

Use of Acceleration-Deceleration Lanes

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INTRODUCTION

On the basis of various and recent research studies, it is apparent that highway designers must become more concerned with the relationship between highway design and traffic behavior. An excellent example of current interest in highway design is the design of acceleration and deceleration lanes. In order to obtain maximum efficiency and safety in the operation of acceleration and deceleration lanes, as well as for the main facility, it is necessary to relate the design of these special lanes to the requirements and desires of drivers. Drivers leaving a highway at an interchange usually need to reduce speed when leaving. On the other hand, drivers entering a highway at an intersection need to accelerate in order to reach the desired speed of the traffic on the main facility. Whenever this deceleration or acceleration by exiting or entering traffic takes place on the traveled way of the main highway, it disrupts the smooth flow of the through traffic and is hazardous. Thus, in order to minimize undesirable friction, maximum use should be made of acceleration and deceleration lanes.

Acceleration and deceleration lanes should be used, preferably, for the entire acceleration and deceleration phase by vehicles entering or leaving the through traffic lane. Each such acceleration and deceleration lane should be of sufficient width and length to enable a driver to maneuver his vehicle onto it without a major change in speed and, once on it, to make the necessary change between the speed of operation on the main facility and the lower speed on the interchange ramp. The optimum conditions of operation for an acceleration lane is to have acceleration lane traffic accelerate on the acceleration lane and merge at approximately the same direction of travel and at the same speed into through lane traffic. That for the deceleration lane is to have deceleration lane

traffic leave the through lane at about the same direction of travel as through lane traffic and at the same speed, with all deceleration taking place in the deceleration lane. There are no specific warrants for the use of acceleration and deceleration lanes as there are many factors to be considered such as speeds, traffic volume, capacity, type of highway, accident experience, etc., but acceleration and deceleration lanes are definitely warranted at intersections on all highway facilities which carry high traffic volumes at high speeds.

Acceleration and deceleration lane design varies very significantly from state to state. Some states follow the standards set forth in the manual, "A Policy on Geometric Design of Rural Highways" by the American Association of State Highway Officials. Other states have developed their own standards, using the "ASHO" manual as a guide.

The State Highway Commission of Indiana has used several designs for acceleration and deceleration lanes. The parallel lane type of acceleration lane was initially adopted as a standard. This design consisted of a full width lane 350 feet long plus 400 feet of taper; this design was constructed at several locations. Later the length of the parallel acceleration lanes was changed to 250 feet of full width with 250 feet of taper.

A few years later the direct taper type of acceleration lane was adopted in order to correct a tendency for entering traffic to move into the through lane too quickly. This latter acceleration lane design used a 750 foot taper. More recently a standard acceleration lane having 50:1 taper was adopted. This design is similar to one described in "Traffic Behavior on Freeways," Highway Research Board Bulletin 235.

Adopted standards for the state of Indiana for deceleration lanes have also included the parallel lane type and the direct taper type. One design used a taper from 0 to 12 foot lane width in 250 feet, followed by 50 feet of tangent and 190 feet of curve. The exit nose in this design is offset 12 feet from the through lane edge and has 360 feet of recovery. A second design utilizes a continuous radius curve. A third design has a taper followed by a curve and a fourth design uses a straight taper.

This research study on the use of acceleration-deceleration lanes when completed will provide a factual background regarding traffic behavior as affected by acceleration and deceleration lane geometry.

The purposes of this research are:

1. To determine the speed and lateral placement of vehicles on various designs of acceleration and deceleration lanes on high type facilities.

2. To correlate acceleration and deceleration lane designs with traffic behavior and driver requirements and determine the acceleration and deceleration lane design or designs which provide the most efficient and safest operation.

This paper deals only with the progress obtained to date in this research study. It describes the results obtained on two study locations, the Indiana Toll Road and Interstate 65 in the vicinity of the city of Lebanon.

METHODS OF COLLECTING DATA

The data for this study were obtained by the use of motion picture techniques using a 16mm. motion picture camera. Grid lines were established at a particular location by placing transverse paint lines on the pavement, as was done at the interchange of Interstate 65 with SR 39 or by using a 2 by 12 foot board covered with white adhesive tape. In the latter case a movie was taken with the board placed at each grid line location. These grid lines were placed perpendicular to the center line of the acceleration and deceleration lanes at specific locations.

