*Abridgment*

# Effect of Illumination on Rural At-Grade Intersection Accidents

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The at-grade intersection has been recognized as one of the more hazardous elements of the rural highway system. This is substantiated by the fact that 15 percent of fatal rural accidents and 25 percent of all rural accidents occur at intersections (1). The intersections, however, account for only a small portion of the total rural highway mileage. Further analysis of highway accident statistics reveals that the nighttime period is much more hazardous for the motorist (2, 3).

The installation of roadway lighting at rural intersections can potentially reduce the higher levels of hazard at these locations. The highway engineer, however, must weigh the benefits of lighting against other intersection safety improvements such as channelization, delineation, signalization, or geometric changes. To make such decisions, the engineer should know the probable benefits to be gained from the installation of lighting. The literature contains diverse reports regarding the benefits of roadway lighting; thus, an examination of the effect of illumination on accidents was undertaken as part of a study of warrants for rural at-grade intersection illumination in Illinois. The discussion that follows summarizes the research associated with the accident study (4, 5).

## STUDY METHODOLOGY

A review of previous studies indicated that, in addition to illumination, variables such as traffic volumes, intersection geometry, traffic control devices, and channelization all have a significant effect on accidents. Thus, any research method directed toward isolating the relation between illumination and accidents has to be designed to control the effects of many important variables other than illumination.

The method of analysis used in this study compared lighted and unlighted intersections on the basis of accident experience. Initially, seven measures of accident experience were actually considered: (a) night accidents per year, (b) day accidents per year, (c) total accidents per year, (d) ratio of night accidents to total accidents per year, (e) night accident rate, (f) day accident rate, and (g) total accident rate. For the measures that indicated an accident rate, the rate was calculated on the basis of the number of accidents per million vehicles through the intersection.

While all seven measures were subsequently analyzed in the study, measures that compared day and night accidents in terms of ratios were more valid for this study. In this case, the ratio of night accidents to total accidents was used. The use of the ratio greatly reduces the possibility of error since the decision to install lighting was not randomized. The ratio measure is far less sensitive to variables such as good geometrics, which might be systematically related to illumination, than to illumination per se.

## DATA COLLECTION

The data base used to measure the relation between illumination and accident experience consisted of data collected at rural at-grade intersections in Illinois. The intersections included in the sample were selected from a list of rural intersections on U.S. and Illinois state highways. For each location, information was collected that pertained to illumination conditions, physical characteristics, traffic volume data, and accident data.

For the purpose of the study, guidelines were developed to decide which rural intersections in the state would qualify as unilluminated intersections. Only the major unilluminated intersections were sampled and were identified by referring to intersection average daily traffic and geometrics, type of traffic control, and vertical and horizontal alignment. Each intersection year was used as the basic element for analysis. The final sample contained 445 intersection data years with 263 lighted intersection data years and 182 unlighted intersection data years.

The intersections in the sample were categorized according to (a) presence or absence of illumination or (b) presence or absence of channelization. Depending on how the intersection's characterization matched the two di-

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Table 1. Mean values of accident measures before and after illumination.

| Measure | Before | After | Change (%) |
|---|---|---|---|
| Night accidents per year | 1.96 | 1.67 | -15 |
| Day accidents per year | 3.61 | 3.89 | +5 |
| Total accidents per year | 5.56 | 5.55 | -1 |
| Night accident/total accident ratio | 0.330 | 0.258 | -22 |
| Night accident rate | 0.224 | 0.124 | -45 |
| Day accident rate | 0.204 | 0.151 | -26 |
| Total accident rate | 0.222 | 0.144 | -35 |

chotomous factors, each intersection was placed in one of four groups. Channelization is frequently used in connection with rural intersection improvements, and illumination and channelization improvements are frequently undertaken at the same time. Because of the effect channelization has on the roadway environment, it was included as a variable in the analysis.

## ANALYSIS OF RESULTS

The analysis of variance test examined the relations between the two independent variables (lighting and channelization) and the seven dependent variables (accident measures). The test also measured the effects of interactions between the independent variables. An analysis that contained computed means and levels of significance revealed all the significant relations between each of the seven dependent variables and the following combinations of independent variables:

1. The effects of lighting versus no lighting,
2. The effects of channelization versus no channelization, and
3. The interaction between the effects of lighting and channelization.

The initial test determined if there were significant differences between lighted and unlighted intersections as measured by the seven dependent variables at the 10 percent level of statistical significance. The night accident/total accident ratio, night accident rate, day accident rate, and total accident rate had significantly better accident statistics for the lighted intersections. Of these four, only the day accident rate yielded results that were unexpected; lighting reduces the day accident rate. It was concluded that the unsystematic distribution of lighting to intersections that may have unusual geometric conditions, high traffic volumes, or other peculiar characteristics could be responsible for this unusual result.

Table 1 gives the percentage change in accidents for the seven measures. The largest decrease in accidents is in the night accident rate, which is 45 percent lower for illuminated intersections. The 26 percent decrease in the day accident rate can again be attributed to the unsystematic distribution of lighted intersections.

Although analysis of the interactions between lighting and channelization did not prove to be significant, there were differences in the accident measures for combinations of these two variables. The mean night accident/total accident ratio for lighting and channelization conditions indicates that when both lighting and channelization are present the night accident/total accident ratio (0.238) is lower than for either lighting without channelization (0.277), channelization without lighting (0.306), or no lighting and no channelization (0.354). Thus, the simultaneous introduction of channelization and illumination at locations experiencing a high number of night accidents should be encouraged. Because of the nature of the sample, however, it is impossible to draw a conclusion regarding this interactive effect.

The above analysis illustrates the importance of isolating the effects of illumination so that the effectiveness of rural lighting programs can be measured. Only two of the seven dependent variables, night accident rate and night accident/total accident ratio, serve as potential measures of lighting effectiveness. Of these two, the night accident/total accident ratio is the most reliable because it measures changes in accident totals that are related directly to differences in visibility conditions and accounts for variations in traffic volumes. Also, this statistic is easier to compute since night traffic volume estimates are not needed.

When the data are analyzed by using the two dependent variables that can account for differences due to lighting, the beneficial effects of illumination are seen. Thus, the intersections with lighting proved to have significantly better accident statistics than those intersections without lighting. The magnitude of reduction, from 22 to 45 percent for the various measures of effectiveness, indicates that the installation of illumination improves the night driving environment and reduces hazards at locations that have experienced a high total of night accidents.

## CONCLUSIONS

This study serves to further validate the general safety benefits that may be derived from the use of illumination at rural at-grade intersections. Furthermore, it substantiates the increased levels of hazard that are associated with rural at-grade intersections during the nighttime period. Based on this study, it may be concluded that

1. Night accidents are significantly reduced at rural at-grade intersections when illumination is installed (the magnitude of reduction varies with the dependent variable that measures accident experience);
2. The night accident rate and the night accident/total accident ratio are significant measures of accident experience when the influence of illumination on night accidents is considered;
3. Illumination results in a 45 percent reduction in the night accident rate and a 22 percent reduction in the night accident/total accident ratio; and
4. Other safety improvements of rural at-grade intersections may reduce both the day and night accident potential at these locations (channelization and illumination together can result in a greater combined reduction in accidents, and thus the implementation of illumination along with other improvements should be encouraged at high accident locations).

It must be recognized that the figures presented in this paper are generalized values and represent the influence of illumination. If illumination is applied to a number of intersections, these values could be expected for the composite group. However, some variation could be expected for the individual intersections since the degree of reduced visibility contributes to the cause of accidents.

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