Traffic Calming Design Standards for New Residential Streets: A Proactive Approach

ONE U.S. COUNTY HAS DEVELOPED A PROACTIVE APPROACH TO ACHIEVE TRAFFIC CALMING IN NEW SUBDIVISIONS THAT HAVE NOT YET BEEN BUILT. DEVELOPERS WILL BE REQUIRED TO INCLUDE IN THEIR PLANS DESIGN FEATURES TO ENSURE REASONABLE SPEEDS ON NEIGHBORHOOD STREETS, SUCH AS SPECIFICATIONS FOR TANGENT LENGTHS AND CURVES OR DEVICES SUCH AS TRAFFIC CIRCLES OR SPEED HUMPS.

BY JOSEPH E. WOMBLE, P.E. AND W. MARTIN BRETHERTON JR., P.E.

PROBLEMS ASSOCIATED WITH residential speeding, both real and perceived, require an inordinate amount of traffic engineers' time and effort in local jurisdictions. Gwinnett County, GA, USA, located in the metropolitan Atlanta area, certainly is no exception. As the population of the county has grown—from 166,808 in 1980 to 352,910 in 1990 to 588,448 in 2000—so has the number of residential speed complaints.

EARLY TRAFFIC CALMING EFFORTS

Since 1985, Gwinnett County has had an aggressive program of residential speed control. The first effort consisted of selective closures of streets that carried large volumes of traffic taking shortcuts through residential neighborhoods. However, it did not take long to discover that street closures can be quite controversial and that, therefore, the approach should be considered for only the most egregious cases of "cut-through" traffic.

The next effort was a program known as Neighborhood Speed Watch, which sought compliance with residential speed limits through behavior modification brought about by peer pressure, increased awareness and a greater sense of responsibility.[1] It was designed specifically for self-contained residential areas, where such an approach is most successful.

Neighborhood Speed Watch worked well for Gwinnett County. Neighborhoods that were in the program for two to three years realized 85th-percentile speed reductions in the range of 11 to 13 miles per hour (mph), which corresponded closely with the results obtained through speed humps. The program did have a serious drawback: To function adequately, it required considerable support from Gwinnett County staff. Neighborhood Speed Watch was eliminated in 1992 during a budget crunch. However, it is interesting to note that speeds in subdivisions that were in the program for two to three years have not returned to their pre-program levels, indicating a lasting modification in behavior.

Following the release of the Institute of Transportation Engineers' first draft on speed hump guidelines, Gwinnett County began an extensive program of retrofitting speed humps on existing streets. Speed humps are installed on a petition basis and capital costs are funded by a special purpose local option sales tax, levied by Gwinnett County to fund transportation and other capital improvements. On a street with 85th-percentile speeds in excess of 35 mph, the approval of 70 percent of the property owners is required. On a street with 85th-percentile speeds less than 35 mph, 90 percent of the residents must approve. In addition, each property owner on a street with speed humps must pay a special tax assessment of $12 per year in perpetuity for the maintenance of the humps.

Gwinnett County's speed hump program has proven quite popular. Since the inception of the program, 797 humps have been installed in 126 subdivisions.

RESIDENTIAL STREET DESIGN STANDARDS

Throughout this period, the Gwinnett County Department of Transportation (DOT) has sought to reduce future residential speed problems by taking a proactive role in the development review and rezoning process and by promoting street design layouts that discourage higher speeds. Only limited success in this endeavor has been achieved, as evidenced by the number of speed hump petitions that continues to be received from new subdivisions. One aspect of the problem is the relatively low operating speed required for strong complaints to be voiced. For example, 18 percent of the speed hump petitions received in past months have involved 85th-percentile speeds in the 30–35 mph range, which require approval by 90 percent of area residents.

Residential street design standards typically specify minimum values for geometric design features such as horizontal curves but do not specify maximum values. Gwinnett County design standards are no exception.[2] By specifying both maximum and minimum design standards, streets can be designed to operate at speeds that are acceptable in a residential area.

