Stop Versus Yield Signs on Low-Volume Rural Roads

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Although research concerning Yield sign installation has been conducted in urban or suburban settings, Yield signs are prolific in rural areas. Rural areas generally have higher speed limits, low traffic volumes, and unlimited visibility. The use of Yield signs would seem to be ideal. However, the large number of accidents resulting in fatalities and serious injuries suggests that some other factors are at work in the rural areas. Because of the committed zone of the driver's vision, it is recommended that Yield signs be restricted to use on roadways with speed limits of 50 kph (30 mph) or less.

The Yield sign has not been in use for a long time. Its widespread use did not begin until the 1950s. Ideally, when we started widespread use of this new regulatory sign, we should have removed all existing signs, started over, and decided which traffic control devices would be used for controlling rural intersections. The ideal intersection would have no control given the correct circumstances. Intersections that demonstrated the need for some right-of-way control would warrant Yield signs. Those requiring more control would require Stop signs. As an intersection changed in character, the type of control would change to something more or less restrictive. A difficult task of the traffic engineer is to move from a more restrictive device to a less restrictive device. For example, changing from a traffic signal to a Stop sign has many problems, most of which are political.

Many articles have been written on using Yield signs in place of Stop signs. This move from more restrictive control to less restrictive control makes sense in some locations. The reason often cited for using Yield signs in place of Stop signs are that they use less fuel, cause less air pollution, reserve the Stop sign for those locations that require full stop, and do not breed contempt for the Stop sign.

The studies that have addressed this issue have been conducted primarily in urban and suburban locations. The criteria for installing traffic control devices at intersections are contained in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD). The speed criterion, mentioned as one of the warrants for using a Yield sign, is whether the motorist can travel at 16 kph (10 mph) or more approaching the intersection. If the motorist cannot safely approach the intersection at a speed of at least 16 kph (10 mph) and have adequate sight distance, a Stop sign should be used. However, the method for calculating the 16 kph (10 mph) is not included in the MUTCD. For guidance on calculating the 16-kph (10-mph) limit, one must turn to the *Traffic Control Devices Handbook* Critical Approach Speed Chart (included here as Figure 1) (*1*). In no place is an upper limit of speed mentioned as a criterion for Yield sign use. The Critical Approach Speed Chart does not show approach speeds higher than 65

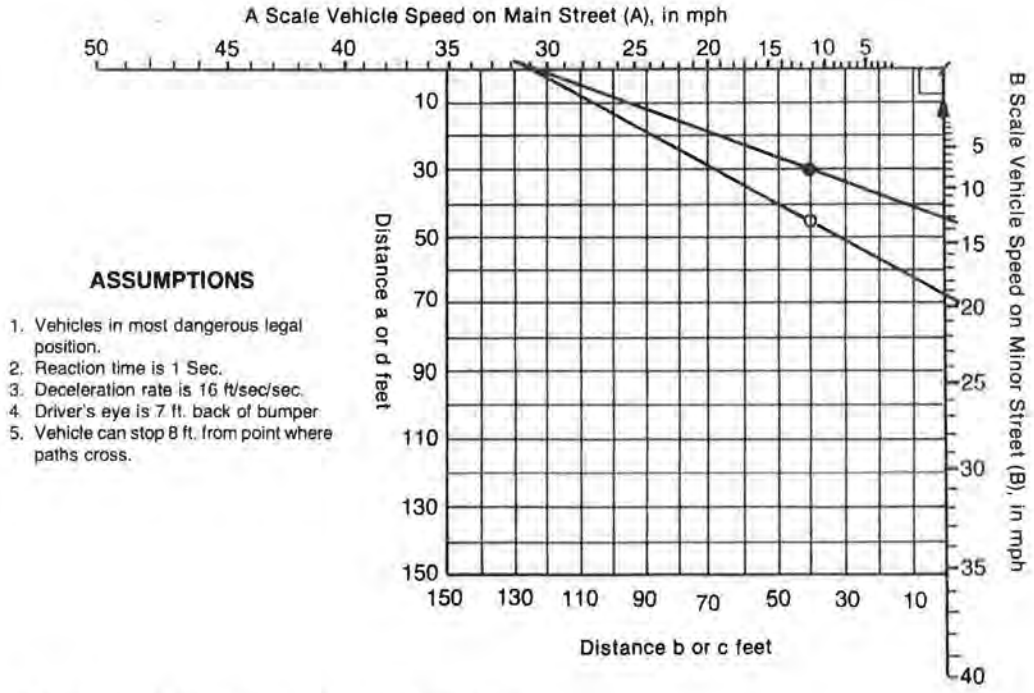


FIGURE 1 Critical Approach Speed Chart (*1*).

kph (40 mph) on minor streets or higher than 80 kph (50 mph) on main streets.