The filming was done from a vantage point, usually from the overpass over the main facility at the interchange. The traffic operations on the acceleration and deceleration lanes were recorded on film by use of the 16mm. motion picture camera. The film was then analyzed by projecting it through a time-motion study projector (see Figure 1). The projector can be stopped for "still" or single frame viewing and a frame

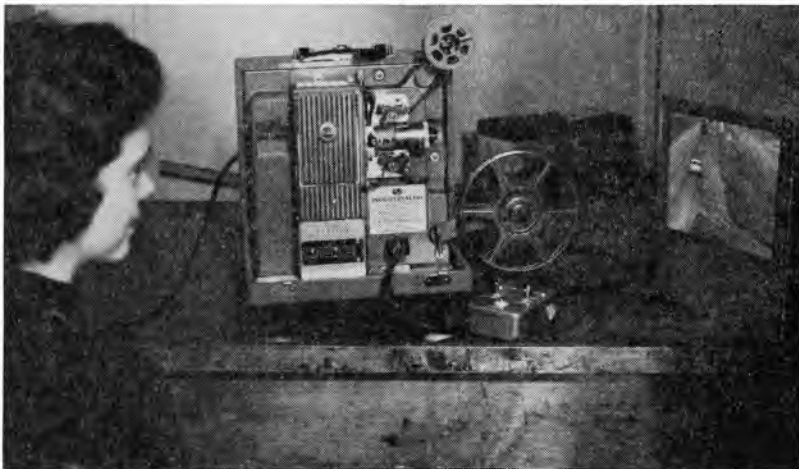


Fig. 1. Time-motion study projector in operation.

counter and push-button control allows manipulation of individual frames and the determination of specific data on speeds or lateral placement.

A grid was also traced on the screen to the same relative scale as that which was placed on the pavement. The vehicle speeds at various locations on the acceleration and deceleration lanes were computed by use of the grid system by determining the distance traveled in a time which was obtained from the number of frames each vehicle traveled between the two grid lines.

The lateral placement of vehicles on the acceleration-deceleration lanes were also traced by using the grid system. The speeds of through traffic at various locations on the main facility were obtained by use of a radar meter.

PROCEDURE AND RESULTS

The research study to date has been conducted on two different designs of acceleration lanes and two of deceleration lanes.

ACCELERATION LANES—TOLL ROAD

One of the acceleration lane types studied was on the Indiana Toll Road. A typical design of this type is shown in Figure 2.

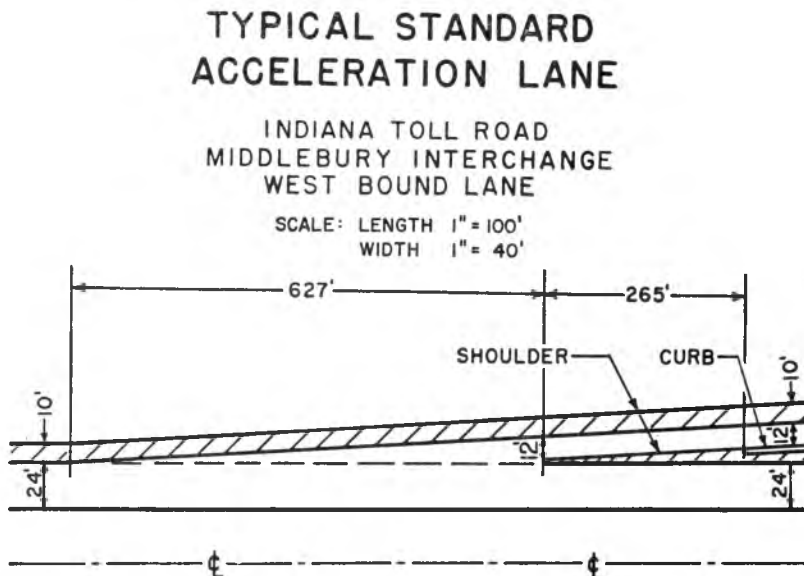


Fig. 2.

The length of the acceleration lane at this interchange was 893 feet from the edge of the curb to the intersection with the right edge of the through lane. A shoulder, which is paved but of different color, separates the acceleration lane and the through lane for a distance of 265 feet. This distance varies for different locations of acceleration lanes on the Toll Road. Beyond this point of separation the acceleration lane is an extra lane with a 52:1 straight taper from a width of 12 feet to 0 feet in a distance of 627 feet.

Five locations of this type of acceleration lanes were studied on the Indiana Toll Road. Each location exhibited certain special characteristics and each will be discussed separately.

One of these locations is at the Middlebury Interchange for west bound traffic (Figure 3). The acceleration lane meets the through lane on a straight tangent at this interchange.

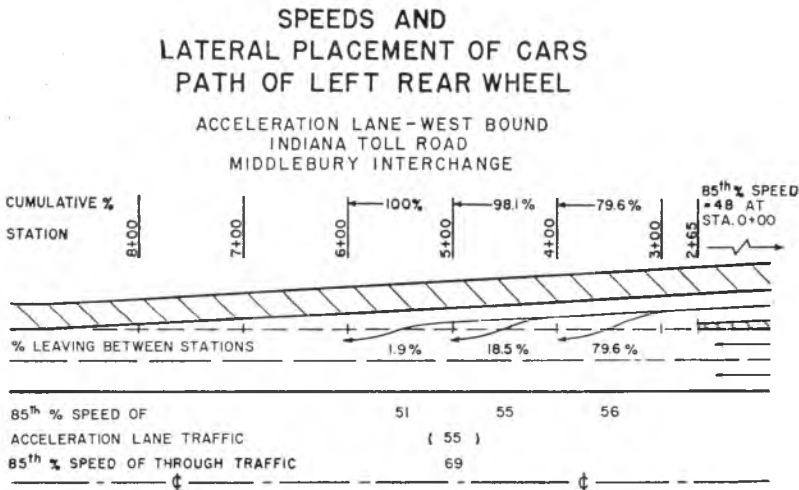


Fig. 3.

