Establishing Speed Limits on Low-Volume Roads

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This study identifies alternative methods for determining realistic speed limits for roads with insufficient traffic volumes to merit a meaningful spot speed survey. Safe curve speed, roadway geometrics, sight distance restrictions, and crash experience were found to be the primary factors deserving attention in establishing these speed limits.

Low-volume roads constitute two-thirds of the U.S. public highway mileage but carry only 8 percent of the total U.S. travel. This project was undertaken to develop a mechanism for establishing proper speed limits on these roads.

For this study (*1*), low-volume roads were defined as county roads and state highways with an average daily traffic (ADT) of 400 vehicles or less. Traditional engineering techniques for establishing regulatory speed limits are not applicable on roads with such low volumes. It is difficult to obtain an adequate sample of free-flowing vehicle speeds using typical spot speed survey methods.

The travel speed selected by a motorist can be influenced by numerous factors, including the posted speed limit. Other factors, such as horizontal and vertical alignment, sight distance, pavement surface condition, traffic congestion, frequency of intersections, and apprehension about speeding citations, may also influence a motorist's speed. Rather than assuming that most drivers will comply with a posted speed limit, this study assumes that a realistically established speed limit on low-volume rural roads will provide meaningful information to the prudent road user.

Development, Distribution, and Analysis of Questionnaire

The questionnaire that was sent to traffic engineers in 40 state highway and transportation departments with responsibility for significant mileage in low-volume rural roads covered the following:

- The importance of various factors that affect speed limits on low-volume roads,
- The importance of sight distance in altering speed limits at critical locations,
- Factors that affect actual running speeds on low-volume roads,
- Use of regulatory speed limits versus advisory speeds, and
- Design speeds on low-volume roads.

Questionnaires with usable responses were returned by 27 states. Values in the following summaries represent the number of these states responding in the following manner.

1. *How would you rate the importance of the following factors in establishing speed limits on low-volume roads?*

Table 1 shows the number of respondents who believed that the factors were of high, moderate, or low importance. The options listed for this question were not intended to be exhaustive, and respondents were asked to identify additional factors that they consider in establishing speed limits on these roads. Accident history and statutory regulations were judged to be highly important by at least half of the respondents; roadside development, safe curve speed, curvature, sight distance, intersection frequency, and pedestrians were mentioned by 40 to 50 percent of the state traffic engineers. Although seven states mentioned the 85th-percentile speed, the respondents may not have considered the difficulty of collecting reliable information on low-volume roads.

2. *Sight distance restrictions may justify the setting of lower speed limits. Please rank the importance of limited sight distance in reducing speed limits at the following locations:* (a) *horizontal curves*, (b) *vertical curves*, (c) *intersections*, (d) *narrow bridges*.

Most respondents ranked the factors in decreasing order of importance as c, a, b, d. Thus, they would be most likely to reduce the regulatory speed because of sight distance restrictions at intersections or horizontal curves. However, several states indicated that they place warning signs with advisory speeds rather than reduce regulatory limits for short sections of roadway. They reasoned that speed zone signing is not the appropriate way to deal with these situations since it has little chance of success.

3. *What values of design speeds do you use on low-volume roads? Maximum, ____ mph; minimum, ____ mph; typical, ____ mph.*

Maximum and typical design speeds ranged from 64 to 97 km/hr, and minimums were 32 to 97 km/hr. Consistent with AASHTO geometric design policy (2), many states based their design speeds on the topography, for example, 64 km/hr in mountainous or rolling terrain and 50 km/hr on level terrain.

4. *In your opinion, what are the primary factors affecting drivers in their choice of speeds on low-volume roads?*

Parameters identified by multiple respondents were horizontal curvature (13), pavement surface condition (10), sight distance (8), vertical curvature (8), roadside development (6), alignment of highway (5), lane width (5), traffic congestion (3), and speed enforcement (3). Comfortable speed, warning signs, side friction, safe curve speed, amount of truck and farm equipment traffic, and number of access points were mentioned by one or two states.

