Relationship of Roadway Lighting and Traffic Accidents

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Sufficient reliable documentation is available to support the assumption that nighttime traffic accident rates are considerably higher than daytime. The National Safety Council has determined that on a mileage basis the accident frequency at night in urban areas is 3 times that during the day, and in rural areas it is 2½ times higher. A study in Great Britain revealed that the ratio of accidents in darkness to those in daylight is about 3 to 4. Countless other studies made in cities throughout the country illustrate the disproportionate number of accidents at night.

There are many reasons for this unbalanced night accident rate. The following are but a few of the factors which cause driving at night to be hazardous.

1. The average person is poorly equipped to see adequately at night. This problem becomes more serious as one grows older. For example, the glare resistance of the over 65 years of age driver is one-third that of the 25-year-old motorist (1). Persons at 60 years of age require eight times as much light as those at 20. Therefore, many of the driving assignments involving such factors as speed and roadway conditions become more difficult and hazardous to most drivers when confronted with darkness (2).
2. The physical condition of the average motorist must be recognized. Fatigue, drowsiness, influence of alcohol, and psychological aspects all have a definite influence on one's driving.
3. There is a lack of understanding by many motorists and pedestrians regarding the hazards of night driving. One study revealed that motorists drive faster in the dark than under roadway lighting or in the daytime (3).

The contribution of artificial illumination has been measured in many ways. Substantial reductions have been found in accidents and more significantly, in the serious or fatal rates. However, the degree of illumination necessary to bring about a satisfactory reduction in night accidents has not been scientifically derived. Nor is there an acceptable level of night-to-day accident ratio which would give assurance that proper steps have been taken to provide a safe night-driving environment.

Nevertheless, the provision for improved roadway lighting can bring about accident reduction by reducing some of the problems affecting the night driver. A study by the Texas Transportation Institute revealed that illumination reduces driver tension (4). Another interesting effect on roadway lighting concerns alcohol and the driver. Since an increase of alcohol level decreases the visual field, an increase in illumination through street lighting may be effective in reducing night traffic accidents caused by those under the influence of alcohol (5).

The Road Research Laboratory has established that the improvement of poor lighting can be expected to reduce all such accidents during hours of darkness by 30 percent. The results also have indicated that fatal accidents may be reduced by 50 percent, and those in which pedestrians are involved by 45 percent (6).

Thus, in summary, it is acknowledged that night driving is hazardous due to many variables. Although we cannot accurately predict the degree of accident reduction through varied levels of roadway illumination, evidence is available to substantiate night accident reduction due to various before-and-after studies.

TABLE 1

EFFECTS OF RELIGHTING ON NIGHT FATAL ACCIDENTS

Street	Miles Relighted Since 1952	Night Fatal Accidents	
		3 Year Average, Before	8 Year Average, After
Western Ave.	23.5	10.33	4.37
Halsted St.	14.3	7.33	6.12
State St.	9.6	9.67	2.75
Diversey Ave.	6.3	3.67	0.63
Roosevelt Rd.	5.8	5.00	2.12
Michigan Ave.	7.2	6.00	1.38
63rd St.	11.0	3.00	1.12

RESUME OF BEFORE-AND-AFTER STUDIES

The following studies contain valuable information illustrating to some degree the success several cities achieved by installing new or improved roadway lighting.

Chicago, Ill.

Street Lighting Modernization Program. Since 1952, the City of Chicago has embarked on a street lighting modernization program on 77.7 miles of arterial streets which comprise about 10 percent of the total Chicago arterial street system mileage. The lighting units were designed for an intensity of 2.0 ft-c. Table 1 gives the before and after results in traffic accidents. The average per year of night fatal accidents fell from 6.43 to 2.64; this represents a 59 percent reduction.

Michigan Boulevard. A study of the effect of illumination on the nighttime accident rate of Michigan Boulevard revealed a substantial accident reduction, and was directly related to the degree of illumination (7). Table 2 summarizes the results of this study.

Chicago Expressway Study. A two-year study was made of 50 miles of freeways in the Chicago Metropolitan Area (8). The night-to-day rates for all accidents ranged between 1.3 and 2.0 for the lighted freeways while the unlighted had a ratio of 3.1. The night fatal accident rate for the lighted freeways had an average of 3.6 as contrasted to 12.5 for the unlighted. At least 100 lives have apparently been saved as a result of the lighted freeways.

Detroit, Mich.

This study was made on Evergreen Road which is a major street in a residential area. It is 40 ft wide with parking on each side. Street lighting was improved in 1964. The section was 1 mile long with a 35-mph speed limit. The ADT before was 9046; after, 9744. Illumination before was 0.6 ft-c; after, 1.0 ft-c. Table 3 gives non-pedestrian accident experience for one year before and after the lighting improvement.