The 85th percentile speed of cars at station C+00 on the acceleration lane was 48 mph. The 85th percentile speed of through traffic within the area of conflict between the acceleration lane and through lane traffic—the area from about station 3+00 to station 8+00—was 69 mph. The majority of acceleration lane traffic, namely 79.6 percent, merged into the through lanes at an 85th percentile speed of 56 mph between station 3+00 and 4+00. The speed differential between the through lane traffic and the acceleration lane traffic in this area is approximately 13 mph (69-56). This speed differential is significant.

A small percentage, namely 1.9 percent of the vehicles, merged into the through lane between station 5+00 and 6+00 at an 85th percentile speed of 51 mph. This small percentage of cars made use of a longer distance of acceleration lane yet they merged at lower speeds than those at the previous indicated locations. The reasons for this are either that these cars had to slow down due to conflicts with through traffic or that these drivers hesitated before merging due to inexperience of driving on

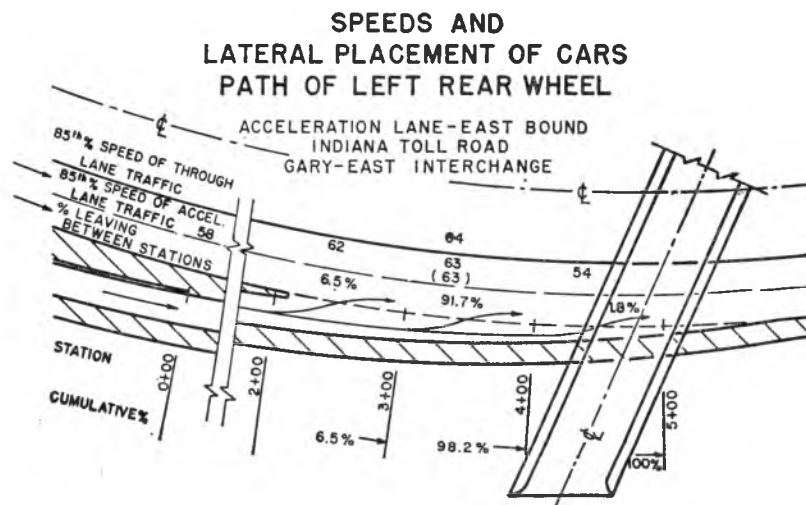


Fig. 4.

high type facilities or not understanding the proper usage of acceleration lanes. The percentage of the observed cars that stopped on this acceleration lane before merging was only 1 percent; a very small percentage—but still too may.

A second acceleration lane studied was at the Gary East Interchange for east bound traffic (Figure 4). The acceleration lane meets the through lanes on a slight horizontal curve to the left.

The 85th percentile speed of acceleration lane traffic at station 0+00 was 58 mph. The 85th percentile speed of through traffic within the area of conflict was 64 mph.

Most of the acceleration lane traffic, 91.7 percent, merged into the through lanes at an 85th percentile speed of 63 mph between stations 3+00 and 4+00. The speed differential between the through lane traffic and acceleration lane traffic at this point was one mph (64-63). This result approaches the optimum conditions of operation for accelera-

tion lanes as the acceleration lane traffic merges in approximately the same direction of travel and at the same speed as the through lane traffic.

A very small percentage of acceleration lane traffic, 1.8 percent, merged between station 4+00—5+00 at an 85th percentile speed of 54 mph. This speed is considerably less (nine mph) than the speed at which acceleration lane traffic merged at the previous location. The reasons for this condition are the same as those previously stated for the preceding acceleration lane. No cars stopped on this acceleration lane.

The third acceleration lane of this type studied was at the Chesterton-Valparaiso Interchange for west bound traffic (Figure 5). The

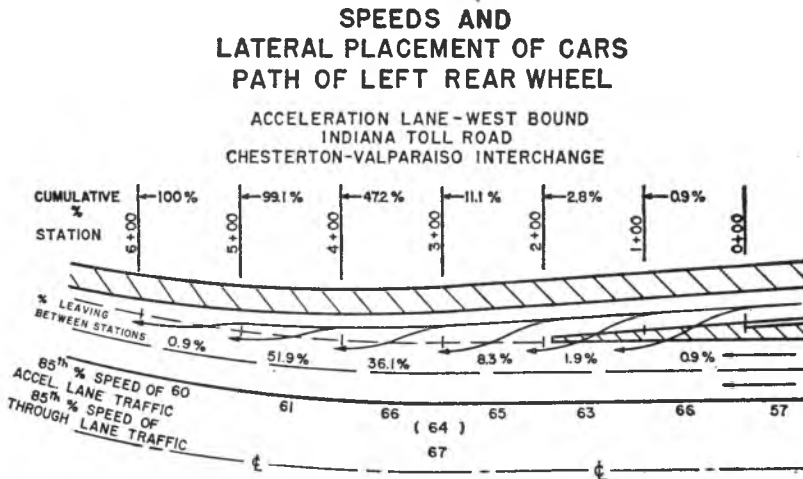


Fig. 5.

acceleration lane meets the through lane on a slight horizontal right curve.

