position adjacent to trucks (Vancouver).

FIGURE 8 Vehicle spacing just before entrance (Vancouver).

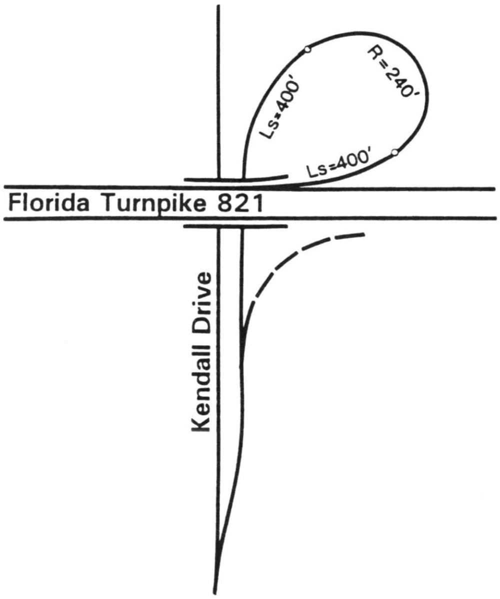


FIGURE 9 Florida Turnpike 821–Kendall Drive (Miami).

I-75N to I-285W—Atlanta, Georgia

Figure 10 shows the layout of the two-lane ramp after widening. The controlling curve has a radius of 200 ft with a left shoulder of 4 ft, a right shoulder of 7 ft, and a pavement width of 37 ft. The peak hour volume is 1,040.

Backups frequently occurred before the addition of a second lane. After construction, the two-lane loop ramp operated smoothly, with both lanes being used. The right lane carried more traffic than the left. Traffic was not heavy enough to really test the capacity of the two-lane loop. However, even with the 18 percent truck traffic, cars were able to pass and experienced no delays. The ample width of the ramp allowed the traffic to run smoothly.

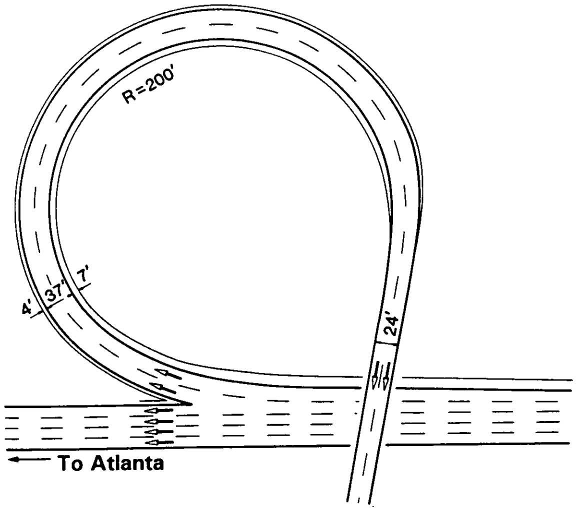


FIGURE 10 Two-lane loop ramp I-75 to I-285W.

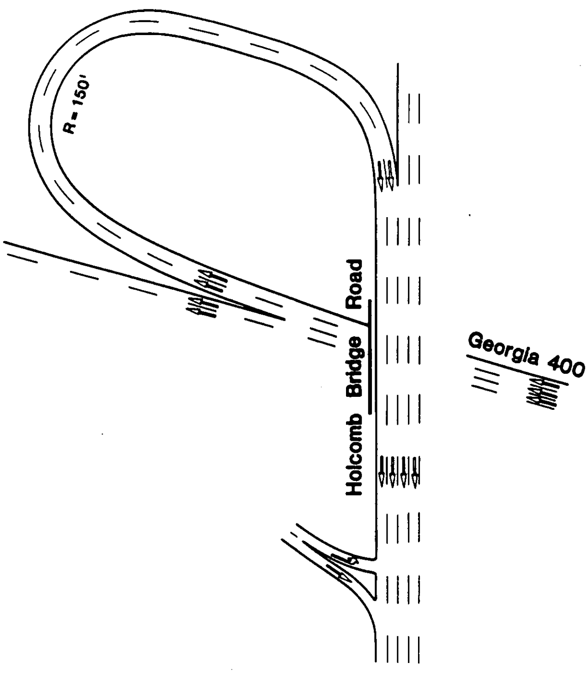


FIGURE 11 G 400 and Holcomb Bridge ramp.

G 400 and Holcomb Bridge—Atlanta, Georgia

The G 400 Holcomb Bridge ramp has an irregular shape as shown in Figure 11. It has a wide left shoulder of 10.6 ft, a modest right shoulder of 4.3 ft, and a narrow pavement width of only 23.5 ft. The peak-hour traffic is high at 2,070. Studies at this location indicated that the pavement width is too narrow and should be widened. Backups into the curve of the ramp were reduced. However, there are several encroachments from lane to lane, some due to vehicles traveling too fast. There were also incidents of following too closely and conflict between lanes in the curve.

