OPERATIONAL EFFECTS OF GEOMETRIC DESIGN AT FREEWAY LANE DROPS

Diane Nelson Goodwin, Technology Service Corporation, Santa Monica, California

ABRIDGMENT

Traffic operations at freeway lane drops suffer when geometric design or traffic control devices provide insufficient or misleading information to drivers. This paper discusses the nature of traffic operation problems at freeway lane drop locations and presents eight design principles that should be considered when a lane drop is constructed or updated. These principles include recommendations for planning visibility, location, taper and escape lane characteristics, and traffic control device requirements. A before and after study conducted at a lane drop site in metropolitan Los Angeles illustrates a method for using the design principles to evaluate the effectiveness of a change in traffic control devices at the site.

•OPERATIONAL problems stemming from a reduction in the number of traffic lanes on a freeway are frequent and sometimes severe. A project (1) was undertaken to define the nature and extent of the operational problems of freeway lane drops so that operational improvement of existing lane drop locations and guidelines for future site construction could be recommended. Field observations at 65 lane drop sites throughout the United States were made, and interviews with representatives of over 20 transportation agencies were conducted.

The results of the study pinpoint two basic types of operational problems: those attributed to an excessive demand on the system and those attributed to insufficient information available for the driver to respond effectively to the lane drop situation.

Although not easy to accomplish, the solution to operational problems caused by demand exceeding downstream capacity is fairly straightforward. Two solutions for existing problem locations are (a) extend the lane until demand is reduced to a level below lane reduction capacity and (b) reduce upstream demand. A Policy on Geometric Design of Rural Highways (2) indicates a design capacity of 1,200 vehicles per hour (vph) on suburban freeways and 1,500 vph on urban freeways. If the demand predictions hold true, then a lane can be dropped, and a geometric bottleneck will not be created.

Operational problems associated with the inability of drivers to perceive, interpret, and react properly to a lane drop situation are much more subtle and more difficult to analyze.

By definition, an operational problem exists if a significant number of drivers make erratic maneuvers in the area of the lane drop. Erratic maneuvers include sudden speed changes; abrupt lane changes; and lane changes that require driving through a ramp gore area, an escape lane, or a lane drop taper. Some of these erratic maneuvers may result in unsafe conditions or even accidents; many may result in increased driver anxiety.

The requirements for negotiating a lane drop are an awareness of an impending lane drop, a knowledge of the location of the lane drop, and an ability to decide on an appropriate maneuver and to execute that maneuver. When drivers are in the vicinity of a lane drop, the longer information regarding these requirements is withheld from them, the fewer options they have for making smooth transitions through the area. Therefore, lack of important information necessary for negotiating the lane drop may be seen as the source of driver-behavior operational problems at lane drop locations.

The analysis of observed traffic operations at many differently configured lane drop

locations has yielded eight design principles that should be considered in the construction or remedial treatment of freeway lane drops.

PROVIDE CONTINUOUS VISIBILITY

The lane drop should be placed where the surface of the roadway remains continuously visible for a significant amount of time. A lane drop that is located just over the crest of a grade or just beyond a horizontal curve is not desirable since such placement results in a loss of valuable visual cues. Conversely, lane drops located at the end of a sagging vertical curve or on an upgrade may operate effectively even without good advance signing because the driver can see such drops in time to take appropriate action.

MINIMIZE ATTENTION-DIVIDING CONDITIONS

The lane drop should be placed away from attention-dividing conditions, such as ramps or complicated directional signing. The driver should have to make only one decision at a time. This does not mean that a lane drop should never be built at an exit ramp. It does mean that, if additional ramps or traffic control devices not directly pertaining to the lane drop exit ramp are nearby, then chances of drivers missing the cues associated with the lane drop are increased.

PROVIDE ADEQUATE TRANSITION CUES

The lane drop taper should allow for a smooth transition for a lane change in the taper area and should provide adequate visual cues that inform the driver that the lane is ending. A taper that is too short will cause drivers to make panic lane changes or speed changes, even though it produces a dramatic visual lane-ending cue to the driver. A lane drop taper that is too long will allow drivers to make a smooth transition into the through lane, but does little in the way of giving drivers visual cues that the lane is ending. Since a visually observable taper is probably the most reliable cue available for informing drivers of the impending lane drop, its loss can seriously impair the effectiveness of the lane drop site. Therefore, stub-end lane drops should be avoided. Where a stub end is desirable from a construction standpoint, it should be made with an artificial taper by covering upstream pavement with dirt and by providing removable curbing. Further research should be conducted to define the standard length of a lane drop taper.

CREATE LANE DROPS ON BETTER SIDE OF FREEWAY

The lane drop should be placed on the better side of the freeway for given traffic and geometric conditions. Whether a lane drop taper should be built on the left or the right has been the subject of considerable discussion. Based on this study, there seems to be no definitive answer to this question. One argument states that the left drop is advantageous because (a) there is usually less traffic in the left two lanes, (b) the left lanes are away from the influence of ramp turbulence on the right, and (c) vehicles generally flow at a more uniform speed in the left lanes since there are few slower commercial vehicles. Another argument states that the right drop is advantageous because (a) drivers are accustomed to having lanes end (i.e., acceleration lanes) on the right and can merge better from right to left than left to right, (b) traffic is generally slower in the right lanes and therefore there will be a slower speed merge, and (c) there is generally less traffic in the right lanes.