The 85th percentile speed of acceleration lane traffic at station 0+00 was 57 mph. The 85th percentile speed of through traffic within the area of conflict was 67 mph.

The highest proportion, 51.9 percent of acceleration lane traffic, merged between stations 4+00 and 5+00 at an 85th percentile speed of 61 mph. Only 0.9 percent of acceleration lane traffic crossed over the paved shoulders and merged between station 0+00 and 1+00 at an 85th percentile speed of 66 mph and 1.9 percent did the same thing between station 1+00 and 2+00 at an 85th percentile speed of 63 mph.

The speed differential between the 85th percentile speed of through traffic and the average 85th percentile speed of all acceleration lane

traffic as it merged into the through lane was about 3 mph (67-64). This result again approaches the optimum condition of operation of acceleration lanes from the speed point of view as acceleration lane traffic speed is approximately the same as through traffic speed. Of all acceleration lane traffic 3.6 percent stopped on this acceleration lane.

The west bound acceleration lane at the LaPorte Interchange (Figure 6) was also studied. The acceleration lane meets the through lane on a horizontal curve to the right and on the upgrade portion of a vertical curve.

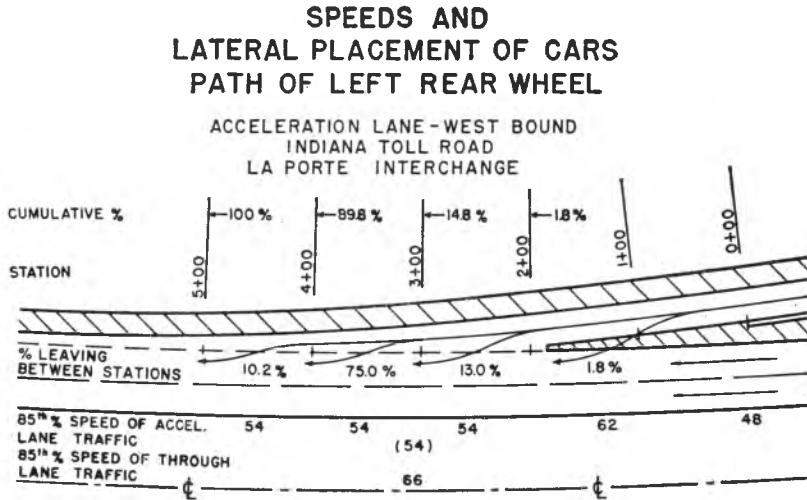


Fig. 6.

The 85th percentile speed of acceleration lane traffic at station 0+00 was 48 mph. The 85th percentile speed of through lane traffic within the area of conflict was 66 mph.

The largest proportion, namely 75.0 percent of acceleration lane traffic, merged between station 3+00—4+00 at an 85th percentile speed of 54 mph. A very small proportion, namely 1.9 percent of acceleration lane traffic, crossed over the paved shoulder and merged between station 1+00 and 2+00 at an 85th percentile speed of 62 mph. This speed is higher than that of the remaining acceleration lane traffic and this could be because those drivers accelerated rapidly so that they could merge as soon as possible. The speed differential between the 85th percentile speed of through traffic and the average 85th percentile speed of acceleration lane traffic as it merged into the through lane was

12 mph (66-54). This speed differential is significant. Af all observed cars, 3.6 percent stopped on the acceleration lane.

The last acceleration lane of this type studied was the one for west bound traffic at the Michigan City Interchange (Figure 7). The ac-

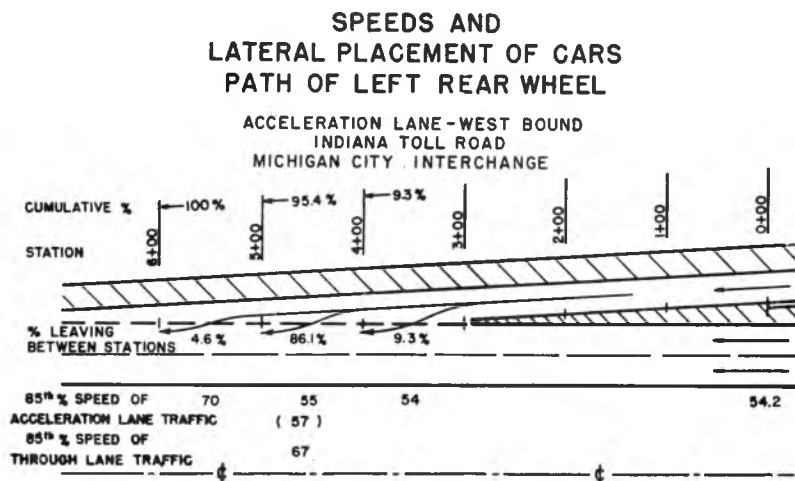


Fig. 7.

celeration lane meets the through lane on a straight tangent and on the down-grade portion of a vertical curve.

