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16. Abstract (Limit: 200 words)

This project sought to understand the effects of warning flashers on the safety of rural intersections. Researchers conducted four separate studies: a literature review; an opinion survey of a sample of Minnesota motorists who lived outside urban areas; an analysis of accident data for rural intersections comparing accident rates three years before and three years after the installation of various configurations of warning flashers; and a field study at the intersection of U.S. 14 with MN 52 in Eyota, Minn. This last study included a baseline period, followed by a phased implementation of various warning flasher configurations, with a week or so between phases.

Researchers concluded that none of the four studies unequivocally supported the effectiveness of warning flashers at rural intersections in promoting safety at rural intersections. While driver alertness or awareness to potential hazards at the intersection may have been enhanced by the installation of warning flashers, this project did not provide data that would demonstrate such enhanced alertness or awareness.

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Warning Flashers at Rural Intersections

Final Report

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Executive Summary

The project, "Warning Flashers at Rural Intersections," was sponsored by the Minnesota Department of Transportation and performed jointly with the University of Minnesota. The objective of this project was to understand the effects of flashers on the safety of rural intersections. Four separate studies were done to meet this objective. First the literature relevant to flashers at intersections was reviewed and analyzed. There was little published work directly bearing on the objective for this project and the results were not in agreement from report to report. Effects suggesting that flashers improved safety were small such as speed reductions of three miles per hour (mph) in approaching an intersection on a through road where the intersecting road had a stop sign.

The second study was an opinion survey of a sample of Minnesota Motorists who lived outside urban areas. This survey showed that while drivers in general understood that flashers near or at an intersection implied potential danger, there were troublesome misconceptions. One such misconception was that some drivers believed that an overhead flasher implied a four-way stop at the intersection when in fact only one road had stop signs. An additional interesting finding from the survey was that there were some clear age-related differences between younger and older drivers.

The third study was analysis of accident data for rural intersections comparing accident rates three years before and three years after the installation of various configurations of flashers. Because accidents are infrequent, it is difficult to demonstrate large effects. The analysis presented here did not strongly support the effectiveness of flashers at rural intersections.

The final study was done in the field at Eyota, MN at the intersection of US 14 with MN 42. This study was hampered by the theft, vandalism and failure of the sensors used to measure traffic counts and traffic speeds as well as by a resurfacing project. In this study there was a baseline period followed by a phased implementation of various flasher configurations with a week or so between phases. There was insufficient data for the road with the stop sign to demonstrate potential effects from flashers. For the through road, US 14, the changes in speed caused by the flashers were very small for all configurations. This finding held for drivers at or above the speed limit of 55 mph as well as for those below the speed limit.

We concluded that none of the four studies unequivocally supported the effectiveness of flashers at rural intersections in promoting safety at rural intersections. While driver alertness or awareness to potential hazards at the intersection may have been enhanced by the installation of flashers, this project did not provide data which would demonstrate such enhanced alertness or awareness.

Introduction

This project which was concerned with the efficacy of flashing lights at rural intersections has several parts which were reported previously. Brief summaries of these earlier reports are included in the text of this report with supporting information documented in the appendices. The field study is the center of attention in this report. The field study in Eyota, Minnesota was not previously reported. This study used the phased introduction of five configurations of flashing lights at the Eyota intersection.

Objective

The objective of this project was to add to the understanding of the effects that flashing lights have on traffic safety at intersections. During the course of this project the potential effects were narrowed to rural intersections at which two lane roads intersected at right angles and there was a through road and an intersecting road with stop signs. The project focused on three flashing light installations: 1) A pedestal mounted yellow flashing light at the sign warning that there was an intersection ahead, 2) A pedestal mounted red flashing light at the stop sign, and 3) An overhead light flashing yellow in both directions for the through road and flashing red for both directions on the intersecting road with stop signs.

Literature Review

The project began with a survey and analysis of the relevant literature. This annotated literature review is Appendix A. This review covered published papers which fell in the following categories: Lighting at Rural Intersections, Pavement Markings and Rumble Strips at Rural Intersections, Sight Distance and Visual Field at Rural Intersections, Traffic Signals at Rural Intersections, and Traffic Signs at Rural Intersections.