A PROACTIVE APPROACH TO ACHIEVE TRAFFIC CALMING

Gwinnett County's population now is increasing by more than 20,000 people per year. Therefore, it has been important to take a proactive approach to modify the elements of street layout and design that lead to excessive speed. This has been accomplished only by developing specific design standards and incorporating them into the county's development regulations. In developing these low-speed design standards, the following factors were considered:

- Once implemented, the standards should result in 85th-percentile speeds in the 25–30 mph range.
- The standards should be easy to understand.
- The standards should offer maximum flexibility to subdivision designers and developers.

The design elements considered in developing low-speed design criteria include tangent lengths and various types of speed control points, such as horizontal curves, breaks in continuity and different types of traffic calming devices.

Tangent Lengths

While numerous studies have been conducted to determine the effect of tangent lengths on operating speeds, additional studies were conducted to determine this relationship based on Gwinnett County's subdivision development standards (such as street widths, setbacks and parking conditions).

Accordingly, speed studies were completed on eight residential streets with 24 tangent sections. The studies were conducted over 24-hour periods with electronic tube counters. The accuracy of the counters was checked by radar. Tangent lengths ranged from 300 to 2,510 feet (ft.) and operating speeds (85th percentile) ranged from 25.5 to 41.2 mph. The studies were conducted at the midpoints of the tangents. Figure 1 shows a scatter diagram of the 24 studied road segments.

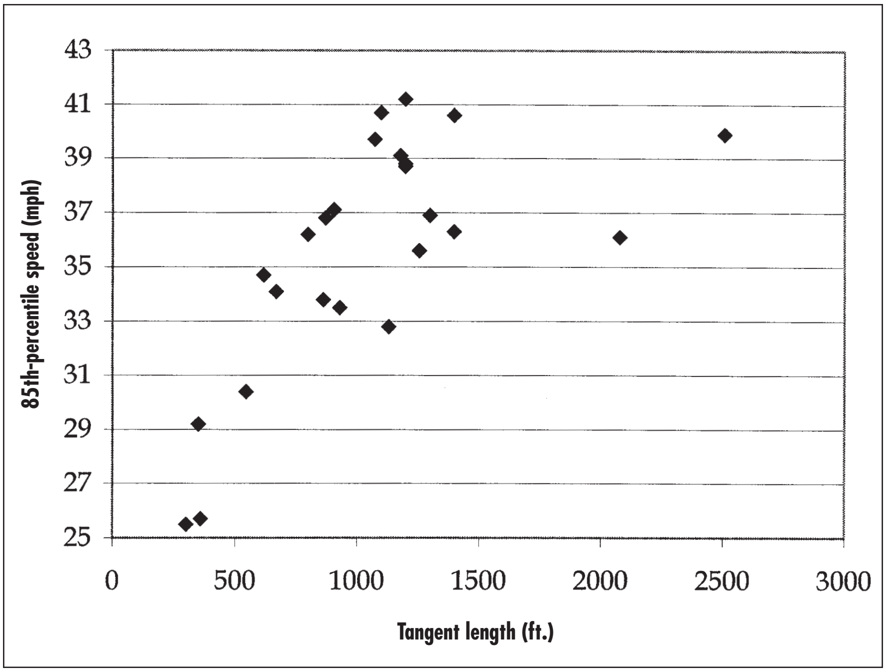


Figure 1. Scatter diagram of the 24 studied road segments on eight residential streets.

A regression analysis was conducted to determine the relationship between operating speeds and the length of tangent segments on residential streets. The model found the following relationship:

$$V = 16.6 + 0.03484\,L - 0.0000138\,L^2$$

V = 85th-percentile speed (mph)

L = length of straight residential street (ft.)

The results of the application of this model, based on Gwinnett County's subdivision street standards, are presented in Table 1. Other results include the following findings:

- The model fits the data well with an R-squared value of 0.83. All residuals are within 1.5 standard error from the expected value.

Table 1. Relationship between tangent length and operating speed on residential streets.