The 85th percentile speed of acceleration lane traffic at station 0+00 was 54 mph. The 85th percentile speed of through lane traffic within the area of conflict was 67 mph.

The largest promotion, namely 86.1 percent of acceleration lane traffic, merged between station 4+00 and 5+00 at an 85th percentile speed of 55 mph. The speed differential between the 85th percentile speed of through traffic and the average 85th percentile speed of acceleration lane traffic as it merged into the through lanes was 10 mph (67-57). This speed differential is significant. Of all observed cars, 1.8 percent stopped on the acceleration lane.

ACCELERATION LANES—INTERSTATE 65

The second type of acceleration lane studied is shown in Figure 8. Two such designs studied are located in Interstate 65 at Lebanon at the interchange with SR 39. Here the acceleration lanes are of the parallel type having a full width lane 350 feet long plus 400 feet of taper.

TYPICAL STANDARD ACCELERATION LANE

INTERSTATE 65
STATE ROUTE 39 INTERCHANGE
NORTH BOUND LANE

SCALE: LENGTH 1" = 100'
WIDTH 1" = 40'

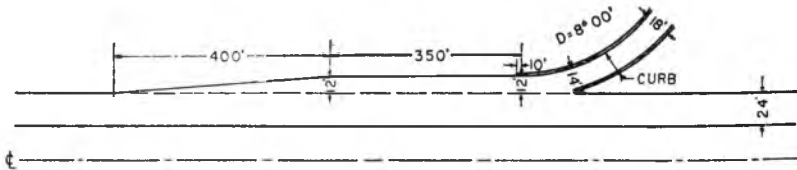


Fig. 8.

The acceleration lane for north bound traffic at this interchange meets the through lanes on a straight tangent (Figure 9). The 85th percentile speed of acceleration lane traffic at station 0+00 was 42 mph. The 85th percentile speed of through lane traffic within the area of conflict was 66 mph.

Acceleration lane traffic merged into the through lane for the entire length of the acceleration lane and with no definite pattern. The speed differential between the 85th percentile speed of through lane traffic and the average 85th percentile speed of acceleration lane traffic as it merged into the through lane was 19 mph (66-47). This speed differ-

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE-NORTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

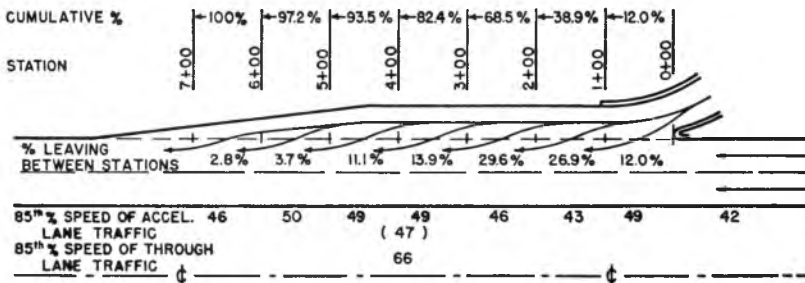


Fig. 9.

ential is very significant and indicates clearly that this type of acceleration lane design is not being properly used by drivers at this location.

Of all the cars using this acceleration lane, 9.3 percent came to a stop. This is a relatively high percentage and may be due to the fact that the general public using these facilities is not properly informed as to the proper use of acceleration lanes.

A second study of acceleration lanes at this same interchange but of the acceleration lane for south bound traffic was also made (Figure 10). There the acceleration lane meets the through lane on a slight left curve.

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT REAR WHEEL

ACCELERATION LANE-SOUTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

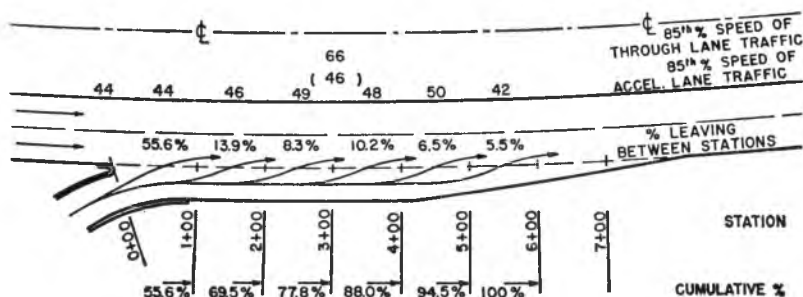


Fig. 10.

The 85th percentile speed on the acceleration lane at station 0+00 was 44 mph. The 85th percentile speed of through lane traffic within the area of conflict was 66 mph.