From this literature review some conclusions were made on the state of the art in rural intersection traffic research. The works and methods [1] of Bruede, U., & Larsson, J. in 1992, from the National Swedish Road & Traffic Safety Research Institute, [2] Lyles, L. W. in 1980 from the Maine University Social Science Research Institute, and [3] Pant, P. D., Park, Y., & Neti, S. V. (1992) from Cincinnati University's Department of Civil and Environmental Engineering appear to be protocols likely to be influential in this project. In [4] Mounce, J.M. in 1981, placed an interesting emphasis on means of influencing drivers' behavior.

Additionally, [5] Pline, J. L. in 1988 appears to have produced a greater awareness of the US Manual on Uniform Traffic Control Devices' ambiguity or lack of standardization in addressing the traffic control device needs of rural motorists and may have been the stepping stone for research such as ours regarding such significant problems as uniformity of flashers at rural intersections.

Opinion Survey

A mail survey was conducted for obtaining drivers' opinions on the effectiveness and meaning of flashing lights at rural intersection. There were 144 respondents consisting of older and younger drivers of both genders. There were 25 questions in the survey and the results for each of these questions was presented. Specific conclusions relevant to each question are given in Appendix B which contains the survey, the results, and a discussion of the results.

The major conclusion drawn from this survey was that for most drivers, all the flashing light configurations used at rural intersections have the desired effect. That is, they warned drivers that the intersection they were approaching was potentially more dangerous than an intersection without flashing lights. This finding did not show that drivers responded to flashing lights by reducing their speed *because of the flashing lights*. Rather this finding implied that traffic engineers should be parsimonious in the use of flashing lights. If there were flashing lights at all rural intersections, they might lose their value in warning of particularly dangerous intersections.

A secondary, and less pleasing, conclusion that was drawn from this survey was that many drivers misconstrued the meaning of the flashing lights used in some configurations. Some of these misconceptions could well be the cause of some the accidents which occurred at rural intersections.

The final conclusion we could draw was that there were a few striking age differences in the interpretation of flashing lights. Although neither age group was consistently correct in interpreting the meaning of flashing lights at intersections.

This survey data failed to provide a uniform preference for a particular configuration of flashing lights. Given the usually slight differences of opinion for any particular configuration as well as the differences in opinion based on age, the survey data cannot uniformly support even the use of flashing lights in any configuration compared to not using flashing lights at all. There was always some amount of disagreement among the respondents. This outcome implies that traffic engineers should be concerned with providing the greatest good for the greatest number while at the same time urging the adoption of means for better educating the driving public to the meaning of flashing lights at rural intersections and correct responses to flashing lights.

Intersection Accident Analysis

An analysis of accident data was done comparing accident rates and total accidents at rural Minnesota intersections. The analysis was based on accident experience three years before and three years after the installation of flashing lights. Twelve intersections were examined. Each met the MnDOT Technical Advisory Panel definition of rural intersection. The definition established was: 1) All intersections must be four-way and intersect perpendicularly, 2) Average Daily Traffic (ADT) less than 12,000 vehicles, and 3) Only two-way stop intersections - no four-way stops.

The accident data tables and the presentation of the results are in Appendix C.

Field Study

Introduction

A resurfacing project and a desire by District 6 of the Minnesota Department of Transportation to improve safety at an intersection in Eyota, Minnesota enabled the experiment. The intersection was US 14, an east-west through highway, with MN 42/Olmsted County 7 which is the north-south Highway. MN 42/Olmsted 7 (a single roadway whose name changes) has stop signs at their intersections with US 14. MN 42 is north of US 14 and Olmsted County 7 is south of US 14. Methods

Description of Experiment

The objective of the experiment was to measure the effect on drivers' behavior of five flashing light configurations. Driver's behavior was measured by recording changes in drivers' speeds as they approached the intersection. The speeds were recorded for each of the five flashing light configurations. Data was collected for one or more weekdays for consecutive 30 minute intervals. No data was collected for at least one week following the change of a flashing light configuration. Speed and traffic counts were measured by NuMetrics NC-90A™ magnetic sensors placed on the roadway surface well in advance of the intersection and near the intersection (see Figure 1 for a diagram of sensor locations). Three sensors were place on US 14 west of the intersection at 100 feet (for effect of overhead flasher), 600 feet (for effect of pedestal flasher at the warning sign) and 1100 feet (approach speed unaffected by flashing lights or the warning sign) from the intersection. On MN 42 two sensors were placed 1500 feet (approach speed)and 100 feet (effect of pedestal flasher at the stop sign) before the intersection.