Tangent length (ft.)	Expected operating speed (mph)
300	25.8
400	28.3
500	30.6
600	32.5
700	34.2
800	35.6
900	36.8
1,000	37.6
1,100	38.2
1,200	38.5
1,300	38.6
1,400	38.6

- The model applies only to straight segments between 300 and 1,400 ft.
- The model found the 85th-percentile speed maximum value (38.6 mph) when the straight segment length is 1,260 ft. To be consistent with the theory that longer segment length generates higher speed, it was decided that the model would use a maximum value of 38.6 mph for segments longer than 1,260 ft.

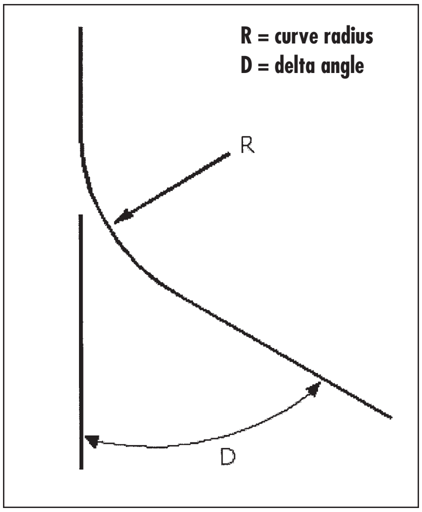


Figure 2. Curve radius and delta angle.

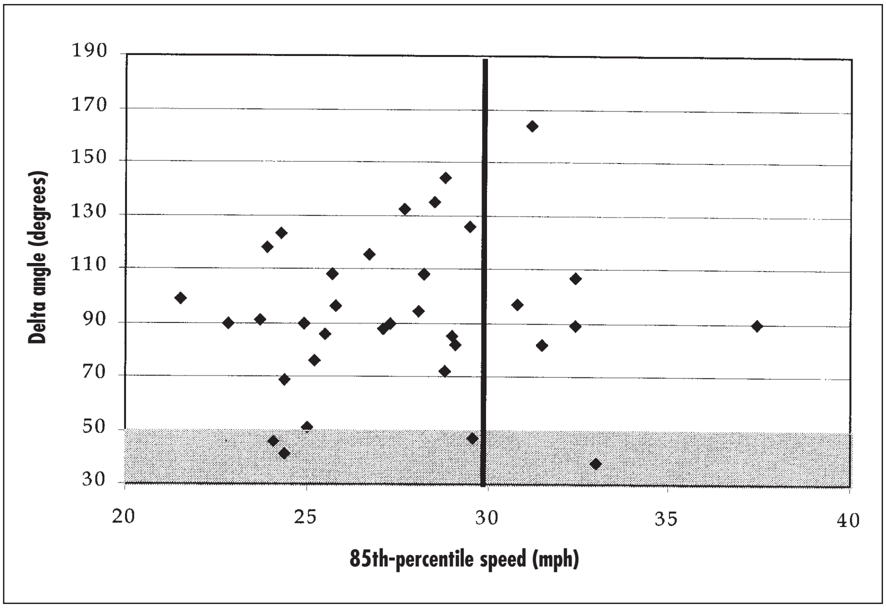


Figure 3. Scatter diagram of the 35 studied curves on eight residential streets.

Speed Control Points

Speed control points are defined as the design elements at the end of tangent sections that can be negotiated safely only at operating speeds of 25–30 mph or less. These include horizontal curves, breaks in continuity and traffic calming devices.

Horizontal Curves. As shown in Figure 2, the two most important curve characteristics influencing operating speed are delta angle and radius. (This assumes super-elevation rate e = o, which is the standard for Gwinnett County's residential streets.)

To determine the effect of horizontal curves on operating speed, a statistical analysis was performed on data collected on eight residential streets. The data included operating speed, delta angle and radius for 35 horizontal curves. The curve data were obtained from final subdivision development plats. Operating speeds in the study ranged from 21.5 to 37.4 mph and were measured at the point of curvature or point of tangency to determine the effect of the curve on speed. In addition, data were collected using automatic 24-hour traffic counters with rubber tubes. Vehicles needed to hit the tubes perpendicularly to obtain accurate readings. The delta angles ranged from 37 to 164 degrees and the curve radii ranged from 51 to 426 ft.

