Adding Turn Lanes/ Channelization

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Description

Turn lanes at intersections are mainly used to separate turning traffic from through traffic. They also provide safety while reducing delays.

Separate left-turn lanes help left-turning vehicles safely decelerate away from the through traffic and eliminate or reduce queues in the through lane.

Right-turn lanes typically have a lessened impact on crashes and roadway capacity. The number of vehicles attempting a right turn in a through traffic lane increases the delay to through traffic. A dedicated right-turn lane segregates these cars from through traffic while increasing the capacity of the road and reducing delays. See Figure 1.

Rural intersections like signalized, unsignalized, four-leg, etc., are treated with the addition of left- and/or right-turn lanes along two-lane highways (Harwood et al. 2002). Channelization adds painted raised medians, or islands, that direct vehicles or pedestrians into specific movements. Channelized islands are also sometimes used to place traffic control devices. Washington et al. (1991) found that intersection approaches with raised medians had accident rates 40 percent less than intersection approaches with flush medians.

Figure 1. Channelized right turn lane (Urban Advantage, CD+A, and H.B. Rue for the Thomas Jefferson Planning District Commission, Albermarle County, and Virginia DOT, from Grant et al. 2012)

Effectiveness of Turn Lanes in Reducing Crashes

The safety impacts of channelization at signalized intersections have been well documented (see Table 1, which summarizes crash modification factors (CMFs) for turn lanes). All CMFs included here are for signalized intersections, so their application to rural intersections should be used with caution.

Several studies have documented their effectiveness for signalized and other intersection types. Crash reduction impacts for these studies are summarized in Table 2.

Iowa Studies

Maze et al. (1994) mentioned left-turning traffic as a major source of conflicts at intersections while researching safety impacts of left-turn treatment at high-speed signalized intersections. Intersection geometry, traffic volume, signal phasing, and accident data were collected for 109 intersections in Iowa by sending questionnaires to municipalities across Iowa. Several left-turn lane alternatives were evaluated after estimating the left-turn accident rates for northbound and southbound approaches for those intersections. The results of the left-turn accident rates were lowest with protected left-turn phasing, which included a left-turn lane for both the northbound and southbound approaches. The alternative of adding

Table 1. CMFs for Left Turn, Right Turn Lane Installation Treatments on Intersection Approaches (*Highway Safety Manual* 2010)

Treatment	Left Turn Lanes at # of Approaches	CMF for Left Turn Lane	CMF for Right Turn Lane
Addition of left-/right-turn lane on three-approach signalized intersection	1	0.93	0.96
	2	0.86	0.92
	3	0.80	—
Addition of left-/right-turn lane on a four-approach signalized intersection	1	0.90	0.96
	2	0.81	0.92
	3	0.73	0.88
	4	0.66	0.85

Table 2. Crash Reduction for Adding Turn Lanes

Treatment	Sites	Crash type	Changes in crashes
Adding left turn lanes with protected phasing (Maze et al. 1994)	109 intersections in Iowa	All	-56%
Adding turn lanes with signal phasing (Thomas et al. 2001)	94 traffic safety projects	Left turn	-71%
Adding single left-turn lane on a major road (Harwood et al. 2003)	280 improved and 300 unimproved intersections	All	-28%/44%
		Left turn	-10%
Adding right-turn lane on a major road (Harwood et al. 2003)	280 improved and 300 unimproved intersections	All	-18%/-27%
Two-way left-turn lane (Noyce et al. 2006)	9 sites	All	-37%
		Property damage only crashes	-46%
		Left turn	-24%

a left-turn lane with protected phasing was found to be the best in reducing crashes. The percentage reduction in accident rates was approximately 56 percent for protected phasing with a left-turn lane.

Thomas et al. (2001) analyzed 94 traffic safety projects using extensive statewide crash data from the Iowa Department of Transportation (Iowa DOT) to determine crash reduction factors and benefit/cost (B/C) ratios for seven different improvement categories, which evaluated the actual cost effectiveness of the Iowa DOT's safety programs. Additionally, 90 percent confidence intervals for the various crash categories were also determined. Adding turn lanes along with modified signal phasing (i.e., adding left-turn arrows) had the highest crash reduction factor (58 percent), which included a 62 percent reduction in right-angle crashes, a 37 percent reduction in rear-end crashes, a 71 percent reduction in left-turn crashes, and a 42 percent reduction in other crashes.