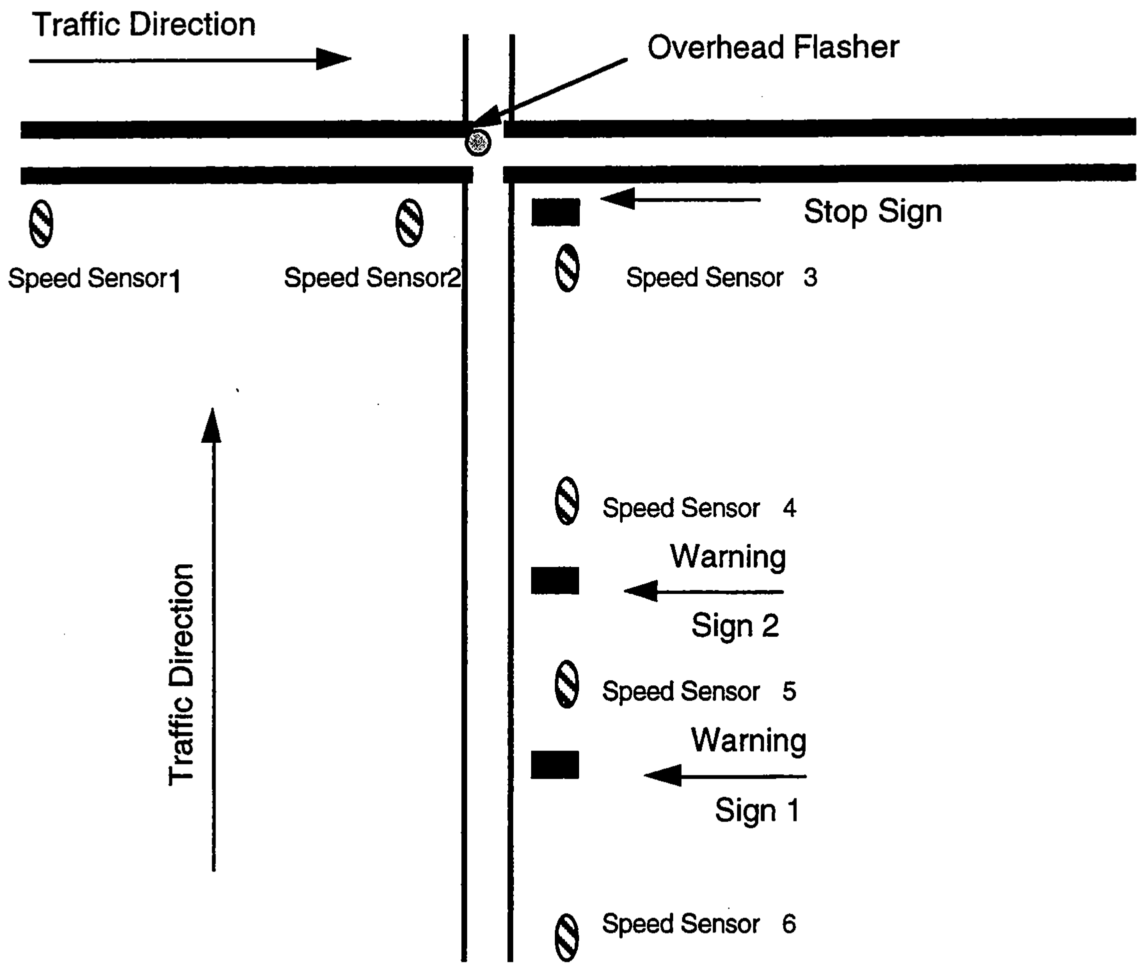

Figure 1. Locations of magnetic sensors for traffic speed and volume measurements.

Flashing Light Configurations

There were three locations for the flashing lights: 1) at the intersection ahead warning sign on US 14 (pedestal mounted); 2) at the stop sign on MN 42 (pedestal mounted); and 3) overhead at the intersection. Five flashing light configurations were used. The pedestal mounted lights always flashed red at the stop sign and yellow at the intersection warning sign on US 14. The overhead light flashed red for MN 42 and yellow for US 14.

1. Baseline. No flashing lights at any location.
2. Both pedestal lights. Yellow flashing lights were turned on over the warning sign on US 14 and red flashing lights over the stop sign on MN 42.
3. Only Overhead lights. The lights flashed yellow for US 14 and red for MN 42.