Figure 3 shows a scatter diagram of the 35 studied curves. Most of the data points are left of the 30-mph marker, showing possible curve designs of less than 30 mph using different delta angles. There is a very strong correlation between delta angle and curve length (correlation coefficient equals 0.94), because the radius (or curve length) usually is not chosen independently once the delta angle is determined; it often is determined on the basis of design criteria. Due to the strong correlation between delta angle and curve length, the speed prediction model based on the regression analysis would have only one of the two as an independent variable.

Both analysis of variance and regression analysis were conducted to determine the relationship between operating speed and horizontal curve design on residential streets. No model could be found because all relationships were statistically insignificant (best R-squared equals 0.66). The study plotted all data points on a graph and drew a line at 30 mph, as shown in Figure 3. The reasonable grouping of data points was used. Based on this study, Table 2 shows curve values required to maintain operating speeds in the 25–30 mph range.

Table 2. Curve values required to maintain 25–30 mph operating speeds.

Delta angle (must be greater than 30 degrees)	Radius
30 degrees – 40 degrees	100 ft.
41 degrees – 50 degrees	120 ft. (minimum) – 130 ft. (maximum)
Greater than 51 degrees	120 ft. (minimum) – 150 ft. (maximum)

Breaks in Continuity. Conditions that require a motorist to come to a complete stop include a T intersection or a stop-controlled intersection between a residential street and a collector or arterial road. These conditions do not include unwarranted multi-way stop control at an intersection between local subdivision streets. (Section 2B.05 of the *Manual on Uniform Traffic Control Devices* states that, "Stop signs should not be used for speed control." Experience has shown this to be a sound policy, which the Gwinnett County DOT supports).[3]

Traffic Calming Devices. While there are various traffic calming devices available, those now considered for use in Gwinnett County are limited to speed humps, traffic circles, median islands and roundabouts.[4] Design details for these devices will be presented in the "Traffic Calming Guide for the Approved Design and Spacing of Traffic Calming Devices," currently under development. Design guidelines for roundabouts are contained in the Federal Highway Administration guidelines.[5]

TRAFFIC CALMING CRITERIA FOR NEW RESIDENTIAL STREETS

With this research to serve as background, very simply stated criteria have been developed to govern low-speed design of residential streets in new developments. As such, subdivision streets should be designed to encourage and maintain 85th-percentile speeds in the 25–30 mph range. To achieve this objective, the maximum length of a roadway section between speed control points should be 500 ft. A speed control point is defined as any one of the following:

- Any design condition that requires a complete stop, such as the intersection of a local residential street with a collector or arterial road or a T intersection between local streets. (Unwarranted stop-sign control at an intersection between local streets does not qualify.)
- A horizontal curve with the design features shown in Table 2.
- A traffic calming device of which the design is subject to review and approval by the Department of Transportation. (See the "Traffic Calming Guide for the Approved Design and Spacing of Traffic Calming Devices," currently under development.)

APPLICATION OF TRAFFIC CALMING CRITERIA

Figure 4 shows how traffic calming criteria might be applied to a new residential subdivision. Figure 4a illustrates a subdivision that was submitted for development review. Although it was a small subdivision, the straight tangent length of its principal street (greater than 1400 ft.) was certain to generate operating speeds in excess of 30 mph—beyond the threshold at which residents express concerns about residential speeding.

Figure 4b illustrates a conceptual redesign of the subdivision utilizing short tangent lengths and curves to ensure operating speeds less than 30 mph. Figure 4c illustrates how the same objective can be achieved by retaining the original street layout but adding strategically placed traffic calming devices such as traffic circles.