5. *Choose between two alternatives for signing a 1.6-km segment of low-volume road with a safe speed of 55 km/hr located between two extended sections with a safe speed of 80 km/hr:*

- *Reduce the regulatory speed limit to 55 km/hr on the segment in question, or*
- *Place a series of warning signs with 55 km/hr advisory plates along that segment.*

Most engineers agree that the introduction of a single element, such as a horizontal curve with a safe speed of 55 km/hr, can be handled with a warning sign and advisory speed plate. When given the binary choice of a reduced regulatory speed limit or warning signs with advisory speeds over a 1.6-km section, 75 percent of the

TABLE 1 Respondents' Ratings of Importance of Selected Factors in Establishing Speed Limits on Low-Volume Roads

	Importance		
Factors	High	Moderate	Low
Roadway			
Functional Classification	2	6	19
Curvature	10	13	5
Length	5	14	9
Sight Distance	10	14	3
Surface Type	7	11	8
Safe Curve Speed	11	10	5
Adequacy of Shoulders	5	10	12
Lane Width	8	8	10
Lateral Clearance to Obstacles	6	7	14
Centerline Marking	6	5	16
Frequency of Intersections	10	12	4
Roadside Development	12	8	6
Roadside Distractions (e.g., advertising)	2	6	19
Traffic Volume	6	14	7
Pedestrians	10	8	3
Public Attitude Towards Speed Regulation	4	9	15
Vehicle Type (Trucks, Farm Equipment)	5	9	12
Accident History	19	5	2
Statutory Regulations	13	11	2

respondents chose warning signs. Nevertheless, supplementary comments from several states suggest that their choice might change because of other conditions. Ambivalence of the responses implies that both the regulatory and warning sign options deserve consideration.

Safety Evaluations on Low-Volume Rural Roads

Since many respondents considered accident history a primary factor in establishing speed limits, a pilot study was undertaken to assess accident experience on New Mexico's low-volume roads. Safety analyses on higher-volume roads often use multiple years of accident data, which increases sample size and reduces the influence of a single miscoded accident. A 3-year period is usually sufficient to minimize short-term fluctuations. Because of the low numbers of both accidents and travel, a 3-year study period is an absolute minimum for low-volume roads. The accident rate, which depends on the number of accidents, the ADT, and the length of the study period, is given as

$$\text{Accident rate}_{(\text{per mvkm})} = \left[\frac{\text{Accidents} * 1{,}000{,}000}{\text{ADT} * \text{length}_{(\text{km})} * \text{days}}\right]$$

A 1.00-km section of rural road with an ADT of 200 vehicles per day (vpd) and with one accident during a 3-year (1,095-day) study period would have an accident rate of 4.57 accidents/mvkm. This result highlights one of the problems with using accident rates on low-volume roadways. The number of accidents on a section during a 3-year period must obviously be an integer {0, 1, 2, . . .}. However, the relatively small amount of travel in the denominator results in large jumps (+4.57) in the accident rate caused by a single accident. This problem can be ameliorated by considering longer roadway sections with greater amounts of travel; however, this solution will mask truly high accident rates at shorter spots within the section.

It is not evident if a particular accident rate (e.g., 3.0 accidents/mvkm) is safe or hazardous. To help make such a judgment, it is necessary to calculate the overall accident rate for all low-volume road sections, using the total number of accidents and the total travel. If there are sections {1, 2, 3, . . ., n} within a highway category,

$$\text{Average accident rate} = \left[\frac{1{,}000{,}000 * \sum_{i=1}^{n} \text{accidents}_i}{\sum_{i=1}^{n} (\text{ADT}_i * \text{length}_i * \text{days}_i)}\right]$$

Rural Traffic Accidents in New Mexico

An analysis was performed to compare the safety on New Mexico's low-volume roads and high-volume-rural (HVR) roads. For the purposes of this study, the New Mexico State Highway and Transportation Department (NMSHTD) rural road system was subdivided into two categories, and samples were randomly selected from each.

- *Low-volume roads*: NMSHTD roads with volumes less than 400 vpd. The sample consisted of 47 sections with a total length of 1890 km and an average traffic volume of 175 vpd. Most roads were federal-aid secondary or state highways.
- *HVR roads*: NMSHTD rural roads with traffic volumes between 2,000 and 4,000 vpd. The sample had 10 sections with a total length of 800 km and an average traffic volume of 2,480 vpd.

Accident data were extracted from the computerized accident record system for the years 1988 to 1990. The low-volume roads had a total of 469 accidents for an average of 0.083 accident per kilometer per year (acc/km/yr). The HVR roads had a total of 1,291 accidents for an average of 0.538 acc/km/yr. Approximately 45 percent of the crashes on both low-volume and HVR roads resulted in injuries. Accident rates for individual low-volume routes ranged from zero to more than 13; the 3-year average accident rate for the 47 low-volume roadway sections was 1.30 acc/mvkm. By contrast, accident rates on the 10 sections of HVR roads ranged from 0.30 to 1.24 acc/mvkm, with an average of 0.59 acc/mvkm.