The reduction in nighttime accidents from the number of accidents that would be expected without the lighting improvement is 14 percent. The total number of night accidents was reduced from 33 to 18 for a one-year period.

TABLE 2

EFFECT OF ILLUMINATION ON NIGHTTIME ACCIDENT RATE

Section	Illumination (ft-c)	Night Accident Rate (per MVM)	Reduction[a] (%)
River to 12th St.	0.14	17.9	—
12th to 16th St.	0.35	11.9	71.5
16th to 22nd St.	0.88	9.5	71.7

[a]The actual reduction in nighttime accidents from the number that would be expected without lighting improvement.

TABLE 3

NON-PEDESTRIAN ACCIDENTS BEFORE AND AFTER IMPROVED LIGHTING

Accident	Before			After		
	Day	Night	All	Day	Night	All
Fatal	0	0	0	0	0	0
Injury	9	6	15	6	3	9
Property damage	30	27	57	19	15	34
Total	39	33	72	25	18	43

TABLE 4

ACCIDENTS BEFORE AND AFTER IMPROVED LIGHTING

Type	Before		After	
	Day	Night	Day	Night
Non-Pedestrian:				
Fatal	0	0	0	0
Injury	38	34	24	40
Property damage	100	94	124	60
Pedestrian:				
Fatal	0	0	1	0
Injury	6	6	5	6
Total	144	134	154	106

The 14 percent reduction is derived as follows:

B = Day accidents before improvement = 39
A = Day accidents after improvement = 25
b = Night accidents before improvement = 33
a = Night accidents after improvement = 18

In estimating the effect of lighting, R is designated as the ratio of the actual number of accidents in darkness after the lighting improvement to the number of night accidents expected if the improvement were not made. Thus,

$$R = \frac{\text{Number of night accidents after improvement}}{\text{Expected number of night accidents}}$$

The expected number of night accidents without improvement is calculated as $b\frac{(A)}{(B)}$.

Thus,

$$R = a \div b\frac{(A)}{(B)} = \frac{a}{b} \div \frac{A}{B}$$

$$R = \frac{18}{33} \div \frac{25}{39} = 0.86$$

Therefore, the reduction in night accidents attributed to the improvement is 14 percent.

Washington, D.C.

Benning Road, a major arterial street located in the eastern section of the city, had its street lights improved from 0.24 to 0.83 ft-c. There were no installation charges for this improvement in 1964 since it consisted only of relamping. However, street light energy costs for the 2-mile section increased $4074 per year. Before 1964, the lamps were 6000 lumen incandescent. They were replaced with 10,000 lumen mercury vapor lamps in new luminaires.

The safety results of this improvement indicated a 26 percent reduction in nighttime accidents from the number of accidents that would be expected without the lighting improvement.

Table 4 gives the actual number of before and after accidents.

Cincinnati, Ohio, Study

In an effort to get a more significant understanding of the value of improved roadway lighting to accident reduction, a comprehensive study was undertaken in Cincinnati by the National Highway Safety Bureau in conjunction with the Traffic Engineering Division of Cincinnati. This study was under the direction of Joseph Lema, Traffic Safety Specialist of the Bureau.

TABLE 5

ACCIDENTS BEFORE AND AFTER IMPROVED LIGHTING

Accident	Before			After		
	Day	Night	All	Day	Night	All
Non-Pedestrian:						
Fatal	0	0	0	0	0	0
Injury	2	0	2	2	1	3
Property damage	34	13	47	36	8	44
Pedestrian:						
Fatal	0	0	0	0	0	0
Injury	1	0	1	0	0	0
Total	37	13	50	38	9	47

TABLE 6

ACCIDENTS BEFORE AND AFTER IMPROVED LIGHTING

Accident	Before			After		
	Day	Night	All	Day	Night	All
Non-Pedestrian:						
Fatal	0	0	0	0	0	0
Injury	0	1	1	4	1	5
Property damage	50	16	66	47	11	58
Pedestrian:						
Fatal	0	0	0	0	0	0
Injury	0	0	0	0	0	0
Total	50	17	67	51	12	63

TABLE 7

ACCIDENTS BEFORE AND AFTER IMPROVED LIGHTING

Accident	Before			After		
	Day	Night	All	Day	Night	All
Non-Pedestrian:						
Fatal	0	1	1	0	1	1
Injury	4	5	9	11	4	15
Property damage	63	19	82	80	17	97
Pedestrian:						
Fatal	0	1	1	0	0	0
Injury	0	0	0	0	0	0
Total	67	26	93	91	22	113

TABLE 8

ACCIDENTS BEFORE AND AFTER IMPROVED LIGHTING

Accident	Before			After		
	Day	Night	All	Day	Night	All
Non-Pedestrian:						
Fatal	0	0	0	0	0	0
Injury	3	2	5	2	2	4
Property damage	18	7	25	23	2	25
Pedestrian:						
Fatal	0	0	0	0	0	0
Injury	0	0	0	0	0	0
Total	21	9	30	25	4	29

Paddock Road

A study of the relationship of safety and lighting was made along three sections of this roadway: Reading to Tennessee, Tennessee to Laidlaw, and Laidlaw to Seymour.

