Oregon Department of Transportation
Traffic Management Section
Traffic Engineering Services Unit
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Safety Comparison of 4-Way Cross and Offset T Intersections File Code: TRA 10-05-12

Recently, the Traffic Engineering Services Unit was asked to review the research on the safety differences between 4-way and offset T-intersections at rural locations. This document is a summary of those findings.

In general, the research indicates that crash rates at T-intersections are usually lower than those of 4-way cross intersections but is dependent on volumes and other factors. Separating cross intersections to T-intersections is a possible safety countermeasure for high crash cross intersections. The number of conflict points at a standard cross intersection is 32 which is reduced to 22 at two offset T-intersections. The offset T-intersections can be classified as either right-left or left-right depending on the turning movements required for a through movement on the minor road. Figure 1 shows the conflict points at a 4-way and a right-left offset T-intersection.

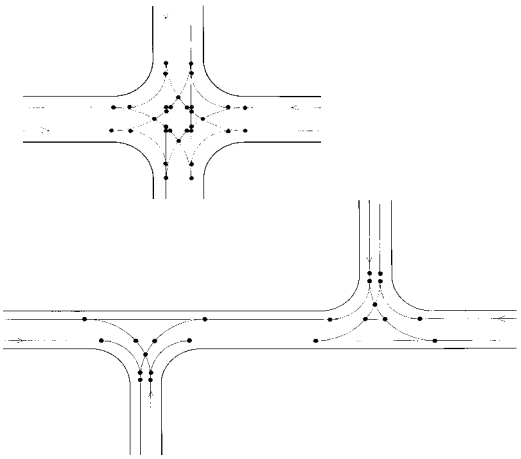

Figure 1 Conflict Points of Cross and R-L Offset T Intersections (From Bared and Kaisar)

In a study by Hanna et al., 300 intersections in 42 rural Virginia cities (population average of 15,000) were analyzed and the crash rates for various intersection geometries were reported (*1*). A total of 2,300 crashes from 24 months (1969-1973) were considered. No data was presented on the operating speeds, volumes, or type of stop control (two-way, three-way, four-way). For all intersection types (including Y's and offset) crash rates were higher at signalized approaches. Crash rates were lower at T-intersections than cross intersections in all cases. A roundabouts brochure by Leif Ourston includes 1989 crash data from California state highways (*2*). Crash rates were reported for rural, suburban, urban 4-way and T-intersections (*3*). The California data does include some multi-leg, Y-type and offset intersections mixed with T and 4-way types. Again, crash rates of T-intersections are lower. Ogden presents fatality rates presented by Barton from research in Australia that are shown in Table 1(*4*). Again, T-intersections have lower rates. All of these studies are summarized in Table 1.

Other international studies (presented in Ogden) report that paired t-intersections are 1.5 to 2.0 times as safe as cross-intersections for the same traffic flow and that the injury consequence is 1.5 times greater at cross intersections (Hedman). In another study in Australia, Nairn reports a 47 percent reduction in crashes when replacing cross intersections with staggered T intersections.

In an unpublished paper, Bared and Kaisar discuss the operational and safety advantages of offset t-intersections (*5*).Their paper includes a discussion of research by Mahalel et al. who preferred operation right-left layout staggered T's for operational concerns (although crash reductions were better at left-right layouts). In addition, Bared et al. include a discussion of the maximum offsets between the two intersection that minimize interference on the major road based on equations in the 2001 AASHTO Green Book. For example, the maximum offset (not including storage for a left-turn pocket) for a right-left offset T intersections with a 55 mph major road speed is 186 feet.