The results of adding turn lane(s) only as a safety improvement included a 10 percent overall reduction in crashes, which included right-angle crashes being reduced by 8 percent, rear-end by 21 percent, left-turn by 64 percent, and other crashes by 31 percent. Adding a new traffic signal with one or more turn lanes showed a 29 percent reduction in overall crashes, with a 71 percent reduction in right-angle, 24 percent in rear-end, 31 percent in left-turn, and 27 percent in other crashes. The highest B/C ratios were for the new traffic signal with turn lane(s) projects.

Other National Studies

Many research projects demonstrated the safety effects of providing left-turn lanes at intersections. The safety effectiveness depends on the location (e.g., rural or urban, number of legs, number of approaches, and type of traffic control). One study depicted that crashes can be reduced up to 15 percent for rural three-leg intersections and 33 percent for rural four-leg intersections. The same study indicated that crashes may be reduced up to 7 percent at urban three-leg intersections and up to 19 percent at urban four-leg intersections. Another study showed that crashes may be reduced up to 58 percent when a left-turn lane and turn phase are added (Rodegerdts et al. 2004).

Rodegerdts et al. (2004) reviewed research available on safety and operations of signalized intersections and summarized safety impacts of various treatments and best practices in use across the United States. The safety impacts for left-turn and right-turn lanes and channelization improvements are summarized in Table 3.

Harwood et al. (2003) performed a before-after evaluation of the safety effects of providing left-turn and right-turn lanes at at-grade intersections. Geometric design, traffic control, volume, and accident data were evaluated for 280 improved intersections as well as 300 similar intersections that were not improved during the study period. The improvement projects included adding left-turn and right-turn lanes and extension of the length of existing left-or right-turn lanes. An observational before-after evaluation of these projects was performed using the matched-pair (yoked comparison), comparison group, and the Empirical Bayes approaches. The results showed that adding left-turn and right-turn lanes was effective. For example, a single left-turn lane on a major road reduced total intersection crashes at rural unsignalized intersection by 28 percent for four-leg intersections and by 44 percent for three-leg intersections. At a four-leg signalized intersection, the addition of left-turn lanes ensured a 10 percent reduction in accidents. Adding a right-turn lane reduced crashes on individual approaches to four-leg intersections by 27 percent at rural unsignalized intersections and by 18 percent at urban signalized intersections. The research also concluded that the Empirical Bayes method provided them with the most accurate results.

In researching channelized right-turn lanes at signalized intersections, a questionnaire survey was done by Al-Kaisy and Roefaro (2010) to review the practice of channelized right-turn lanes at signalized intersections. The questionnaire revealed that around 49 percent of state agencies and 67 percent of local agencies believed that the treatment has the potential of improving vehicular safety. Additionally, there was a very positive attitude by most state and local agencies about the safety benefits of signal control at channelized right-turn lanes.

Table 3. Safety Impacts for Left-Turn and Right-Turn Lanes and Channelization Improvement from Selected Findings (Rodegerdts et al. 2004)

Treatment	Safety impact
Adding left-turn lane at urban intersection	26% reduction in all collisions
	66% reduction in left-turn collisions
Adding left-turn lane with signal upgrade	62% estimated reduction in all collisions
	78% estimated reduction in left-turn collisions
	63% estimated reduction in rear-end collisions
	67% estimated reduction in injury/fatal collisions
Adding left-turn lane with no phasing	25% reduction in all collisions
	45% reduction in left-turn collisions
Addition of protected left-turn lane	56% reduction in right-angle collisions
	35% reduction in rear-end/overtaking collisions
	46% reduction in left-turn collisions
	64% reduction in all collisions
Left-turn phasing	12% reduction in all collisions
	38% reduction in left-turn collisions
Add protected-permissive left-turn phase	10% reduction in all collisions
	40% reduction in left-turn collisions
Add right-turn lane on multi-lane approach	40% estimated reduction in fatal/injury collisions
	10% estimated reduction in head-on/sideswipe collisions
Left-turn lane physical channelization	26% estimated reduction in all collisions
	79% estimated reduction in head-on/sideswipe collisions
Left-turn lane-painted channelization	45% estimated reduction in all collisions