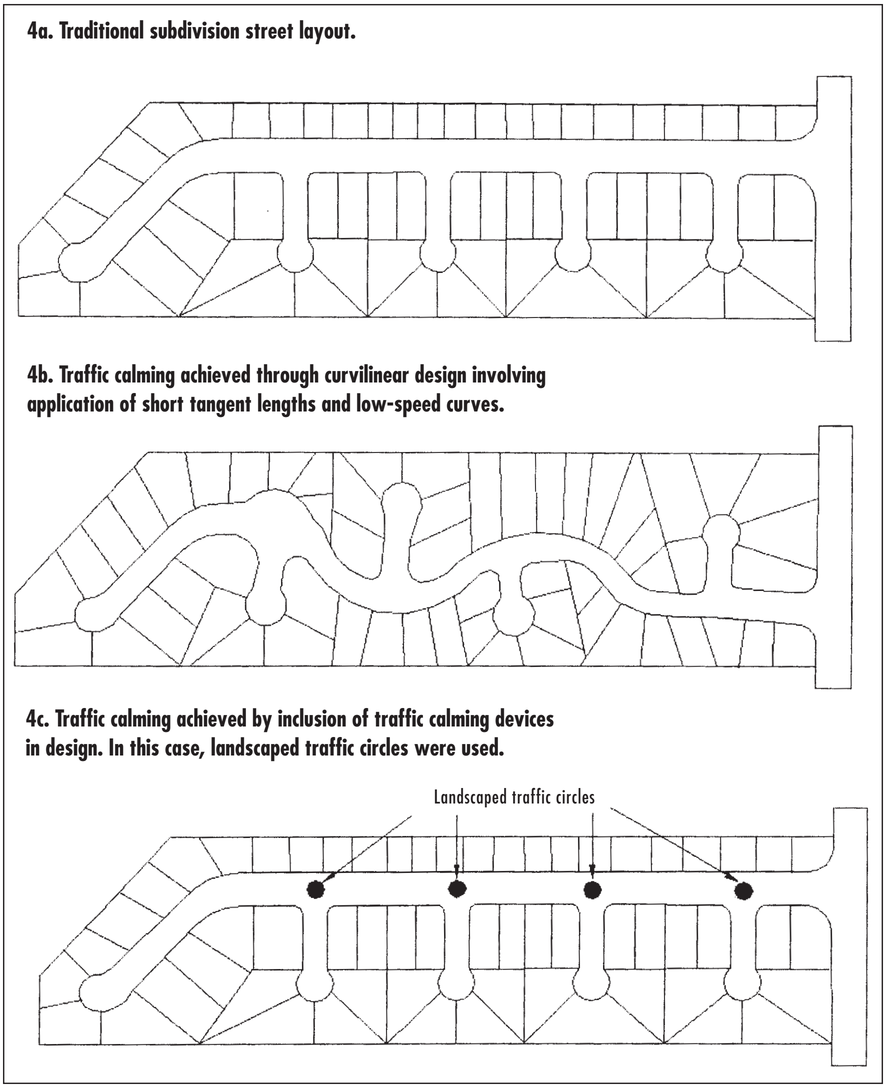


Figure 4. Application of traffic calming design standards to a new residential subdivision.

Another solution might be a combination of curvilinear design and traffic calming devices. This offers developers maximum flexibility and ensures that traffic calming measures can be accommodated with little or no loss in lot yield.

The preferred solution is a curvilinear design that encourages a constant and reasonable speed; this design does not require vehicles to accelerate and decelerate frequently, which results in wasted fuel and increased noise and air pollution. In addition, a curvilinear design eliminates the maintenance requirements associated with traffic calming devices. This not only ensures acceptable operating speeds but also improves the aesthetics of the area, contributing to a better quality of life for residents.

SUMMARY

There are various proven and well documented ways to implement traffic calming measures in existing residential areas. However, for new residential developments, it is far preferable to design streets to maintain acceptably low operating speeds rather than to face the need to retrofit traffic calming devices, with all the attendant disruption and controversy it often entails. To achieve wide acceptability, traffic calming, or low-speed design, should satisfy the following criteria:

- When applied, the standards should result in 85th-percentile speeds in the 25–30 mph range.
- The standards should be specific, yet simple and easy to understand and apply.