The articles on the use of Yield and Stop signs do not mention an upper limit to the approach speed. This would imply that motorists traveling in rural areas at 90 kph (55 mph) or more could encounter a Yield sign in open terrain. Because of the factors mentioned above, Yield signs have proliferated in rural intersections in the Midwest. The flat farm areas of the Midwest would seem to be ideal locations for Yield signs. Visibility tends to be unlimited.

In the Midwest, Stop signs on all county roads that intersect state highways are common. However, where county, county-township, or township-township roads intersect, Yield signs are a common type of traffic control. Also common are intersections with no signs controlling the assignment of right-of-way. Studies have been conducted by state highway agencies that show that accidents at Yield sign–controlled intersections are no higher than at Stop sign–controlled intersections. However, in the fine print, no intersections were posted with Yield signs for right-angle collisions with state highways. Only Stop signs are used where county or township roads intersect state highways, so no data would exist.

Yield signs controlling such intersections seem to be a good choice. The volumes tend to be low in rural areas, ranging from 10 to 200 vehicles per day on a minor road and 100 to 900 vehicles per day on a major road. Sight distances tend to be excellent—often a mile or more—with cornfields being the only obstruction, and then for only a few months of the year. One of the unique aspects of the flat midwestern rural intersections is the change in crops over the years. For the years in which soybeans, alfalfa, or sugar beets are grown, corners contain no site obstructions. However, in the one year in which corn is grown, visibility disappears. The other commonly encountered problem is the extension of the farm field onto the public right-of-way. In seeking that extra row or more of corn each year, the farmer gradually moves closer to the road.

However, the terrain tends to be flat, and speed limits tend to be high—90 kph (55 mph) on all approaches. One would not expect accidents at this type of intersection. In spite of this, the number of serious and fatal accidents at Yield sign–controlled intersections in rural areas is far greater than at Stop sign–controlled intersections. From examination of traffic control devices in various counties throughout the upper Midwest (Iowa, Minnesota, North Dakota, South Dakota, and Wisconsin), the number of Stop and Yield signs was found to be approximately equal. The majority of fatal and serious injury accidents were occurring at Yield signs where visibility was essentially unlimited.

A total of 40 fatal or serious injury, right-angle intersection accidents, which occurred in the years 1989–1993 in the upper Midwest, were examined for this paper. In my experience, the approximately equal

number of Stop and Yield signs at rural intersections should result in an equal number of fatal and serious injury accidents. In reviewing my files of accidents at rural right-angle, high-speed intersections, accidents involving drivers who violated a Stop sign at high speed were rare.

The answer to why so many accidents are occurring at rural high-speed Yield sign–controlled intersections appears in the *Transportation and Traffic Engineering Handbook* from the Institute of Transportation Engineers. The driver approaching an intersection is concentrating on the committed zone (see Figure 2) (2). This zone is an area that is speed dependent. That is, the faster the driver is traveling, the narrower the zone. Various studies have determined that the zone ranges from 12 to 18 degrees on each side of the center for a motorist traveling at 90 kph (55 mph). The quantification of the concept is shown in Figure 3 (3). We have all approached an intersection where we have seen a vehicle on the crossroad also approaching the intersection. Sometimes we have had a moment of panic, wondering whether the vehicle on the crossroad facing a Stop sign is going to stop for us. In that situation, the vehicle on the crossroad has entered our committed zone and constitutes a hazard because of the other vehicle's proximity to the intersection. If that same vehicle had been 30 or 60 m (100 or 200 ft) back from the intersection, we would not have the same level of concern. It is the driver's experience that when a vehicle is back away from the intersection 30–60 m (100–200 ft), that vehicle on the crossroad can stop. Conservatively, even in a rural area, each driver traverses 75,000 intersections each year [the number of miles driven in rural areas averages three to four times the average 16 000 km (10,000 mi) for nonrural residents even though intersections are less numerous]. The vehicle on the crossroad with a traffic control device always stops. Rarely, if ever, do we actually see a vehicle run a Stop sign. The driver who runs a Stop sign violates the expectancy of the driver on the through road.