4. Overhead and Red Pedestal lights. Yellow flashing lights and intersection warning sign removed.

5. All Flashers turned on, warning sign replaced with pedestal yellow flashers turned on and red pedestal flashers turned on at stop sign as well as the overhead flashers.

Descriptive statistics for the data collected for each of the conditions will be analyzed and tabulated so that comparisons among flashing light configurations can be made.

Results

The experimental plan called for a complete design in which data would be collected from each sensor for the baseline condition and each of the flasher configurations. Vandalism, sensor theft and sensor failures reduced the amounts of data which were actually collected. Thus the results were not complete and not all comparisons which were planned could be made. This will become clear from the data shown in the following. Frequency histograms showing vehicle speeds for each of the conditions for which measurements were made are shown in Appendix D.

The usual reason that flashing lights were installed at rural intersections was to reduce the speed of traffic approaching the intersection and to increase motorists awareness of potential danger at the intersection. Table 1 shows the effect of flashing lights on reducing the speed of eastbound traffic on US 14 as it approached the intersection with Minnesota 42. The posted speed limit was 55 mph. For each condition the speeds of about 1,000 vehicles were recorded. Speed reduction for the baseline condition was presumably due to random fluctuations in the data or to the presence of the intersection since no flashing lights were installed.

Table 1. Percent of vehicles exceeding 55 mph on US 14 approaching MN 42.

	100 feet	600 feet	1100 feet
Baseline	36%	--	32%
Overhead	40%	37%	25%
Pedestal	24%	27%	29%
All Flashers	--	46%	30%

In Table 2 the average speeds and speed standard deviations are shown along with the differences between the average speeds for the baseline conditions and the average speed for each of the flasher conditions.

Table 2. Mean speed (mph),standard deviation and speed reduction from the baseline, US 14.

	100 feet	600 feet	1100 feet
Baseline Mean	53 ± 11	--	55 ± 7
Overhead Mean	53 ± 11	55 ± 8	53 ± 7
Overhead Change	-1	+1	-1
Pedestal Mean	50 ± 12	53 ±8	54 ± 7
Pedestal Change	+4	-1	0
All Flashers Mean	--	56 ± 8	55 ± 7
All Flashers Change	--	+2	+1

(The rows labeled "Change" show the differences between the Baseline mean values and the mean values for the various flasher conditions. The mean of the two Baseline values was used to obtain the differences.)

Much more data was lost for MN 42. The data which was collected is only for the baseline condition and this is shown in Tables 3 and 4 which correspond to Tables 1 and 2 for US 14.

Table 3. Percent of vehicles exceeding 55 mph on MN 42 approaching US 14.

	100 feet	1500 feet
Baseline	0%	21%

Table 4. Mean speed (mph) and standard deviation for the baseline condition, MN 42.

	100 feet	1500 feet
Baseline	6 ± 5	53 ± 9

Discussion

In the introductory and results sections we have presented four lines of evidence concerning the effectiveness of flashing lights at rural intersections; 1) Findings published in the literature, 2) The survey conducted as a part of this project, 3) The analysis of accident data before and after the installation of flashers and 4) The results from the field study at Eyota, MN.

Literature Review

In the part of the literature review pertaining there were few papers relating to the effectiveness of flashing lights at low volume intersections and the findings were mixed. Benioff [1] and [2] found that flashers did not provide effective control on major roads and only a slight degree on control on the minor road with a stop sign. By contrast Pant [7] found that flashers were not effective in reducing stop sign violations on the minor road but were effective in reducing accidents on the through road. Cribbins [5] found a significant reduction in property damage at low volume intersections based on the introduction of flashing lights. Cribbins [5] also noted that there were few data on the effects of flashers. In a survey of state highway departments Bonneson [3] found that 74 percent of them used flashing lights at some low volume intersections; effectiveness was not reported. Lyles [6] found that flashers at warning or stop signs reduced drivers' speeds by an average of three mph. Lyles [6] also found that flashers increased drivers' sign recall and recollection of a vehicle parked on the side road near the intersection. This was interpreted to mean that flashers increased drivers' awareness of the properties of the intersection.