Table 1 Crash Rates of T and 4-way Intersections

Intersection Type	Traffic Control	Crash rate (MEV)				Fatality Rate (10^7EV)	
		Hanna et al. (Rural City)	CalTrans (Suburban)	CalTrans (Urban)	CalTrans (Rural)	Barton (Rural)	Barton (Urban)
4-Way Cross	Signalized	1.47	0.77	0.54	0.98	2.5[1]	1.7
	Stop or Yield	1.27	0.42	0.32	0.40	5.2	2.4
T-intersection	Signalized	0.82	0.47	0.37	0.49	2.1[1]	1.4
	Stop or Yield	0.79	0.26	0.17	0.26	3.3	1.5

Notes: [1] High speed

Two FHWA studies developed crash prediction models for rural two and four-lane highway intersections. Models were developed for both T-intersection and 4-way intersections from HSIS data in California and Minnesota (*6*, *7*). While not specifically developed to analyze offset T's, the safety of two T's should be similar if the proper offset is used to minimize interference between the minor roads. The two-lane major highway model predicts crash frequency based on ADT of the major and minor roads, presence of horizontal or vertical curves, average posted speed limits, roadside hazard rating, right turn lane on major road, number of driveways, and skew type for both T-intersection and 4-way intersection. Application of the model with assumptions constant between the T-intersection and 4-way yield predicted crash frequencies greater for 4-way than T-intersections. A graph, showing predicted crash frequencies, based on a minor road ADT or 2,000, posted speed on the major road of 55 mph, no curves, no right turn lane, and 90 degree intersection is shown in Figure 2. No graphs were generated from the 4-lane major highway model.

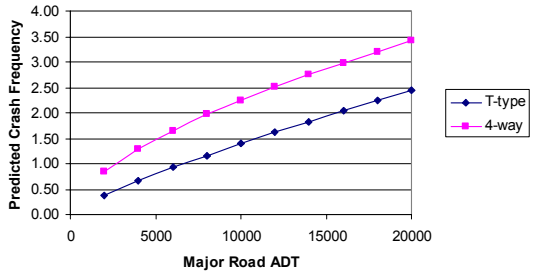

Figure 2 Predicted Crash Frequency (Vogt)

Kulmula studied the safety performance of 4-way cross intersections and offset T-intersection. Kumula analyzed 2,700 junctions in Finland (*8*). Separate models were developed for three-leg and four-leg intersections. Five years of crash data were collected and models to predict the crash frequency were developed. Kumula found that the crash rates were 1.4-1.3 times as high at 4-way than T intersections. Results of the model were used to predict crash rates at 4-way and staggered T's, which are are shown in Figure 3.

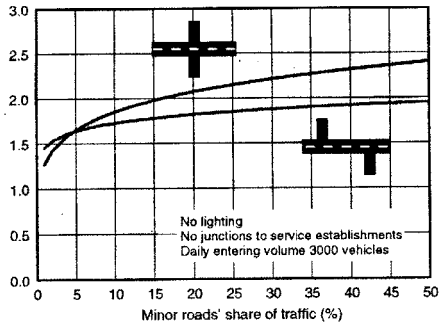

Figure 3 Expected number of injury collisions in five years (Kumula)

Research by Sayed and Rodriguiez studied 419 urban unsignalized intersections (186 T-Leg and 233 four-leg) in British Columbia and found similar results (*9*). Sayed developed a GLIM model based on AADT of the major and minor roads. The predicted crash frequencies based on the model results are shown in Figure 4.

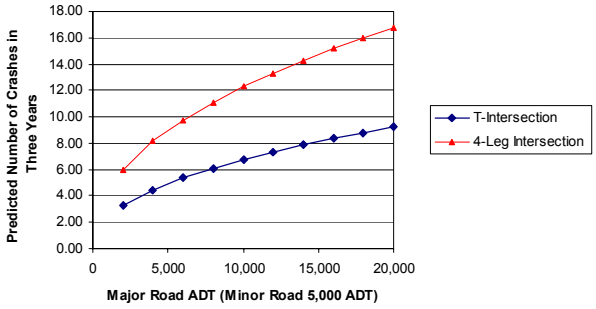

Figure 4 Predicted Crash Frequencies (Sayed)

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6 Vogt, Andrew and Joe G. Bared . *Accident Prediction Models on Two-Lane Rural Roads: Segments and Intersections*. FHWA-RD-98-133, FHWA, Washington D.C. October 1998

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9 Sayed, T, Rodriguez, F. Accident Prediction Models For Urban Unsignalized Intersections In British Columbia. In *Transportation Research Record 601*, TRB, National Research Council, Washington D.C. 1999, pp 93-99

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