Most (55.6 percent) of the acceleration lane traffic merged between station 0+00 and 1+00 at an 85th percentile speed of 44 mph. This indicates that more than half of the acceleration lane traffic did not adequately use the acceleration lane as they merged into the through lane as soon as possible after they passed the nose at too low a speed. The remainder of acceleration lane traffic merged all along the remaining length of the acceleration lane traffic with no definite pattern and at speed much lower than that of the through lane traffic.

The speed differential between the 85th percentile speed of through traffic and the average 85th percentile speed of acceleration lane traffic

as it merged was 20 mph (66-46). This speed differential is very significant and indicates clearly again that for this condition and type of design of the acceleration lane, drivers are not properly using the acceleration lane.

A relatively high percentage—10.7 percent—of the cars stopped on this acceleration lane before entering the through lane.

DECELERATION LANES—TOLL ROAD

One of the deceleration lane types was on the Indiana Toll Road and is shown in Figure 11. The deceleration lane is 980 feet long. It consists of 835 feet of straight taper connected to a 145 feet of off-

TYPICAL STANDARD DECELERATION LANE

INDIANA TOLL ROAD
GARY-WEST INTERCHANGE
EAST BOUND LANE

SCALE: LENGTH 1" = 100'
WIDTH 1" = 40'

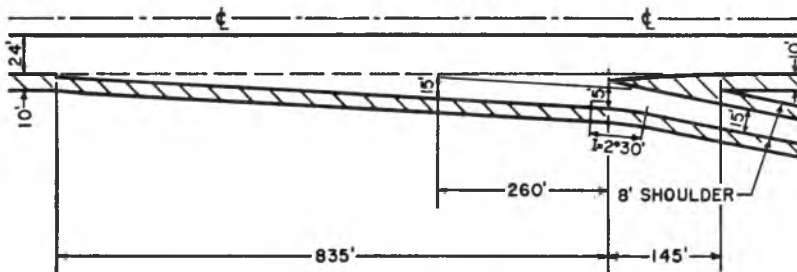


Fig. 11.

parallel lane by a $1\frac{1}{2}$ degree curve. For a distance of 575 feet the deceleration lane is not separated from the through lane. After that it is separated from the through lane by a solid white line for a distance for 260 feet. Then a shoulder, which is paved but of a different color, separates the deceleration and the through lane for the remaining 145 feet.

One of the deceleration lanes studied on the Indiana Toll Road was for eastbound traffic at the Gary West Interchange (Figure 12). There the deceleration lane leaves the through lane on a straight tangent. At this location the median is 20 feet wide with a raised barrier in the center instead of the standard 50 foot wide median.

The 85th percentile speed of through traffic within the area of conflict was 63 mph. This is somewhat lower than the speed generally encountered on the Indiana Toll Road and is possibly due to the narrower median. The largest percentage, 43.5 percent, of deceleration lane traffic diverged between station 5+00 and 4+00 at an 85th percentile speed of 69 mph.

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

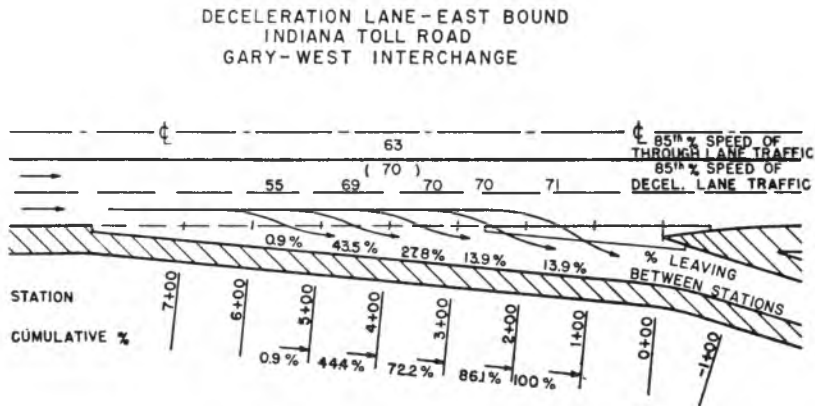


Fig. 12.

Of all deceleration lane traffic, 13.9 percent crossed the solid white line and diverged between station 3+00 and 2+00 at an 85th percentile speed of 70 mph and between stations 2+00 and 1+00 an equal percentage left at an 85th percentile speed of 71 mph.

A very small percentage, namely 0.9 percent, of deceleration lane traffic diverged at an 85th percentile speed of 55 mph between station 6+00 and 5+00. This speed is slower than that of other deceleration lane traffic and could be because the drivers involved here started to decelerate on the through lane before diverging into the deceleration lane.

The speed differential between the 85th percentile speed of through lane traffic and the average 85th percentile speed of deceleration lane traffic as it diverged into the deceleration lane was minus 7 mph (63-70). In other words those diverging were traveling faster on the average when they entered the deceleration lane than those vehicles which remained in the through lanes. This indicates that most of the deceleration lane traffic did not start to decelerate until after it diverged into the deceleration lane. This approaches the optimum

condition of operation of deceleration lanes as the deceleration lane traffic diverges at about the speed of the facility.