Opinion Survey

The survey results yielded some surprises in the form of misconceptions about the meaning of flashing lights at a rural intersection and also in the finding that there were, in some cases, pronounced differences in the opinions of younger and older drivers.

When asked the meaning of a warning sign without flashing lights on a main road, the majority of respondents correctly stated that drivers should simply be especially careful when approaching the intersection, that cross traffic is not usually heavy and that they will not need to stop at a stop sign. More older than younger drivers stated that the warning sign means that drivers should reduce speed. In comparing the effectiveness of a warning sign with a flasher and a warning sign without a flasher the great majority stated that the meanings were the same; to reduce speed. However, many older but not younger drivers felt that the warning sign with a flasher implied that cross traffic did not stop (one in five older drivers). If the warning sign does not have a flasher, one in five drivers believed that cross traffic does not stop. Older drivers are much more convinced than younger drivers that cross traffic does not stop if the warning sign has a flasher but there is no overhead flasher. Very few of either age believe this if there are flashers at both the warning sign and overhead. When there are flashers at both the warning sign and overhead about one-half of the drivers believe that the intersection is especially dangerous. However, 50 percent more older drivers than younger drivers believe that flashers at both locations mean that the intersection is especially dangerous. For any of these conditions only one percent to four percent of the respondents believe that cross traffic must stop. For these three conditions, drivers have the correct general idea that flashers mean that they are approaching an intersection which could be hazardous. However, some drivers in both age groups entertain certain incorrect notions.

The comparisons for approaching the intersection from the side road are of respondents ideas about: 1) Stop signs only; 2) Stop signs with flashers; and 3) Stop signs with flashers and with overhead red flashers. A worrisome finding for all three conditions and both age groups was that from eight percent to 22 percent believed that a four-way stop was implied. For younger drivers the belief that the intersection is a four-way stop decreases as the number of flashing lights decreases from two flashers to one to none. Just the reverse was true for older drivers who believed that the intersection is a four way stop increased as the number of flashers increased. It is not clear why any drivers believe that the intersection is a four-way stop, however, the older drivers' misconception is easier to rationalize than that of the younger drivers.

In a separate question the majority of drivers correctly stated that the flashers indicated that the intersection was especially dangerous in that there was heavy cross traffic. This result did not agree with the findings just described. Why the responses to this question disagreed with the responses described in the preceding paragraph could not be determined.

In general, the survey respondents correctly identified the purpose of flashing lights at a rural intersection. There were some striking age-related differences in specific interpretations of the meaning of flashers. Some of these misinterpretations could well lead to accidents.

Accident Data

The accident data did not offer convincing support for a strongly positive effect following the introduction of either pedestal mounted or overhead flashing lights at rural intersections. One of the difficulties is using the occurrence of accidents as a dependent variable is the rarity. Accidents at the intersection studied occurred on the order of once in a million crossings. Thus, if over the course of three years the number of accidents decreased from say twelve to six, then while this is a 50 percent reduction it is still just a decrease of two accidents a year. Changes of this size are difficult to attribute to a single factor such as the installation of flashing lights.

Eyota Field Study

The results from the field study, while limited, show that on the main road, US 14, flashers had no effect in reducing speeds. Whether or not drivers were made more alert, as was suggested by Lyles [6], cannot be determined from the data collected at Eyota. The results show that the higher speed drivers, 55 mph or greater, were not differentially affected in terms of speed reduction. The overall changes in speed related to any flasher condition compared with baseline values were minuscule. The impending intersection alone (no flashers) resulted in substantial decreases in speed which could be attributed to either the warning sign or prior knowledge of the location of the intersection or both.

In summary, the field study results did not support hypothesis that flashing lights would reduce speeds on the main road approach to the intersection.

Conclusion And Recommendations

Neither the published reports, nor the opinion survey, nor the analysis of accident data, nor the field study unequivocally supported the effectiveness of flashers at rural intersections in promoting safety at rural intersections. While driver alertness or awareness to potential hazards at the intersection may have been enhanced by the installation of flashers, this project did not provide data which would demonstrate such enhanced alertness or awareness.

A recommendation for more research is customary. We recommend that if more research on the effectiveness of flashing lights at a rural intersection is contemplated it should be conducted in a situation such as that reported here at Eyota, MN. That is at a location permitting the phased installation of various configurations of flashing lights without any other changes occurring at the intersection or the roads approaching it. If sensors cannot be found which are highly reliable and proof against theft and vandalism, then the data collection should be done by people. High quality data for each conditions, even if limited in amount, would be preferable to large volumes of data for a few conditions and no data for other conditions.

