Research Report
KTC-08-02/SPR 330-07-1I

KENTUCKY TRANSPORTATION CENTER

USE OF EDGE LINE MARKINGS ON RURAL TWO-LANE HIGHWAYS

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USE OF EDGE LINE MARKINGS ON RURAL TWO-LANE HIGHWAYS

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16. Abstract

The objective of this study was to review roadway characteristics and crash data in Kentucky and determine if revisions should be made to current guidelines for the use of edge lines. Recommendations were made concerning the use of edge lines, centerlines, and paved shoulders on rural, two-lane roadways with varying pavement widths.

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EXECUTIVE SUMMARY

The Manual on Uniform Traffic Control Devices (MUTCD) gives guidelines for the placement of edge lines on rural two-lane roads. One guideline provides for a width of 20 feet between the edge lines. This had been treated as a policy in Kentucky. The MUTCD also allows for the use of edge lines without a centerline in certain instances. The objective of this study was to review roadway characteristics and crash data in Kentucky and determine if revisions should be made to current guidelines for the use of edge lines.

The analysis resulted in the following conclusions.

1. Overall crash rates and fatal crash rates decrease dramatically on rural two-lane roads as the lane width increases.

2. The percentage of single vehicle crashes increases as lane width decreases with the highest percentage for lane widths under 10 feet.

3. The percentage of single vehicle crashes is more than four times the percentage of "opposite direction sideswipe" crashes on roads with the most narrow lane widths.

4. An analysis of several miles of road with a width of approximately 19 feet between edge lines found that the crash rate did not increase compared to the statewide rate for roads with nine and 10 foot lane widths. The percentage of single vehicle crashes on these roads decreased compared to roads with similar lane width.

5. An edge line, with no centerline, can be placed on a narrow, low volume road without increasing crashes and without causing a problem with opposite direction crashes.

6. The ADT on roads with the most narrow lane widths (where an edge line with no centerline may be placed) is close to that for a low volume road as defined in the MUTCD.

7. A large percentage of roads do not have edge lines, and there is a potential to add edge lines to many of these roads.

Recommendations were made concerning the use of edge lines, centerlines, and paved shoulders on rural, two-lane roads with varying pavement widths. Rumble strips should be placed where there is a paved shoulder. To maximize lane and shoulder widths, consideration should be given to use of a rumble stripe where the edge line is placed over a portion of the rumble strip. The recommendations would result in an increase in the number of miles of edge lines. However, this increase in miles striped would be offset by decreasing the miles that are restriped each year based on data that show many lines which are still acceptable are currently included in striping projects.

1.0 BACKGROUND

The Manual on Uniform Traffic Control Devices (MUTCD) (1) states that edge line markings **shall** be placed on paved streets or highways with the following characteristics:

a. freeways,
b. expressways, and
c. rural arterials with a traveled way of 20 feet or more in width and an average daily traffic (ADT) of 6,000 vehicles per day or greater.

The MUTCD also states that edge line markings **should** be placed on paved streets or highways with the following characteristics:

a. rural arterials and collectors with a traveled way of 20 feet or more in width and an ADT of 3,000 vehicles per day or greater and
b. at other paved streets and highways where an engineering study indicates a need for edge line markings.

It is noted that edge line markings should not be placed where an engineering study or engineering judgment indicates that providing them are likely to decrease safety. One reason for not using an edge line is the traveled way edges are delineated by curbs, parking, bicycle lanes, or other markings. It is noted that edge line markings **may** be placed on streets and highways with or without centerline markings.

The MUTCD defines a low volume road as a rural road with an ADT of less than 400. It is noted that edge line markings **should** be considered for use on paved low-volume roads based on engineering judgment or an engineering study. An example of where edge lines can be used is for roadway features such as horizontal curves, narrow bridges, pavement width transitions, and curvilinear alignment.

The Kentucky Transportation Guidance Manual provides requirements for pavement markings on the state highway system. It is noted that edge line striping **shall** be installed on all state highways where the following conditions are satisfied:

a. ADT greater than 3,000,
b. minimum roadway width of 20 feet on two-lane roadway (excluding the shoulder), and
c. minimum driving lane width of 10 feet on multi-lane roadways.