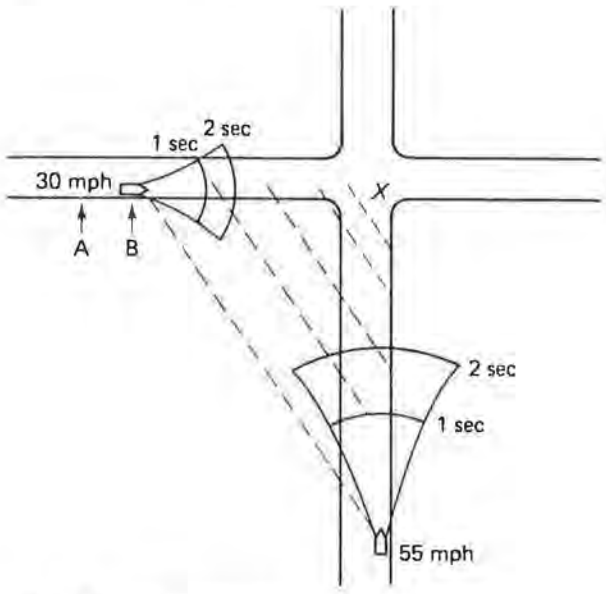
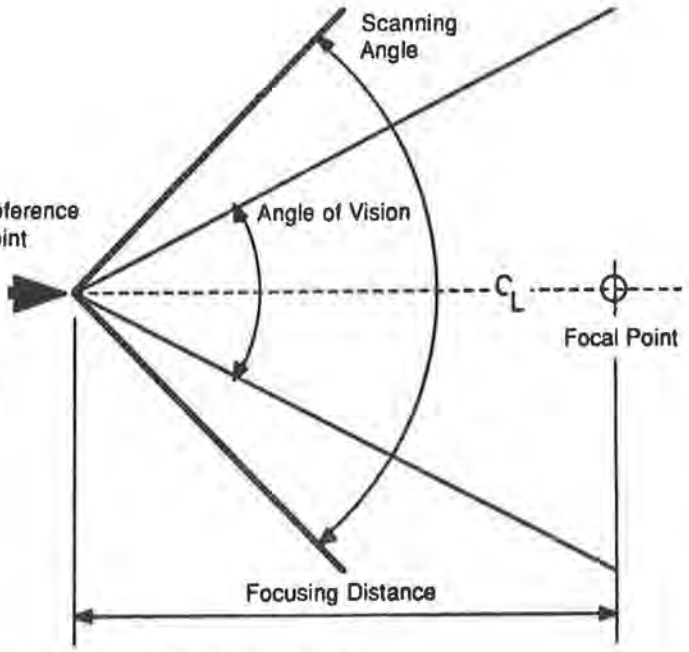


FIGURE 2 Committed zones for two vehicles approaching an intersection (2).

Peripheral vision is often mentioned in opposing the concept of the committed zone. Studies have shown that the faster the driver travels, peripheral vision is suppressed to an ever-narrowing area. This phenomenon is often referred to as "tunnel vision." Vehicles outside the area of the angle of vision or committed zone are not seen or recognized by the driver as they do not pose a threat. When the vehicle on the crossroad enters the committed zone, the brain identifies the offending vehicle as entering the committed zone.

Over time, we as drivers have learned to determine the distance of the vehicle on the crossroad from the intersection and whether that vehicle is a hazard. An example will help illustrate the point. If two vehicles approach the same intersection traveling at 90 kph (55 mph) at right angles to each other, they are traveling at approximately 25 m per second (80 ft per second). The two vehicles are also at a 45-degree angle to each other. The driver on the through road may see the other vehicle, but the other vehicle is outside the committed zone. At 90 kph (55 mph), a vehicle can be stopped between 50 m and 60 m (160 and 200 ft). This does not include a perception-reaction time because the stop or yield on the side road is an expected event. At 25 m per second (80 ft per second), the vehicle on the side road can be as close as 2 to 2.5 seconds and still stop, as perceived by the driver on the through road.

The perception-reaction time of the driver on the main road is important. The value sometimes used in accident reconstruction and collision avoidance is 0.75 seconds. However, studies conducted in the past 5 years have indicated a time of at least 1.6 seconds, with values of 2.0 to 2.5 seconds being more appropriate for the public at large. The value used in AASHTO's *Policy on the Geometric Design of Streets and Highways* is 2.5 seconds. Therefore, if a driver's perception-reaction time is 2.0 seconds, the vehicle on the side road can be 50 m (160 ft) from the intersection—enough distance for the vehicle on the side road to stop. Once the driver on the through road exceeds the 2.0-second point, the driver has passed the point of no return and must depend on the vehicle on the minor road to stop. A further complication is the cone of vision, which may have the driver concentrating on a distance much closer to the intersection than 60 m (200 ft). At 2.0 seconds before the intersection, the driver on the main road is 50 m (160 ft) from the intersection at 90 kph (55 mph). Con-