We would also recommend that thought be given to the inclusion of a cost benefit analysis which would include such hard to estimate factors as the value to local citizens of having the highway department respond to their concerns about what they perceive as a dangerous intersection.

Finally we suggest that in drivers education courses and perhaps in *55 Alive* courses sufficient attention should be paid to explaining the meaning of flashers of different kinds placed at different locations sometimes in conjunction with signs.

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[9] **Bonneson, J.A., McCoy, P.T., and Truby, J.E. Jr. (1993**). "Safety improvements at intersections on rural expressways: a survey of state

departments of transportation." *Transportation Research Record* No. 1385, Intersection And Interchange Design, pp 1-47.

Appendix A

Literature Review for Flashers at Rural Intersections

Introduction

The following notes on the literature take the form of a categorized and annotated bibliography. All notes have been alphabetically entered by author into five categories where a category is based on similarities of the work performed.

We have made use of author abstracts or other author created material in addition to our own comments and summaries. We will use only this general attribution to the authors rather than using quotation marks or other means of showing which material was transcribed directly from the authors' work.

Background

Rural intersections in Minnesota generally do not warrant standard traffic light signal installations for two reasons. Firstly, economic limitations preclude putting full function traffic lights at every intersection. Secondly, putting a full function traffic light at every intersection would result in over-control with consequent loss of drivers' time and the promotion of scoff-law behavior. With this in mind we find that many rural intersections are equipped with flashers. Flashers are similar to regular traffic lights but they are meant to flash repeatedly in one state. This usually means they are constantly flashing yellow (to tell motorists to approach with caution on the major street) or red (the equivalent of a stop sign on minor streets). Rural roads have relatively light traffic flow and motorists approach intersections at high speeds. Confusion on what the current state of lights signify at these intersections has led to tragic results. This confusion has a number of causes including the lack of standardization of flashers and their use in different contexts. To illustrate the problem with varying contexts, consider that during power failures the regular traffic lights in most towns will automatically default to the red flasher mode. This means the intersections has a four-way stop. Urban motorists who are used to this, on leaving the town environment, might expect that the same situation exists when they see the red flashers in a rural setting, even though the rural red flashing light actually signifies a two-way stop. Such motorists on a minor road would operate under the false impression that approaching motorists from the major road will also stop at the intersection lights.

Previous flasher designs include overhead flashers (which can function in wig/wag mode or include other signs) and pedestal mounted flashers (may include various types of signs and be located at varying distances from the intersection).

The decision on what type of flasher to use is currently somewhat arbitrary and few design standards are available. The Manual on Uniform Traffic Control Devices for instance only gives very broad outlines, leaving much open to interpretation of the individual manufacturers. The proposed research intends to address these limitations by proposing standards for flashers on rural intersections based on video and simulator studies.

The following annotated bibliography is provided to establish a scope of not only the investigations and research regarding the inconsistencies in flasher design, placement, etc. at rural intersections but also to give an idea of current means of investigating rural intersection safety. A few studies may be regarded as rural intersection protocols and may serve as models for simulator studies.

Bibliography Categories

Five categories were selected from Lay, M. G. (1986). Handbook of Road Technology: Volume 2 - Traffic and Transport as independent measures of driver behavior and safety and are couched in the context of rural intersections. The handbook, prepared for use by professional transportation practitioners, postgraduate students, and academic persons working in the field, was selected as a reference based both upon its detailed theoretical and practical analysis of significant independent measures of driver behavior and its emphasis on driver safety measures. The handbook does not solely address issues pertaining to rural intersections but within each chapter pertinent issues relevant to rural intersections are discussed.

The five categories are:

- Lighting at Rural Intersections
- Pavement Markings and Rumble Strips at Rural Intersections
- Sight Distance and Visual Field at Rural Intersections
- Traffic Signals at Rural Intersections
- Traffic Signs at Rural Intersections

The following is intended to provide general information regarding the five categories presented in the annotated bibliography which follows:

1) Lighting

The general concept of road lighting design is that the road environment and objects in it need to be made sufficiently visible to enhance traffic and pedestrian flows, mainly through increased volumes and greater safety. Lighting must display the carriageway ahead for tracking and navigating, reveal its surrounds and permit the detection of the presence, position and movement of other road users. Objects to be detected include pedestrians, parked cars, traffic control devices, moving cars, pavement edges and changes in road conditions.