Edge line striping **may** be installed on roadways with an ADT less than 3,000 provided they meet the pavement width requirements. Roadways at least 16 feet wide but less than 20 feet **may** receive an edge line instead of a centerline if an engineering study indicates it is more important to mark the edge of the roadway than the center. Roadways less than 16 feet wide **may** receive edge lines instead of being unmarked if an engineering study indicates the need for

edge line striping. Conditions that indicate the need for edge line striping for narrow roads include: greater potential for run-off-roadway crashes versus head-on and sideswipe crashes, low volume roads, high percentage of local traffic, severe drop-offs near the pavement edge, and routine occurrence of fog or other adverse weather conditions.

Recent research dealing with the use of edge lines on rural two-lane highways was reviewed. An analysis of a few roads in Louisiana where the pavement width was less than 22 feet and the ADT was between 86 and 1,855 found that, after the implementation of edge lines, vehicles tended to move away from the pavement edge which could reduce run-off-road crashes (the most common type of crash on narrow two-lane highways) (2). The analysis also found that, even though the counts of centerline crossings increased at several sites during the daytime, they decreased at night when the distribution of vehicles' lateral position is more centralized.

A Texas study of rural two-lane roads with and without edge lines found that edge line treatments may reduce accident frequency up to 26 percent (3). The highest safety impacts occurred on curved segments with a lane width of nine to 10 feet. Edge lines also showed a positive impact in reducing speeding-related crashes during darkness that may be related to better driver path and speed perception.

The next phase of the Texas study focused on edge line effects on driver behavior and reactions (4). The study found that edge line treatments on rural two-lane highways: a) increased speed by five mph or nine percent on both straight and curved highway segments. b) moved vehicles toward the pavement edge during both daytime and darkness an average of 1.5 feet on roads with lane widths of 10 to 11 feet with no change in lateral position on the narrowest lane width of nine feet, c) reduced vehicle lateral position fluctuation by 20 percent, d) reduced driver mental workload, e) improved driver's estimation of roadway curvature, and f) increased driver's advance time of intersection identification.

The objective of this study was to review roadway characteristics and crash data in Kentucky and determine if revisions should be made to current guidelines for the use of edge lines.

2.0 PROCEDURE

2.1 Crash Analysis

The Collision Report Analysis for Safer Highways (CRASH) database was used in conjunction with the Highway Performance Monitoring System (HPMS) database to determine crash rates on rural two-lane roads as a function of lane width. The CRASH database was also used to determine crash characteristics at specific locations identified where there were variations in the placement of edge lines compared to usual guidelines.

2.1 Current Edge Line Installations

Contact was made with traffic engineers in the 12 highway districts across Kentucky to determine any locations where: a) edge lines have been placed on rural two-lane roadways with a width of less than 20 feet between the edge lines and b) edge lines were placed with no centerline. Estimates were also requested of the district traffic engineers of the number of roadway miles with and without edge lines.

3.0 RESULTS

3.1 Crash Analysis

Crashes on rural two-lane roads were analyzed relating as a function of lane width. The results are shown in Tables 1 and 2. Three years of crash data were used (2004 through 2006). The HPMS file was used to identify rural two-lane roads and the approximate lane width on these roads. Several roads were inspected to verify their lane width as given in the HPMS. It was found that the lane width was wider than that given in the HPMS file in several instances. However, the trends shown in Tables 1 and 2 can be used to show changes relative to lane width.

Major differences in crash statistics were identified as the lane width increased. The crash rate decreased as the lane width increased. The overall crash rate for rural two-lane roads (for 2004 through 2006) is 222 crashes per 100 million vehicle miles (C/100MVM) with the fatal crash rate 3.5 C/100MVM (5). The overall crash rate varied from 264 C/100MVM for roads with a coded lane width from seven to nine feet compared to 199 C/100MVM for a lane width of 10 to 12 feet. The fatal crash width decreased from 4.5 C/100MVM for lane widths of seven to nine feet to 3.0 C/100MVM for lane widths of 10 to 12 feet. About 58 percent of all crashes and 55 percent of fatal crashes were on roads with coded lane widths of 10 to 12 feet.

The ADT varied from 413 for the roads coded as having seven-foot lanes to 5,731 to those with 12-foot lanes. The most common coded lane width was nine feet with 69 percent of the lane widths from seven to nine feet. As previously noted, observations showed the HPMS file tended to underestimate the lane width.