ACCIDENT EXPERIENCE

The Highway 401–Weston Road ramp has only had six accidents in 3 years (1988 through 1990): one rear-end, two sideswipes, and three single-vehicle. Four accidents were in daylight and two at night. Five were in dry conditions and one was in wet conditions.

Before-and-after studies of the I-75N to I-285W and G 400 and Holcomb Bridge ramps have been carried out by Selph and Caylor (*1*). The before findings showed that the rear-end collisions at the I-75 to I-285 ramp occurred in the first two-thirds of the ramp. These could have been caused by two factors: (*a*) cars having to reduce speed abruptly because of trucks climbing the 3 percent upgrade of the ramp and (*b*) the lack of deceleration or transition distance between the nose and the controlling curve. Vehicles exiting from the high-speed I-75N have insufficient distance to decelerate to the ramp speed.

The before studies showed that rear-end collisions occurred on the G 400 ramp near the entrance to Holcomb Road. The longer speed transition of the exit allowed traffic to adjust to the ramp curvature. However, the problems at the entrance probably occurred because of the cyclical stop-and-go traffic due to the signal on Holcomb.

After-accident data also indicated an increase in angle-intersecting accidents on the exit section of the G 400 ramp. This ramp did not have an advisory speed sign, and the narrow width of the two-lane ramp left very little room for vehicles to maneuver. The Parclo B type loop with a direct exit from the freeway also required the high-speed traffic from the freeway to adjust very quickly to the slow ramp speed. These could be factors in the angle-intersecting accidents on this ramp. Further studies and research are needed to verify these assumptions.

DESIGN CONSIDERATIONS

Design features of a two-lane loop ramp can be broken into three main categories: the exit, the ramp, and the entrance. The following discussion suggests some design criteria for two-lane loop ramps on the basis of the author's observations and experience. Research is required to assess these criteria.

Exit Design

Exit From Arterial (Parclo A)

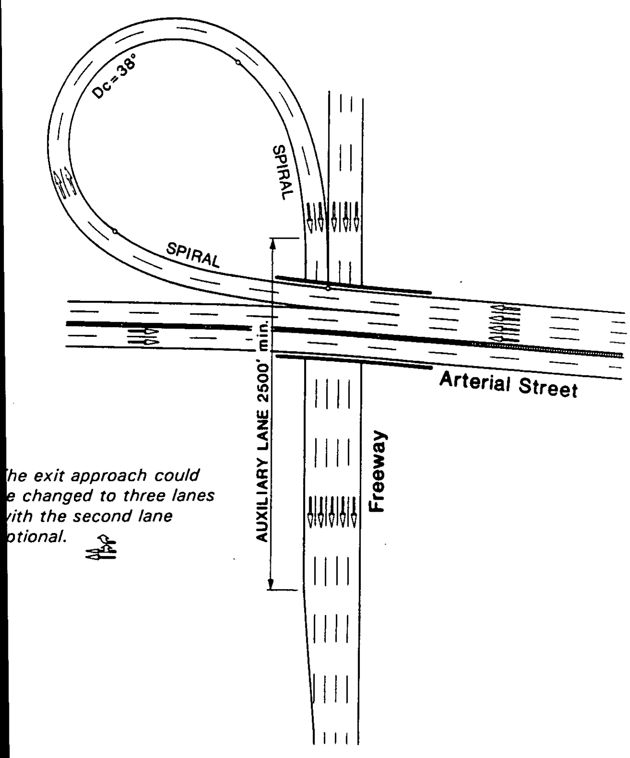
Figure 12 shows a typical Parclo A two-lane loop ramp exiting from an arterial street. Two lanes are dropped at the exit to increase the capacity of the ramp. The two lanes continue back through the signalized intersection. This allows traffic to line up in the proper lanes at the intersection and increase the flow to the ramp. The exit approach could be changed to a three-lane approach with the second lane optional. This would provide better lane balance but would reduce the capacity of the ramp. The selection of either of these designs would depend on the intersection spacing and capacity requirements.

Overhead lane signs are required at the signal to ensure that traffic is positioned in the proper lanes. Must Exit signs would also be required.

Exit From a Freeway (Parclo B)

A single exit before the structure is recommended as shown on Figure 13. The two-lanes exit requires an auxiliary lane upstream for 2,500 ft to develop exit capacity. After the exit, the ramp splits two to one with two continuing to the loop ramp.

A 150-ft radius (25 mph) is normally used for restricted urban conditions. A 230-ft radius (30 mph) could be used in more open or rural situations to reduce the speed transition by 5 mph.



GURE 12 Typical two-lane loop design, Parclo A.