Critical Accident Rates

The high variability of accident rates makes it difficult to determine when a particular route should be considered hazardous, especially on low-volume roads where both the numerator (accidents) and the denominator (vehicle-kilometers of travel) in the accident rate equation are small. One potential solution is to use the rate-quality control technique (*3*) to identify roadway sections with abnormally high accident rates. This method is useful for screening a large number of candidate locations to identify those that may deserve further study. The critical accident rate (R_c) for a specific roadway section, which is a function of the systemwide accident rate (R_a); the amount of travel (m, expressed in mvkm) on the section during the study period; and a factor k, reflecting the statistical level of significance, is given by

$$R_c = R_a + k * \sqrt{\frac{R_a}{m}} + \frac{1}{2 * m}$$

For a significance level of $\alpha = 0.05$, k is 1.645. Since $R_a = 1.30$ accidents/mvkm, the only remaining variable in the equations is m, the amount of travel on each analysis section. For illustrative purposes, the average low-volume road study section was 40 km long with an ADT of 175 vpd, resulting in 3-year travel of 7.7 mvkm; for such a section, R_c would be 2.04 accidents/mvkm. Critical accident rates were calculated for each of the 47 low-volume roadway sections. Results ranged from 1.6 on lengthy sections with (relatively) higher ADTs to 3.0 to 4.5 on sections with less travel. Sections where the actual rate exceeds the critical rate warrant more detailed study.

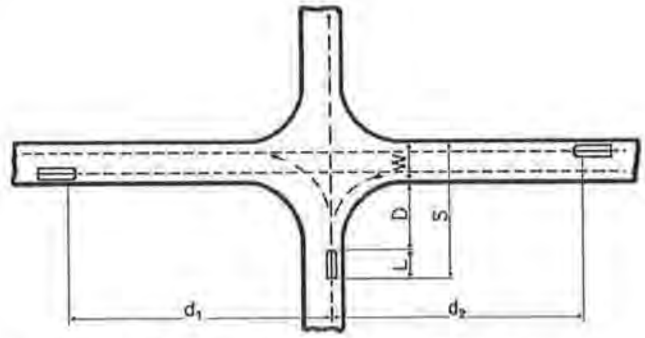

FIGURE 1 Type III Stop control on minor road.

Conclusions and Recommendations

Statutory regulations in New Mexico restrict the maximum speed limit on rural non-Interstate highways to 90 km/hr. Therefore, the recommended starting point for establishing a reasonable regulatory speed limit on these roads would be the minimum of 90 km/hr or the design speed for a predominant length of the roadway.

Actual and critical accident rates for each low-volume road section should be calculated using 3 calendar years of accident and traffic volume data. If the actual rate exceeds R_c, the section should be examined in greater detail to identify accident patterns that can be addressed with engineering techniques. Concentration of crashes should be examined to determine contributing road defects. Factors such as crash type and severity, driver familiarity, and physical evidence (e.g., skid marks) may indicate if vehicle speed was a meaningful contributing factor in the crashes. Most accidents on these roads are single-vehicle crashes, for which reports are often incomplete. This may hamper analysis at this rudimentary level. A crash involving a vehicle exceeding the speed limit by a substantial amount on a low-volume road is unlikely to be affected by the posting of lower limits.

The engineering investigation to establish a speed limit must include a field review of the route's physical characteristics. The investigation should include the following:

- A ball-bank indicator (4) to determine safe speeds in both directions on each horizontal curve;
- Evaluation of stopping sight distance restrictions at vertical and horizontal curves that could be ameliorated by obstacle elimination or lower speeds;
- Review of the AASHTO (2) Case II and/or Case IIIA sight distance (see Figure 1) at intersections and driveways;
- Examination of special conditions, such as narrow lanes or bridges, unshielded steep slopes, and significant amounts of slow-moving equipment or nonmotorized traffic, that deserve warning or regulatory control.

Data assembled in the preceding steps should be carefully analyzed in light of the survey responses. Although technicians trained in traffic data collection and analysis may be able to assemble the necessary information and perform appropriate calculations, a traffic engineer must be involved at this stage in the process. If geometrics or sight distance restricts speeds over a short section of road, warning signs with suitable advisory speed signs should be used. On the other hand, if the posting of an 80 or 90 km/hr speed limit will require placing warning signs and advisory speed plates at every curve and intersection over an extended section, consideration should be given to lowering the regulatory limit.

References

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