The difference in the type of crash as a function of lane width is shown in Table 2. The "manner of collision" code was used to determine type of crash. The percentage of single vehicle collisions for the most narrow lane widths was approximately twice that for the widest lane widths. The percentage of single vehicle crashes was 31 percent for 12-foot lanes compared to 61 percent for seven-foot lanes. Roads with wider lanes had the highest percentage of rear end, angle, and "same direction sideswipe" collisions. Roads with more narrow lane widths had the highest percentage of "opposite direction sideswipe" collisions. It is important to note that roads with the most narrow lane widths have a much higher percentage of single vehicle collisions compared to opposite direction collisions. There was no pattern to nighttime collisions.

3.2 Current Use of Edge Lines

All of the district traffic engineers were contacted to determine any locations on a rural two-lane road with a width less than 20 feet between edge lines. The engineers stated they followed Cabinet guidelines to not place edge lines on roads where there would be a distance less than 20 feet between the edge lines. Locations were found in two districts with long sections of roads with a distance of 19 feet between the edge lines. Several of the roads were inspected with the finding that portions were 19 feet with some sections wider. However, a significant portion of the roadway width was less than 20 feet. A crash analysis was conducted for all of these roads. A total of 170 miles was included. Following is summary of the results of this analysis.

ADT (average)	2,746
Crash rate	268 C/100MVM
Fatal crash rate	3.9 C/100MVM
Type of Crash (percent):	
Angle	21.4
Head on crash	3.4
Rear end	21.9
Sideswipe	
Opposite direction	6.3
Same direction	4.7
Single vehicle	38.0

The crash rate on these roads was similar to the nine and 10-foot statewide lane widths. The edge lines did not result in a large percentage of head on or "opposite direction sideswipe" crashes. The percentage of single vehicle crashes was similar to roads with wider lane widths. This analysis shows that an edge line can be placed with 19 feet between edge lines without increasing the crash rate and with a decrease in single vehicle crashes. There were 20 fatal crashes on these roads in the three-year study period. Of those crashes, nine (65 percent) were single vehicle, three (15 percent) were head on, and four (20 percent) were angle. The 19-foot roads did not result in a large number of fatal head on or "opposite direction sideswipe" crashes.

The traffic engineers were also asked if there were any roads with edge lines and no centerline in their district. One road was identified with a continuous edge line (KY 3475 in Clay County) over a substantial distance (5.3 miles). A crash analysis was conducted on this road for five years before the edge line was placed and one year after. The weighted ADT for the road is 483. An inspection found the pavement width varied from 15 to 16 feet. There was an average of two crashes per year in the five years before with two crashes in the first year after the installation of the edge lines. One of the two crashes in the first year after was an "opposite direction sideswipe" with three of this type of crash in the five years before. The most common type of crash was a single vehicle. This analysis shows an edge line, with no centerline, can be placed on a low volume road without increasing crashes and without causing a problem with opposite direction crashes.

Information was also obtained from a few districts concerning the percentage of miles of road which currently have edge lines installed. One district estimated that about 71 percent of their roads are striped (42 percent with centerline and no edge lines and 29 percent with edge lines). Another district estimated the type of striping by functional classification as follows: no markings on state supplemental roads, rural secondary roads have 60 percent with a centerline and less than 10 percent with an edge line, state secondary roads have more than 95 percent with a centerline and about 70 percent with an edge line, and all state primary roads have both centerline and edge lines. A third district estimated that 67 percent of their roads were striped (52 percent with centerline and no edge lines and 15 percent with edge lines).

A review of the HPMS file shows that most rural two-lane roads with a lane width of 12 feet are arterials. Roads with a lane width less than nine feet are minor collectors or local roads. The highest percentage of major collector roads has a lane width of 10 feet.

4.0 CONCLUSIONS

The analysis resulted in the following conclusions.

1. Overall crash rates and fatal crash rates decrease dramatically on rural two-lane roads as the lane width increases.

2. The percentage of single vehicle crashes increases as lane width decreases with the highest percentage for lane widths under 10 feet.

3. The percentage of single vehicle crashes is more than four times the percentage of "opposite direction sideswipe" crashes on roads with the most narrow lane widths.