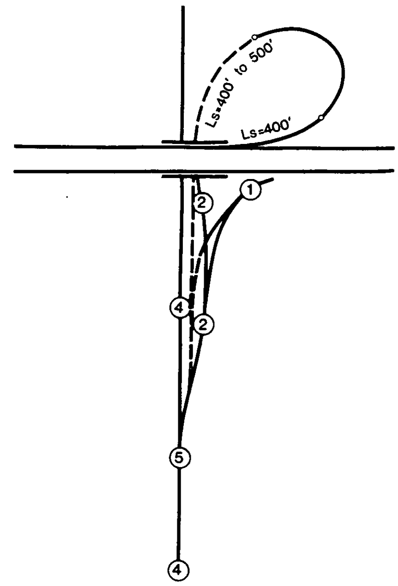


FIGURE 13 Typical two-lane loop design, Parclo B.

Traffic exiting from the freeway will be traveling in the 60- to 70-mph range and will have to decelerate to 25 to 30 mph at the loop ramp. If the configuration is as shown on the dashed lines of Figure 13, there will be a tendency for drivers to speed up instead of slowing down. They will then have difficulty negotiating the sharp curvature of the loop.

When the two lanes of traffic have to negotiate the sharp curvature of the loop, the design has to provide for as smooth an operation as possible. Any erratic maneuvers are much more hazardous with the two lanes. This means that the geometric design has to provide an alignment that allows drivers to transition to the very slow speed of the ramp. If they enter the loop traveling too fast, they will cause accidents.

The curvilinear design (solid line) helps alleviate this problem because drivers will adjust their speed gradually over the whole ramp. A long spiral is preferred at the entrance to the loop ramp to assist in the speed transition. Drivers recognize the curvature of the spiral and can adjust their speed accordingly.

Ramp Design

Figures 12 and 13 show a desirable ramp layout with a spiral transition from the exit to the controlling curve of the ramp. This curve is followed by a spiral transition to the entrance area.

Table 2 gives recommended pavement and shoulder widths for a two-lane loop ramp for 25 mph (150-ft radius) and 30 mph (230-ft radius) ramp design speeds. The pavement width is important to provide good lateral clearance between vehicles and to allow for smooth operation. The shoulder widths, 8-ft right shoulder and 4-ft left shoulder, allow ample space so that drivers do not feel crowded while making the tight radius turn. These dimensions will allow traffic to flow smoothly and provide the required capacity.

TABLE 2 Two-Lane Loop Ramps—Recommended Pavement Widths

Traffic Condition[a]	Left Shoulder	Pavement Width	Right Shoulder	Radius
	feet			
A	4	26	8	150 - 230
B	4	28	8	150 - 230
C	4	30	8	150 - 230

[a] Traffic Conditions A, B, C - See Table X-3 AASHTO - A Policy on Geometric Design of Highways and Streets *(2)*.

Superelevation will depend on the location. However, a 0.08 ft/ft maximum would be considered in snow conditions. Vehicles tend to overdrive ramps, and the 0.08 ft/ft will assist in allowing for this. Normally Parclo A ramps are in a downgrade. Where the ramp is on an appreciable upgrade and there is any chance of trucks' speeds being reduced to a crawl, 0.06 ft/ft could be considered. This requirement would allow for side slippage of vehicles at slow speeds on ice. The compromise has to be established between the extra super, which is used all the time, and the number of times that ice may be a problem. Values higher than 0.08 ft/ft in warmer climates would be desirable.

Entrance Design

The standard two-lane entrance design from AASHTO should be used, which will allow for an auxiliary lane of 2,500 ft for turning volumes of 1,500 to 2,000 vph and 3,000 ft for volumes in excess of 2,000 vph.

Whereas a single-lane ramp can accommodate up to 1,500 vph, it is unlikely that a single exit or entrance can, unless a line is dropped at the exit or added at the entrance. A lane drop at the exit would not provide good lane balance, and therefore a two-lane exit is more desirable for volumes over 1,000 vph. A single lane at the entrance would be acceptable.

SUMMARY

Generally, directional or semi-directional ramps are preferred for high-volume, two-lane ramps. They operate at higher speeds and tend to be safer. However, where there is insufficient space or a need to increase the capacity of an existing one-lane loop ramp, the two-lane loop ramp is a reasonable compromise solution. It will provide the required capacity, although not as good service, as the directional ramp.

With proper exit, entrance, and speed transition zone design, a loop ramp can carry up to 2,000 vph in a safe and reasonable manner. The capacity will depend on the approach road configuration. The recommended widths in Table 2 should ensure smooth flow. Care should also be taken to allow adequate auxiliary lane lengths and acceleration lanes when entering the mainline on an upgrade. The 2,000 vph could require a change in the basic number of lanes or certainly addition of an auxiliary lane as well as care in establishing lane balance.

Volumes of up to 2,500 have been experienced as indicated in Table 1. However, this ramp operates at Level of Service F (15 mph).

REFERENCES

1. S. D. Selph and T. N. Caylor. *Evaluation of Two-Lane Loop Ramps*. Research and Development Bureau, Office of Materials and Research, Georgia Department of Transportation, Atlanta.
2. *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway and Transportation Officials, Washington, D.C., 1990.

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