To help determine which lane to drop from a freeway, the following factors should be considered:

1. What type of lane distribution is expected? It would be preferable to merge the two most lightly traveled lanes.
2. What type of traffic composition is expected? When a large percentage of heavy trucks or recreational vehicles is expected, consideration should be given to merging the two left lanes.
3. What other geometric features, such as ramps, are nearby? Lane drops generally work better away from the influence of ramp turbulence.
4. Will the sight distance be significantly better on one side than the other? Sight distance is always critical.
5. Will it be more difficult to sign a lane drop on one side than the other? Appropriate signing can significantly improve a bad situation.

By examining these factors, the engineer can then make a reasonable judgment concerning which side of the freeway should have the lane drop.

COORDINATE VISUAL AND OPERATIONAL DROP

The lane should appear to physically end on the same side of the freeway as the operational lane drop. In some cases it is physically advantageous, yet not operationally desirable, to drop a lane on a particular side of the freeway. This may occur when a lane is dropped but there is a high probability of a future continuation. From a construction viewpoint, it is desirable to drop the left lane by stubbing the pavement off. However, from an operation view, this treatment of a lane drop may be far from optimum. This situation is usually corrected by merging the right two lanes by striping and signing. Theoretically, this will solve the problem; practically, the results of such situations have been less than optimum. Such treatment sets up a right-of-way problem for two drivers who arrive simultaneously at the lane drop and results in the loss of valuable information cues. A practical solution to this problem should be researched further. Generally, however, the operational merge should be accomplished by disguising the operational drop lane upstream of the physical drop so that it appears to be physically dropped. Figure 1 shows a plan and two perspective views of this situation. This may mean that, as in the case above in which a lane is dropped and future continuation is intended, some pavement may temporarily be unused by traffic so that better operational characteristics can be afforded.

PROVIDE ADEQUATE ESCAPE AREA

When a lane ends at an exit ramp, an escape area of adequate dimensions should be provided to allow for a smooth transition into through lanes. The escape area should be just that: an area for merging into the through lane after the driver is too close to the exit gore to make a normal lane change. The lane drop gore should be plainly visible to the approaching driver. Since the driver is probably traveling at or near freeway speed, a full acceleration lane is not needed, and a full lane width plus shoulder width may confuse the driver by providing too wide an area. Figure 2 shows perspective and plan views of an exit ramp lane drop.

NOTIFY DRIVERS THAT LANE IS NOT CONTINUOUS

When a lane is added at an on-ramp and dropped at a nearby off-ramp, the entering drivers should be notified that the lane they are traveling in is not a continuous lane for through travel. Normal lane lines should not be used as delineators in this situation. The lane should be designed as a special lane through the use of traffic control devices such as contrasting pavement color; overhead signs; or short, wide skip striping.

Figure 1. Plan and perspective views of opposite taper lane drop.

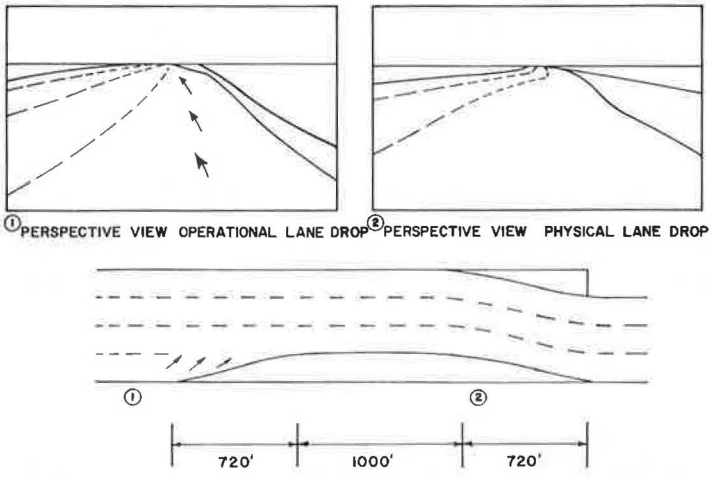
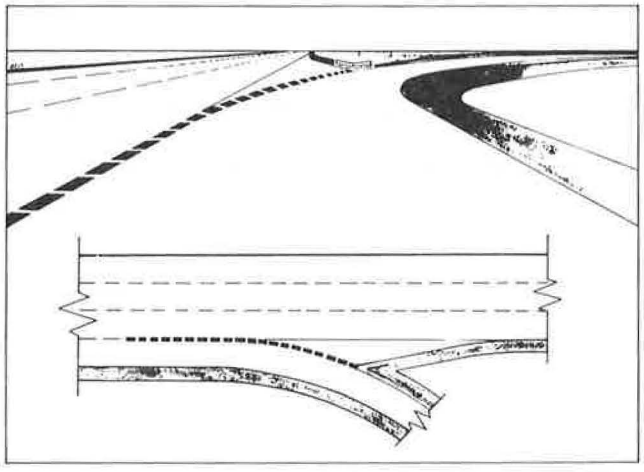


Figure 2. Plan and perspective view of an exit ramp lane drop.



USE ADEQUATE TRAFFIC CONTROL DEVICES

Consistent and appropriate traffic control devices should be used in advance of a lane drop. At many sites, incomplete or misleading information is given to the drivers. Drivers may be told to merge left, but in actuality the other lanes may move into their lane, such as where a lane is operationally dropped on the opposite side of the freeway from the physical drop. Occasionally missing information can be detrimental to lane drop performance. For example, a simple sign that reads ROAD NARROWS does not inform drivers of two important facts: (a) where the road narrows and (b) whether they are supposed to change lanes. Good traffic control devices will tell drivers what is going to happen, where it is going to happen, and what should be done about it. Traffic control devices should not confuse drivers with information not related to the task of traversing the lane drop section.

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