4. An analysis of several miles of road with a width of approximately 19 feet between edge lines found that the crash rate did not increase compared to the statewide rate for roads with nine and 10-foot lane widths. The percentage of single vehicle crashes on these roads decreased compared to roads with similar lane widths.

5. An edge line, with no centerline, can be placed on a narrow, low volume road without increasing crashes and without causing a problem with opposite direction crashes.

6. The ADT on roads with the most narrow lane widths (where an edge line with no centerline may be placed) is close to that for a low volume road as defined in the MUTCD.

7. A large percentage of roads currently do not have edge lines, and there is a potential to add edge lines to many of these roads.

5.0 RECOMMENDATIONS

Following is a summary of recommendations for the use of edge lines (and centerlines) on rural two-lane roads as a function of total pavement width (including paved shoulder). The distances are given in feet.

Pavement Width	Lane Width	Centerline	Edge line	Paved Shoulder Width
28	12	Yes	Yes	2
27	12	Yes	Yes	1.5
26	11	Yes	Yes	2
25	11	Yes	Yes	1.5
24	11	Yes	Yes	1
23	10	Yes	Yes	1.5
22	10	Yes	Yes	1
21	9	Yes	Yes	1.5
20	9	Yes	Yes	1
19	8	Yes	No	1.5
18	8	Yes	No	1
17	7.5	No	Yes	1
16	7	No	Yes	1
15	6.5	No	Yes	1
14	6	No	Yes	1

Rumble strips should be placed where there is a paved shoulder. To maximize lane and shoulder widths, consideration should be given to use of a rumble stripe where the edge line is placed over a portion of the rumble strip.

The recommendations would result in an increase in the number of miles of edge lines. However, this increase in miles of striping would be offset by decreasing the number of miles that are restriped each year based on data that show many lines which are still acceptable are currently included in striping projects. The recommendations are consistent with current guidelines for the use of centerline markings which allow use when the lane width is at least eight feet and require use when the lane width is nine feet or more (with a minimum volume).

6.0 REFERENCES

1. Manual on Uniform Traffic Control Devices, 2003 Edition, U.S. Department of Transportation, Federal Highway Administration.

2. Sun, X.; Park, J.; Tekell, V.O.; and Ludington, N.; "Evaluation of Pavement Edge Lines on Narrow Highways with Low Traffic Volume in Louisiana, Transportation Research Board Record 1989, 2007.

3. Tsyganov, A.R.; Machemehl, R.B.; and Warrenchuk, N.M; "Safety Impact of Edge Lines on Rural Two-Lane Highways, Center for Transportation Research, The University of Texas at Austin, September 2005.

4. Tsyganov, A.R.; Machemehl, R.B.; Warrenchuk, N.M; and Wang, Y.; "Before-After Comparison of Edgeline Effects on Rural Two-Lane Highways, Center for Transportation Research, The University of Texas at Austin, November 2006.

5. Green, E.R.; Agent, K.R.; and Pigman, J.G.; "Analysis of Traffic Crash Data in Kentucky (2002-2006)," University of Kentucky, Report KTC-07-26, September 2007.

Table 1. Crash Rate by Lane Width*

Lane Width (Feet)	Mileage	ADT	Number Crashes	Rate**	Fatal Crashes	Rate**
7	883	413	1,112	278	12	3.3
8	4,128	478	6,346	293	99	4.6
9	11,037	956	29,774	258	520	4.5
10	4,228	2,290	25,873	244	390	3.7
11	1,285	3,830	11,668	217	159	3.0
12	1,623	5,731	14,609	143	232	2.3

* Crashes for three-year period of 2004 through 2006. Lane widths are approximate.

Table 2. Type of Crash by Lane Width

Lane Width (Feet)	Percent by Type of Crash*						Percent Nighttime
	Angle	Head-on	Rear End	SS-opposite	SS-same	SV	
7	9.3	6.0	3.7	16.0	1.6	60.5	28
8	9.1	4.8	6.2	12.6	2.2	61.8	31
9	12.8	3.9	10.3	8.1	2.9	58.4	28
10	15.1	4.2	18.6	6.2	3.7	48.1	26
11	18.1	3.7	27.7	4.4	5.0	35.7	25
12	19.8	3.9	30.1	4.1	6.1	30.9	24

* Based on “manner of collision” code in CRASH; SS-sideswipe; SV-single vehicle.

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