Design Speed	Focusing Distance	Angle of Vision	Scanning Angle
25 mph	600 ft	100°	120°
30	800	90	110
40	1100	75	95
50	1400	60	80
60	1800	40	60

FIGURE 3 Diagram and table for constructing cone-of-vision template (*3*).

sidering a cone of vision with an 18-degree field of view, the driver on the main road is looking for and concentrating only on the area 15.8 m (52 ft) down or along the minor road. The vehicle traveling on the minor road is 50 m (160 ft) away from the intersection in the same 2.0 seconds at 90 kph (55 mph). I believe this is the explanation for why the drivers who survive these types of collisions testify that they did not see the other vehicle.

A motorist approaching the Yield sign has to judge the future location of the vehicle on the through road. At the point where the motorist on the side road is close to the intersection, in the last 60 m (200 ft), that motorist has to assess where he or she is going to be in the next 2 seconds and where the vehicle on the through road is going to be in the next 2 seconds and compare the two locations. From a human factors standpoint, the mind cannot make this assessment and comparison in the last 2 seconds before arriving at the intersection.

The two most often heard comments from the survivors of high-speed collisions at Yield sign–controlled intersections are (a) I never saw the other vehicle and (b) I saw the other vehicle and misjudged my (its) speed. The first comment is explained by the commitment zone concept. The drivers were concentrating on the area where a hazard is expected, 12 to 18 degrees from the center line of the road on which they are traveling compared to the 45-degree location of the other vehicle. Even when both vehicles have produced clouds of dust behind them, drivers have said they did not see the vehicle on the intersecting road. The second comment relates to the inability of the mind to predict the location of two objects traveling at right angles to each other in the short amount of time available.

The same problem exists for the uncontrolled intersection. Neither driver sees the other driver because the driver on the cross road is outside the committed zone. Although the reasoning has been to forgo traffic control devices at rural intersections because the chances of an accident are slight, the collisions that have occurred are fatal or involve serious injuries. Unlimited visibility at low-volume rural intersections is no reason to leave the intersection uncontrolled. Such accidents occur at night when seeing oncoming headlights seem to assist little in preventing fatal accidents. Two of the accidents that I examined were not discovered until the next morning when daylight made the two vehicles off in a field visible. The only appropriate control is the Stop sign.

In the charts of the *Traffic Control Devices Handbook*, the maximum speed is 80 kph (50 mph), not 90 kph (55 mph). The studies in the National Cooperative Highway Research Program Report 320, *Guidelines for Converting Stop to Yield Control at Intersections*, were conducted in urban or suburban areas. No studies have been conducted on the use of Yield signs in rural areas. However, Yield signs have proliferated in high-speed rural areas. The 40 accidents studied for this paper occurred in a five-year period and are not a large sample. However, the accidents have a number of similarities: serious injuries or fatalities, unlimited visibility, high-speed approaches, no evasive action on the part of either driver (lack of skids or turning maneuvers), Yield sign–controlled intersections, and rural areas.

Conclusion and Recommendation

The use of Yield signs is appropriate at urban and suburban locations where approach speeds are in excess of 16 kph (10 mph). However, the use of Yield signs in rural areas appears to be inappropriate.

The use of Yield signs is still evolving. Future studies should occur in rural areas to determine whether Yield signs are indeed the correct traffic control devices where approach speeds are high and visibility is essentially unlimited. An upper speed for which Yield signs should be used may need to be considered. What that speed should be is not clear from the limited work I have done. However, an upper speed of 50 kph (30 mph) would seem appropriate since the majority of the study on Yield signs has been in urban areas. Also, the correlation of the data on field of vision or committed zone for a 50 kph (30 mph) speed is 45 degrees from center. This means that two drivers can see each other if they approach the intersection at 50 kph (30 mph) or less without turning their heads or eyes. The maximum safe speed for two vehicles to approach an intersection at which one road is controlled by Yield signs is thus 50 kph (30 mph). Using Yield signs on roadways with speed limits higher than 50 kph (30 mph) is inviting additional fatalities and serious injuries at rural high-speed intersections.

References

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2. *Transportation and Traffic Engineering Handbook*. Institute of Transportation Engineers, Washington, D.C., 1976.
3. Shanahan, D. M., and R. C. Smardon. Participatory Process for Managing Roadside Vegetation. In *Transportation Research Record 1224*, TRB, National Research Council, Washington, D.C., 1989, pp. 6–14.