FINNISH ROAD ADMINISTRATION

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## IMPACT OF ROAD LIGHTING ON ROAD SAFETY AND DRIVING SPEEDS

This is an excerpt from a report on the impact of road lighting on traffic accidents on roads outside of population centres. In particular, the intent is to study lighting implemented without other measures. Cases where some other measure, such as a bicycle and pedestrian path, a junction upgrade or road improvement was implemented together with lighting were examined separately.

### Literature report on lighting safety studies

The literature report broadly examined primarily European and US reports and articles on the impact of road lighting on safety and speeds.

**Accident risk is clearly greater than average in the dark. Especially serious accidents and pedestrian accidents are emphasised at night**

- Several studies determined that the risk of a personal injury accident is 1.5 times greater in the dark than in daytime.
- The number of accidents resulting in death or serious injury is twice as high and in the USA, 3-4 times as high as in daytime.
- Several studies found that especially the share of accidents involving pedestrians increases in the dark.
- The share of single-vehicle accidents compared to multiple-vehicle accidents is emphasised in the dark.
- The literature contained very little mention of animal accidents.
- Several studies determined that darkness increases the number and seriousness of accidents more in rural areas than in population centres. The situation on motorways placed between rural roads and population centre roads.
- In one study night-time accidents were found to be concentrated on weekends.

**Constructing road lighting reduces the number of accidents, especially serious accidents and pedestrian accidents**

As a rule, construction of road lighting was found to reduce night-time accidents 20…40 %.

The number of serious accidents was reduced more than average. In a meta-analysis dealing with several studies, the impact of road lighting by degree of seriousness was:

| | |
|---|---|
| -fatal accidents, on average | - 65 % |
| -personal injury accidents, on average | - 30 % |
| -accidents resulting in property damage, on average | - 15 %. |

Several studies indicated that the number of pedestrian accidents decreased more than average. The impact on safety was found to be especially high at crosswalks, where additional lighting on already lighted roads was found to be worthwhile.

In several studies it was determined that constructing lighting reduces the number and severity of accidents more in rural areas than in population centres. The results were not clear or consistent regarding differences in the impact of junction lighting and roadway lighting.

Partial switching off or dimming of road lighting has been studied primarily for energy conservation reasons. Decreasing lighting increases the cost of accidents more than the savings in electricity. Switching off lighting always results in more accidents. In Denmark it was noted that a 50 % decrease in lighting led to a 4 % rise in the number accidents. The international meta-analysis has documented an experiment conducted in Finland, where dimming road lighting led to a 13 % increase in the number of accidents.

Several studies on improving the current level of lighting indicate that this measure reduces the number of accidents (Australia -21 %, England - 9 %, Gothenburg - 11 %). The studies usually did not, however, describe the original level of lighting or the amount of change in the level of lighting.

A few studies examined the impact of road lighting on driving speeds. In Sweden it was found that as a result of constructing road lighting, driving speeds increased 3.6 km/h on straight sections of road and 0.5 km/h on curving sections. Also in Germany it was noted that improving road lighting increased driving speeds.

Before and after studies found in the literature did not mention whether other measures, such as pedestrian and bicycle paths, guardrails or junction upgrades were implemented in conjunction with the construction of road lighting. For this reason a separate study was conducted.

## Before and after study on the impact on safety of road lighting constructed in the 1990s

The study material comprised 236 locations where road lighting was constructed in the 1990s. In 184 locations only road lighting was constructed, while in 52 locations other measures were also implemented.

The study compared the number of accidents reported to the police three years before and three years after road lighting was constructed. The data included all accidents, but some of the analyses were also done on only personal injury accidents. Because of their small number, fatal accidents

are included in the personal injury accidents. To ensure sufficient material, distribution evaluations were done only for all accidents.