Reading to Tennessee. The section is 0.9 mile long and 44 ft wide with a 40-mph speed limit. The ADT before was 12,000; after, 10,000. Illumination before was 0.1 ft-c, after, 0.9 ft-c. Table 5 gives accident experience for one year before and after the lighting improvement. Reduction in nighttime accidents from the number of accidents that would be expected without the lighting improvement is 33 percent.

Tennessee to Laidlaw. The section is 0.7 mile long and 44 ft wide with 30 and 35-mph speed limits. The ADT before and after was 17,000. Illumination before was 0.15 ft-c; after 0.90 ft-c.

Accident experience is given in Table 6. The reduction in nighttime accidents from the number of accidents that would be expected without the lighting improvement is 31 percent.

Laidlaw to Seymour. The section is 1.0 mile long and 44 ft wide with a 40-mph speed limit. The ADT was 13,000 before; 12,500, after. Illumination was 0.1 ft-c before; 0.9 ft-c after. The accident experience for this section is given in Table 7. The reduction in nighttime accidents from the number of accidents that would be expected without lighting improvement is 38 percent.

Thus, as a result of increased illumination in foot-candles from 0.1 or 0.15, to 0.9, the night accidents have decreased 33 to 38 percent.

Combining these three sections, the resultant statistics are for daytime: 154 before and 180 after, a change of +17 percent; for nighttime: 56 before and 43 after, a change of -23 percent. The reduction in nighttime accidents from the number of accidents that would be expected without the lighting improvement is 34 percent.

Plainville Road. This study was made along a 0.7-mile stretch between Madison and Bramble. The width was 40 ft and the speed limit was 35 mph.

The ADT was 10,600 before and 10,400 after. Illumination was 0.15 ft-c before and 0.90 ft-c after. Table 8 gives the accident experience. The reduction in nighttime accidents from the number of accidents that would be expected without the lighting improvement is 63 percent.

COST-BENEFIT

Regardless of the cost of lighting, a careful study in accident experience before and after lighting improvement supports economic justifications beyond the initial cost of the project.

A recent study of nine highway locations in Virginia revealed the following:

Three year cost of night accidents before	$584,000
Three year cost of night accidents after	143,000
Annual savings in accident cost	134,000
Annual cost of illumination	14,000

A similar comparison can be made of the improved cost-benefit of street lighting on the several miles studied in Cincinnati. It was previously stated that a street lighting improvement was made on Paddock Road. On this 2.6-mile section, existing light posts were used, and an extension arm and light unit were installed at a cost of $100 per unit. The results of the cost-benefit analysis for one year before and one year after is as follows:

Total night accidents before improvement	56
Total night accidents after improvement	43
Annual savings in accident cost	$33,900
Cost of initial illumination installation	7,300

In a motor vehicle accident cost study in Washington, D.C., it was found that the average cost of involvements occurring during darkness ($760) was much higher than the average for those occurring during daylight conditions ($430). Where street lighting was provided, the average cost of involvements at night was only $550 compared with $1340 at locations without street lighting. This is another factor to be considered in the cost-benefit comparison (9).

ACCIDENT REDUCTION VALUE OF LIGHTING

The value of street lighting can be measured in many ways. In addition to providing peace of mind to the traveling public, it affords protection to pedestrians, reduces crime, enhances street appearance, and most importantly, reduces traffic accidents. While no exact prediction can be made in night accident reduction in terms of illumination provided, it becomes prudent for any city to consider a program of improved street lighting where a high night-to-day accident ratio exists.

The Highway Safety Act of 1966 concerns itself with the high number of traffic accidents at night. As a result, a standard has been established for roadway lighting. It provides for the following:

1. A planned program to provide or upgrade roadway lighting at the following locations:

   A. Expressways and other major arteries in urbanized areas.
   B. Junctions of major highways in rural areas.
   C. Locations or sections of streets and highways where the ratio of night-to-day motor vehicle accidents is more than 1.5 times the average ratio for similar locations or sections on the same system of roads and streets.
   D. Locations or sections of streets and highways with high night-to-day ratios of pedestrian accidents.
   E. Tunnels and long underpasses.

2. The American Standard Practice for Roadway Lighting shall be used as a guide for roadway lighting design.

CONCLUSIONS

Any city that wishes to reduce its traffic accident experience will find a practical solution in a program of well-planned roadway lighting. Ample evidence is available to illustrate a reduction in nighttime accident rates on major arterial streets. The standards published by the National Highway Safety Bureau offer a guide for a proper installation.

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