Many of the arguments for traffic route lighting relate to a reduction in both the rate and severity of night-time accidents. There is general belief that road lighting can reduce injury accidents by about 30 percent and that these savings more than offset the cost of the lighting. However, the relationship between increasing light levels and accident rates will follow a line of diminishing returns.

On an exposure basis, a disproportionate number of accidents occur at night and are, on the average, more severe than daytime accidents. This increased fatality rate can be attributed to the increased severity of multi-vehicle and pedestrian accidents, but not of single vehicle accidents. Multiple vehicle accidents are twice as likely to result in a fatality at night than by day and pedestrian accidents are four times more likely to be fatal at night.

Although part of this pattern can be attributed to the poorer visual conditions at night, we must also recognize that social habits mean that driver alcohol levels, for instance, will be high at night, thus making driving markedly more hazardous in a manner that cannot be aided by lighting levels. We also note that the lighting poles themselves constitute a significant traffic hazard.

The ideal design would start with an examination of the driving task, leading to a determination of its important visual components and an understanding of how visibility was influenced by road lighting. In practice, however, only simple visual components can be analyzed. Attempts made to relate lighting levels to car-following behavior as a performance measure have not been successful. It is therefore necessary to examine the role of lighting in a more pragmatic fashion.

2) Pavement Markings and Rumble Strips at Rural Intersections

Markings are applied to pavements to guide, warn or regulate traffic. They may be used to supplement traffic signs or signals or to act in a "stand-alone" mode. As with traffic signs, the basic requirement for pavement marking is that drivers should be able to interpret its meaning in sufficient time to properly react to its message.

The visibility of pavement markings in most cases is determined by the contrast between the marking and the adjacent portion of the road surface. Both of these areas will be equally illuminated. The luminance contrast is thus exclusively determined by the difference in the reflective properties of the road surface and the pavement marking. Color contrast may also improve the conspicuity of pavement markings.

Pavement markings suffer from the following limitations:

1) They may not be clearly visible, e.g. in the wet or in dusty or sonw or ice cover conditions or at night (unless reflectorized). At night the headlight beam of a vehicle will be incident on the pavement marking at a low angle to the pavement surface and so will provide relatively low illumination of the marking. In this respect rough surfaces will be better than smooth.

2) They wear under traffic and require frequent maintenance.

3) They can be obscured by traffic.

4) They may lower skid resistance.

5) They cannot be applied to unsurfaced roads.

6) They carry less informative messages than do signs.

However, pavement markings have the major advantage of conveying continuous information within the driver's direct field of vision. The need to make markings as large as possible to ensure adequate visibility can be seen to be counteracted by pressures under (2) and (4) above, and by cost pressures, to minimize their total area.

3) Sight Distance and Visual Field at Rural Intersections

Sight distance is defined as the distance at which an attentive driver can see a specified object ahead of him, given clear, well lit conditions, good visual acuity and the object centrally located in his field of vision. There are six main types of sight distance. Our concern is Intersection Sight Distance which provides vehicles stopped at an intersection with sufficient sight distance for them to cross the intersecting road safely. For detailed discussion see Chapter 19 "Road Geometry" and Chapter 20, "Intersections" in the handbook.

Rumble strips are areas of coarse or grooved pavement surfacing, often intermittently spaced in the direction of vehicle travel. This technique relies for effectiveness mainly on the sound and vibration transmitted into the car and thus is less aggressive, and used for less critical trespassing, than a jiggle bar (which is louder and more jolting). Rumble strips must raise noise levels within a car by about 6 dB to be effective. They can be highly effective, both to warn straying vehicles as well as to slow down vehicles approaching potentially hazardous rural intersections.

One of the reasons for the effectiveness of rumble strips appears to be that drivers react more quickly to audible than visual signs. In addition, the device does not interfere with the motorist's visual functioning. For this reason, rumble strips are sometimes used to give advance warning of a visual signal.

4) Traffic Signals at Rural Intersections

Traffic signals are devices which, by means of changing colored lights, regulate the movement of traffic. They are appropriate control devices to alleviate:

1) excessive delays at Stop or Give Way signs

2) problems caused by turning traffic