Accident risk is depicted using an accident level, which according to its definition is the number of accidents per year divided by the annual traffic volume. In this study the accident level in different lighting conditions is calculated by dividing the number of accidents by the whole year's traffic volume. Thus, the night-time accident level depicts the number of accidents that occurred in the dark in relation to the whole year's traffic volume, not night-time traffic volume alone.

A statistical reliability analysis of the results was done. In the following tables the reliability of the results is described as follows:

- very significant result **boldface*****
- significant result **boldface****
- nearly significant result normal*
- result not significant small.

In the before and after comparison of the sites under study not only has the number of night-time accidents decreased, but also the number of accidents in daytime and dim light has decreased 11…12 %. In assessing the impact of road lighting it is necessary to take into consideration this general improvement in safety resulting from better driving habits and vehicles. Based on the results it can be concluded that around half of the reduction in accidents is due to general improvement in road safety and half is due to lighting.

**Construction of road lighting only**

According to tables 1 and 2, it appears that after the construction of road lighting there were 34 % (0.66) less personal injury accidents and 22 % (0.78) less accidents altogether compared to the situation before construction. Thus, the number of serious accidents has clearly decreased more than the number of accidents altogether.

*Table 1. Personal injury accident level (day and night) before and after construction of road lighting.*

| Accident level (pers. inj. acc./100 million vehicle km) | | | Number of accidents | |
|---|---|---|---|---|
| before | after | after/before | before | after |
| **11.91** | **7.89** | **0.66***** | 83 | 55 |

*Table 2. Total accident level (day and night) before and after construction of road lighting.*

| Accident level (acc./100 million vehicle km) | | | Number of accidents | |
|---|---|---|---|---|
| before | after | after/before | before | after |
| **37.45** | **29.13** | **0.78***** | 261 | 203 |

According to table 3, the number accidents occurring in daytime or dim light has also decreased 11 or 12 % (0.89 and 0.88) due to better driving habits, better vehicles, lower speed limits and other reasons. This is about half of the decrease in all accidents attributed to lighting above. Therefore only half of the reduction in accidents shown in the tables below is assumed to be the effect of lighting.

The number of night-time accidents decreased 65 % (0.35), of which half, 32 %, as calculated above, is the effect of lighting. In the three-year period before the construction of road lighting 57 accidents occurred in the dark, but in the three-year period after the construction of road lighting 20 accidents occurred when the lights were on.

*Table 3. Accident level (number of accidents/annual traffic volume) of all accidents by light conditions before and after construction of road lighting.*

| Light conditions | Accident level (acc./100 million vehicle km) | | | Number of accidents | |
|---|---|---|---|---|---|
| | before | after | after /before | before | after |
| Daylight | **24.68** | **21.81** | **0.88**** | 172 | 152 |
| Dim light | **4.02** | **3.59** | **0.89**** | 28 | 25 |
| Dark | | | | | |
| (no lights) | 8.18 | - | } 0.35 | 57 | 0 |
| Lights | - | 2.87 | | 0 | 20 |
| **Total** | **37.45** | **29.13** | **0.78***** | 257 | 197 |

When general development in safety is taken into consideration, it can be estimated that **personal injury accidents decreased about 17 % and all accidents decreased about 11 % in a 24-hour period as a result of road lighting**. If we assume that one third of accidents occur in the dark and lighting decreases only the number of accidents that occur in the dark, the outcome is that road lighting reduces the number of night-time personal injury accidents 51 % and all accidents 33 %.

The changes in accident levels according to accident type are shown in table 4. When we take into consideration that lighting accounts for about half of the total reduction, road lighting decreases the number of pedestrian and bicycle accidents around 17 %, animal accidents only around 3 %, single-vehicle accidents around 8 % and other accidents around 14 %.

The large reduction in pedestrian and bicycle accidents means the degree of seriousness of accidents decreases due to road lighting. The small reduction in animal accidents is due to an increase in the number of moose by about one third in 1988 - 2002.