In a study by Noyce et al. (2006), the researchers studied the safety and operational characteristics of two-way left-turn lanes (TWLTLs) compared to four-lane undivided roadways in Minnesota. From nine Minnesota study sites, operational and crash data were analyzed before and after the change from a four-lane undivided roadway to a three-lane roadway with a TWLTL. A yoked comparison was done that showed statistically significant reductions in total crashes, property damage only (PDO) crashes, and left-turn crashes. The percentage reductions in total crashes after the change was approximately 37 percent, with PDO crashes and left-turn crashes reduced by 46 percent (24 percent, respectively).

The crash rate reduction for total crashes and PDO crashes was found statistically significant. Respectively, the percentage reductions were 46 percent and 45 percent. Thus the results of this research suggests that the safety of a roadway is improved when a four-lane undivided roadway is changed to a three-lane roadway with a TWLTL when daily traffic volumes are less than 17,500 vehicles per day (Noyce et al. 2006).

In a study by Parsonson et al. (1998) on TWLTLs with a raised median, the researchers stated that in 1990 a TWLTL was replaced by a raised median separation on Memorial Drive in greater Atlanta by the Georgia DOT. At this site, there was a 37 percent reduction in total accident rate and a 48 percent drop in injury rate. It was reported that in over 2.5 years after installation of the raised median there was not a single fatality. Parsonson et al. (1998) studied the long-term impact of this raised median on safety. After seven years, the crash rate was reduced to 17 percent and the injury rate reduced to 10 percent (Parsonson et al. 1998).

Exclusive left-turn lanes for vehicles at intersections substantially reduce rear-end crashes. A research study on left-turn lanes demonstrated that exclusive turn lanes reduce crashes from 18 to 77 percent (50 percent average) and reduce rear-end collisions from 60 to 88 percent (FHWA 2003). Left-turn lanes also increases the capacity of many roadways. A shared left-turn and through lane has about 40 to 60 percent the capacity of a through lane. A synthesis of research on this topic found a 25 percent (average) increase in capacity for roadways that added a left-turn lane (FHWA 2003).

Right-turn lanes are seen to have a less substantial impact on crashes and roadway capacity than other types of strategies involved for turning movement. There are fewer studies on safety effects of right-turn lanes. However a clear relationship exists between the number of vehicles attempting a right turn in a through traffic lane and its delay to through traffic. At intersections with substantial right-turn movements, a dedicated right-turn lane segregates right turning cars from through traffic while increasing the capacity of the road (FHWA 2003).

Advantages of Left-turn Lanes

- Exclusive turning lanes at intersections remove stopped vehicles from through traffic
- Left-turn lanes at intersections may potentially reduce rear-end crashes
- Additional capacity; potential for shorter cycle lengths and/or allocation of green to other movements
- Travel time reduced
- Vehicle emissions reduced
- Physical channelization of left turns emphasizes separation of left-turning vehicles from the through traffic stream

Disadvantages of Left-turn Lanes

- May result in longer crossing time and exposure for pedestrians
- Increased intersection size
- Right-of-way and construction costs
- Access restrictions to property

Advantages of Right-turn Lanes

- Separation of decelerating right-turn vehicles
- A reduction in rear-end collisions involving right-turning vehicles and following through vehicles due to improved signal operation
- Through vehicles will experience less delay if right-turning vehicles do not have to decelerate in a through lane
- Higher right-turn capacity, shorter green time, and less delay for following through vehicles

Disadvantages of Right-turn Lanes

- Potential for sideswipes downstream of merge and right-turn crashes with the minor street
- Longer pedestrian crossing distance and exposure
- Higher vehicle speeds
- Right-of-way costs

Advantages of Channelization

- Separation and protection of turning vehicles
- Reduce excessively large paved areas
- Protection of pedestrians
- Control of maneuver angle for merging, diverging, and weaving
- Control of speed
- Blockage of prohibited movements
- Provide space for traffic control devices

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