A second deceleration lane studied on the Toll Road was at the Chesterton-Valparaiso Interchange, again for east bound traffic (Figure 13). The deceleration lane here leaves the through lane on a slight horizontal left curve. The 85th percentile speed of through traffic within the area of conflict was 69 mph.

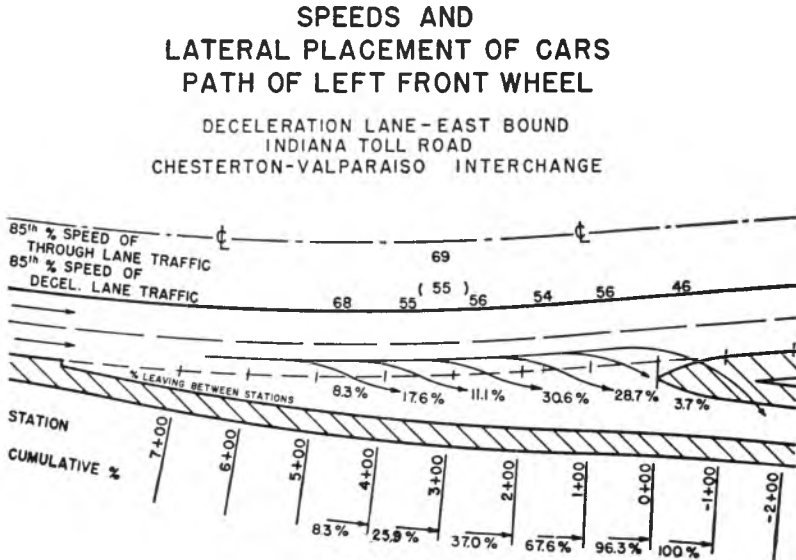


Fig. 13.

Of all deceleration lane traffic, 8.3 percent diverged between station 5+00 and 4+00 at an 85th percentile speed of 68 mph. This speed is almost equal to that of the 85th percentile of through traffic and indicates that these vehicles diverged first and then properly decelerated in the deceleration lane.

A small percentage—3.7 percent—of deceleration lane traffic crossed over the paved shoulder and diverged between station 0+00 and -1+00 at an 85th percentile speed of 46 mph. This speed is lower than that of other observed deceleration lane traffic and this could be because these drivers hesitated on the through lane and then made up their mind at the last moment to leave at this interchange.

The speed differential between the 85th percentile speed of the through traffic and the average 85th percentile speed of the deceleration lane traffic as it diverged into the deceleration lane was 14 mph (69-55). This speed differential is significant and indicates that most

of this deceleration lane traffic started to decelerate on the through lane before diverging into the deceleration lane.

DECELERATION LANES—INTERSTATE 65

The second type of deceleration lane studied is shown in Figure 14. Two lanes of this type are located on Interstate 65 at Lebanon

TYPICAL STANDARD DECELERATION LANE

INTERSTATE 65
STATE ROUTE 39 INTERCHANGE
SOUTH BOUND LANE

SCALE: LENGTH 1" = 60'
WIDTH 1" = 30'

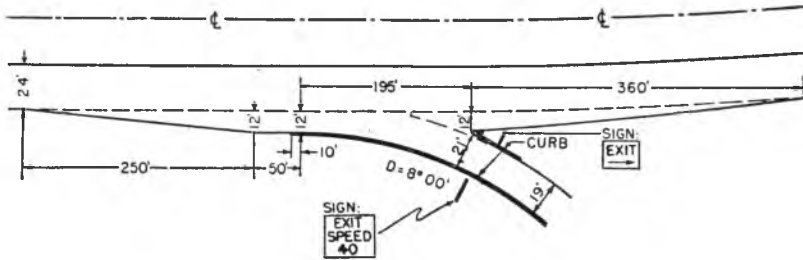


Fig. 14.

at the interchange with SR 39. The deceleration lanes here have a taper from 0 to 12 feet in a distance of 250 feet, then have 50 feet of tangent followed by 190 feet of curve. The exit nose is offset 12 feet and has 360 feet of recovery. Near the exit nose there is a regulatory speed sign, Exit Speed 40.

One of the deceleration lanes studied at this interchange was for south bound traffic (Figure 15). The deceleration lane here leaves the through lane on a straight tangent. The 85th percentile speed of through lane traffic within the area of conflict was 67 mph.

The 85th percentile speed of deceleration lane traffic at the nose station 0+00 was 49 mph. This indicates that the majority of drivers did not obey the signed speed of 40 mph. The majority, 76.9 percent, of deceleration lane traffic diverged between station 2+00 and 1+00 at an 85th percentile speed of 50 mph.