*Table 4. Accident level of all accidents by accident type before and after construction of road lighting (also includes daytime accidents).*

| Accident type | Accident level (acc./100 million vehicle km) | | | Number of accidents | |
|---|---|---|---|---|---|
| | before | after | after /before | before | after |
| Pedestrian & bicycle | 3.73 | 2.44 | 0.65* | 26 | 17 |
| Animal | 4.73 | 4.45 | 0.94* | 33 | 31 |
| Single-vehicle | **9.33** | **7.89** | **0.85***** | 65 | 55 |
| Other | **19.66** | **14.35** | **0.73***** | 137 | 100 |
| **Total** | **37.45** | **29.13** | **0.78***** | 261 | 203 |

**Road lighting combined with other measures**

Table 5 shows sites where other measures were implemented together with construction of road lighting. Only the first two categories included sufficient data to permit a satisfactory before and after comparison.

*Table 5. Quantity, total length and traffic volume of various sites in the research data.*

| Measure | Number of sites | Ttl length (km) | Traffic volume (mill. veh. km/yr) |
|---|---|---|---|
| Road lighting only | 184 | 317.0 | 232.32 |
| RL + pedestrian & bicycle path | 24 | 51.7 | 3.95 |
| RL + junction upgrade | 7 | 8.5 | 6.15 |
| RL + road improvement | 11 | 25.5 | 7.58 |
| RL + pedestrian & bicycle path + junction upgrade | 3 | 3.1 | 2.11 |
| RL + pedestrian & bicycle path + road improvement | 7 | 22.9 | 2.32 |
| **Total** | **236** | **428.7** | **310.90** |

According to table 6, construction of road lighting and a pedestrian and bicycle path appears to reduce all accidents 30 % (0.70), and after taking into consideration general improvement in safety, half, or 15 %. This is more than the 11 % effect of lighting alone. The data on other types of measures are too limited to permit drawing conclusions. There is sufficient data on road lighting only for personal injury accidents in table 7.

*Table 6. Accident level of all accidents by type of measure before and after construction of road lighting (also includes daytime accidents).*

| Measure | Accident level (acc./100 million veh. km) | | | Number of accidents | |
|---|---|---|---|---|---|
| | before | after | after /before | before | after |
| Road lighting only | 37.45 | 29.13 | **0.78***** | 261 | 203 |
| RL + pedestrian & bicycle path | 36.27 | 25.31 | **0.70***** | 43 | 30 |
| RL + junction upgrade | 54.13 | 37.89 | 0.70* | 10 | 7 |
| RL + road improvement | 21.97 | 35.16 | 1.60 | 5 | 8 |
| RL + pedestrian & bicycle path + junction upgrade | 78.99 | 94.79 | 1.20 | 5 | 6 |
| RL + pedestrian & bicycle path + road improvement | 12.93 | 11.49 | 0.89 | 9 | 8 |
| Average/total | 35.70 | 28.09 | **0.79***** | 333 | 262 |

*Table 7. Accident level of personal injury accidents by type of measure before and after construction of road lighting (also includes daytime accidents).*

| Measure | Personal injury accident level (acc./100 million veh. km) | | | Number of accidents | |
|---|---|---|---|---|---|
| | before | after | after /before | before | after |
| Road lighting only | 11.91 | 7.89 | **0.66***** | 83 | 55 |
| RL + pedestrian & bicycle path | 11.81 | 6.75 | 0.57 | 14 | 8 |
| RL + junction upgrade | 16.24 | 16.24 | 1.00 | 3 | 3 |
| RL + road improvement | 4.39 | 4.39 | 1.00 | 1 | 1 |
| RL + pedestrian & bicycle path + junction upgrade | 0 | 15.8 | - | 0 | 1 |
| RL + pedestrian & bicycle path + road improvement | 4.31 | 4.31 | 1.00 | 3 | 3 |
| Average/total | 11.15 | 7.61 | **0.68***** | 104 | 71 |

## Before and after study on the impact of road lighting on driving speeds

The impact of road lighting on driving speeds was studied based on speed data from automated traffic measurement points (ATM points). The study included measurement points where road lighting was constructed after 1997, but where no other changes were made. Hourly average speeds in September at the nine points one year before and one year after the construction of road lighting were compared. The data includes all vehicles in both directions of travel.