ITE 2003 Annual Meeting and Exhibit

in conjunction with the ITE District 6 Annual Meeting

August 24–27, 2003

Washington State Convention & Trade Center Seattle, Washington, USA

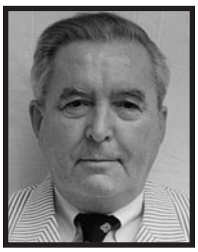
Register Today!

www.ite.org/AnnualMeeting

- The standards should offer maximum flexibility and choice to subdivision designers and developers. ■

References

1. Womble, J.E. "Neighborhood Speed Watch: Another Weapon in the Residential Speed Control Arsenal." *ITE Journal*, Vol. 60, No. 2 (February 1990): 16–17.
2. *Gwinnett County Development Regulations*. Gwinnett County Planning and Development Department. Gwinnett County, GA, USA, August 1998.
3. Bretherton, M. "Multi-Way Stops—The MUTCD Is Correct!" *1999 ITE Compendium of Technical Papers* (August 1999).
4. Day Wilburn & Associates. "Technical Report 7: Traffic Calming." *Gwinnett County Comprehensive Transportation Plan*, October 2001.
5. *Roundabouts: An Information Guide*. Federal Highway Administration, Publication No. FHWA-RD-00-067 (June 2000).



JOSEPH E. WOMBLE, *P.E., is director of the traffic and transportation division of the Gwinnett County Department of Transportation, GA, USA. Previously, he served as a county traffic engineer for Gwinnett County, city traffic engineer for New Orleans, LA, USA and consulting engineer for more than 20 years in North and South America, Asia and Australia. He holds a B.S. in civil engineering from the University of Illinois and is a life fellow of ITE.*

W. MARTIN BRETHERTON JR., *P.E., is chief engineer of the traffic and transportation division of the Gwinnett County Department of Transportation. Previously, he served as traffic engineer for the city of Conyers/Rockdale County, GA, transportation engineer for the Georgia Department of Transportation, and principal traffic engineer for an Atlanta, GA consulting firm. He holds a B.C.E. from the Georgia Institute of Technology and a M.B.A. from Georgia State University. He is a fellow of ITE.*

The Impact of Red-Light Camera Enforcement on Crash Experience *Continued from page 48*

USA: University of North Carolina, Highway Safety Research Center, June 1997.

4. Retting, R.A., S.A. Ferguson and A.S. Hakkert. "Effects of Red Light Cameras on Violations and Crashes: A Review of the International Literature." Insurance Institute for Highway Safety, July 2002.
5. Retting, R.A. and S.Y. Kyrychenko. "Crash Reductions Associated with Red Light Camera Enforcement in Oxnard, California." *American Journal of Public Health* (in press).
6. Vinzant, J.C. and B.J. Tatro. "Evaluation of the Effects of Photo Radar Speed and Red Light Camera Technologies on Motor Vehicle Crash Rates." Prepared for the City of Mesa Police Department, Arizona State University and B. J. Tatro Consulting, March 1, 1999.
7. PB Farradyne Inc. *City of San Diego Photo Enforcement System Review Final Report*. Commissioned by the City of San Diego Police Department. San Diego, CA, USA, 2002.
8. Fox, H. "Accidents at Signal Controlled Junctions in Glasgow." The Scottish Office, Central Research Unit, 1996.

HUGH W. MCGEE, *Ph.D., P.E., is chairman of the board of BMI in Vienna, VA, USA. He has more than 30 years of experience in traffic engineering, operations and safety, providing studies and designs for state and local governments and conducting research at the federal and national level. He holds degrees in civil engineering from Pennsylvania State University. McGee is a fellow of ITE and the American Society of Civil Engineers.*

KIMBERLY A. ECCLES, *E.I.T., is a senior engineer at BMI in Vienna, VA. She has a bachelor's of science degree in civil engineering from Michigan State University and a master's degree in civil engineering from North Carolina State University. Eccles is a member of ITE.*