The speed differential between the 85th percentile speed of the through lane traffic and the average 85th percentile speed of the deceleration lane traffic as it diverged into the deceleration lane was 18 mph (67-49). This speed differential is very significant and indicates

clearly that the drivers started to decelerate on the main facility before they diverged into the deceleration lane.

SPEEDS AND LATERAL PLACEMENT OF CARS PATH OF LEFT FRONT WHEEL

DECELERATION LANE-SOUTH BOUND
INTERSTATE 65
STATE ROUTE 39 INTERCHANGE

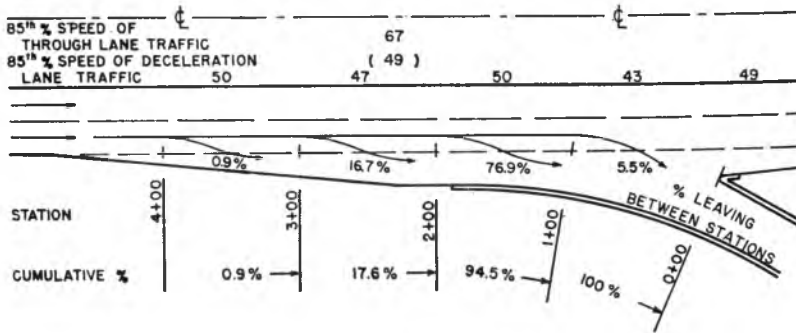


Fig. 15.

The second deceleration lane studied of this type was for north bound traffic at the same interchange (Figure 16). The deceleration lane leaves the through lane here on a slight right curve. The 85th percentile speed of through lane traffic within the area of conflict was 68 mph.

The 85th percentile speed of the deceleration lane traffic at the exit nose station 0+00 was 46 mph. Nearly all deceleration lane traffic diverged between station 3+00 and 1+00, with 47.2 percent diverging between station 3+00 and 2+00 at an 85th percentile speed of 48 mph and 51.9 percent between 2+00 and 1+00 at an 85th percentile speed of 51 mph.

By comparing these results with those of the previous case, it is evident that drivers diverge earlier for this lane but at about the same 85th percentile speeds. This could be due to the fact that this deceleration lane leaves the through lane on a curve to the right, thus causing drivers to diverge earlier than for the previous condition where the deceleration lane left the through lane on a straight tangent.

The speed differential between the 85th percentile speed of the through lane and the average 85th percentile speed of the deceleration

lane traffic where it diverged was 18 mph (68-50). This speed differential is very significant and indicates again that drivers start to decelerate on the main facility before they diverse into the deceleration lane.

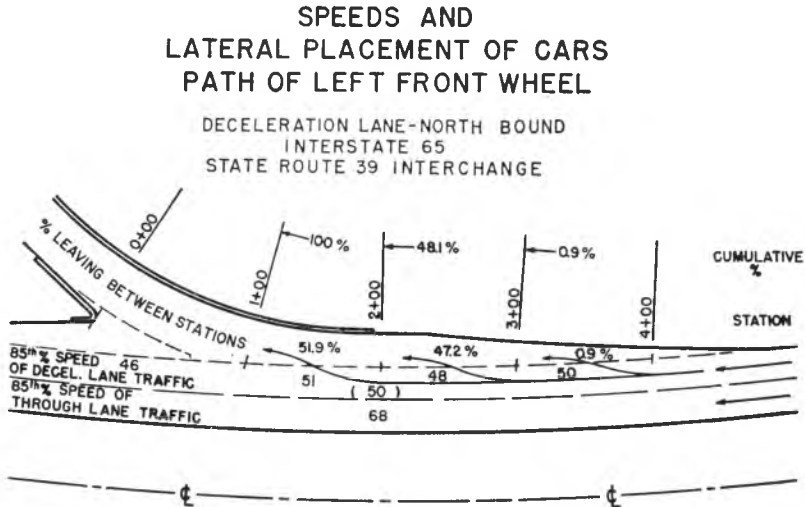


Fig. 16.

CONCLUSIONS

The traffic using the Indiana Toll Road is comprised mostly of through traffic while that using Interstate 65 south of Lebanon is more local traffic. It is very difficult, therefore, to correlate the traffic behavior due to the possible different types of drivers. Before this research is completed, however, a comparison and correlation will be attempted of traffic behavior on the various types of designs of acceleration and deceleration lanes of high type facilities used by the State Highway Commission and on the Indiana Toll Road.

The results of traffic behavior on acceleration and deceleration lanes reported in this paper show very clearly that:

- a. A large number of the general public do not know how to properly use acceleration and deceleration lanes. Thus, for the most efficient and safest operation of traffic, it is imperative that the driving public be better informed on the proper use of acceleration and deceleration lanes.
- b. The data indicate that an optimum design for acceleration and deceleration lanes may be concerned in an important manner with

the horizontal and vertical curvatures of the through lane at the location of the acceleration and deceleration lanes.

- c. The large differences in speed between acceleration or deceleration lane traffic and that of the through lane on Interstate 65 indicates that better designs are desirable for similar facilities which are currently being constructed.

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