Contrary to anticipations and a few results in the literature report, it was found that road lighting did not increase driving speeds on main roads. The result is the same with both 100 km/h and 80 km/h speed limits (tables 8 and 9).

One explanation may be that speeds in the dark are already close to the limit, and there is no ”margin” for increasing them, regardless of the lighting.

*Table 8. Average speeds before and after construction of road lighting at points with a 100 km/h speed limit. All average speeds are weighted with traffic volume.*

| ATM point | Average speed km/h | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24-hour period | | | Hours of darkness 20:00 – 6:00 | | | Hours of light 6:00 – 20:00 | | |
| | before | after | change | before | after | change | before | after | change |
| 115 | 92.2 | 93.2 | +1.0 | 89.6 | 90.8 | +1.2 | 92.7 | 93.6 | +0.9 |
| 133 | 93.8 | 92.5 | -1.3 | 94.4 | 92.9 | -1.5 | 93.7 | 92.5 | -1.3 |
| 229 | 90.3 | 89.5 | -0.8 | 92.6 | 92.0 | -0.5 | 90.0 | 89.1 | -0.8 |
| 826 | 98.3 | 97.8 | -0.5 | 98.2 | 97.5 | -0.7 | 98.3 | 97.9 | -0.4 |
| 1027 | 93.9 | 93.0 | -0.9 | 93.7 | 93.9 | +0.2 | 93.9 | 92.9 | -1.0 |
| 1227 | 94.5 | 93.6 | -0.9 | 94.4 | 93.9 | -0.5 | 94.5 | 93.5 | -0.9 |
| TOTAL | 93.2 | 92.7 | -0.5 | 93.5 | 93.2 | -0.3 | 93.1 | 92.6 | -0.5 |

*Table 9. Average speeds before and after construction of road lighting at points with a 80 km/h speed limit. All average speeds are weighted with traffic volume.*

| ATM point | Average speed km/h | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24-hour period | | | Hours of darkness 20:00 – 6:00 | | | Hours of light 6:00 – 20:00 | | |
| | before | after | change | before | after | change | before | after | change |
| 202 | 81.8 | 81.8 | 0.0 | 81.2 | 81.6 | +0.4 | 81.9 | 81.8 | 0.0 |
| 221 | 83.2 | 82.5 | -0.7 | 84.5 | 84.0 | -0.5 | 82.9 | 82.2 | -0.7 |
| 804 | 85.5 | 84.8 | -0.7 | 88.7 | 86.1 | -2.6 | 85.0 | 84.6 | -0.5 |
| TTL | 83.8 | 83.3 | -0.6 | 84.2 | 83.7 | -0.5 | 83.0 | 82.4 | -0.5 |

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**Previous numbers:**

1. Break-away lighting columns, current practice in Finland in 1993
2. Foundations of luminaire supports. The effect of backfill on strains in foundations.
3. The need of space for snow remover from carriageways in Finland
4. Acoustic performance of simple board and plywood
5. Break-away lighting columns, current practice in Finland in 1996
6. Break-away lighting columns, current practice in Finland in 1998
7. The effect of openings on the insertion loss of noise barriers
8. Improving roadside safety on old roads

9C. Break-away lighting columns in Finland, year 2001
10A. Opta2e.xls tool for design of supports for vertical signs
11A. Safety effects of installing new guardrails and improving existing guardrails
12A Vertical sign supports with passive safety, year 2002

13. Effect of steel grids on the durability of the roads
14. The effect of base material and other properties of pavement on the durability of roads

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