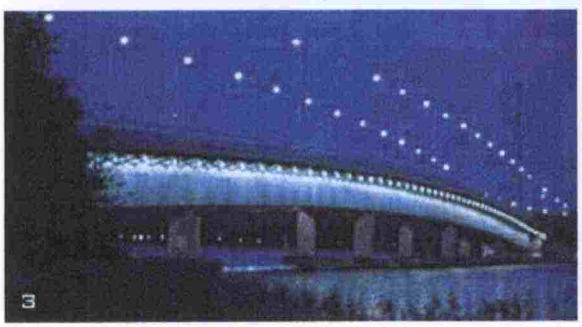
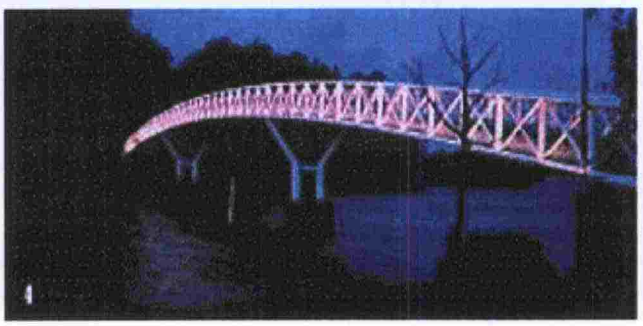
FinnRA

FINNISH NATIONAL CODE OF PRACTICE

FOR ROAD LIGHTING





March 2000

FINNISH NATIONAL CODE OF PRACTICE

FOR ROAD LIGHTING

Summary of the publication No TIEL 214003
"Road lighting handbook" by the
Finnish National Road Administration, Helsinki 1991

CONTENTS

0 HISTORY

The publication No. 3-1963 "Stationary Traffic Lighting" published by The Illuminating Engineering Society of Finland can be considered the first recommendation for road and street lighting.

The first official directives were the Road and Waterways Administration's code of 1968 "Design of Road Lighting". This 6-page document became obsolete very quickly and was in fact applied fairly limited.

From the beginning of 1970's there was rapid changes in design practice along with the development of lighting engineering, the international co-operation, the management of each specific project, new equipment and education. Later on there were also investigations of reducing the lighting periodically. The revised road lighting code of the Roads and Waterways Administration was based on above mentioned facts, and published in 1983 under the name of "Road Lighting - planning and design, installation, operation and maintenance".

The latest revision was completed in 1991. Main reasons were experiences gained from the use of the previous code, new domestic and international standards, research and environmental assessments.

The existing code consists of two parts:

- Road Lighting
  Short, 26 pages, guidelines for decision makers and highway engineers.
- Road Lighting Handbook
  Comprehensive guidelines for design

In the examination below the disposition of the handbook is observed.

1 NEED OF ROAD LIGHTING

1.1 Effect of road lighting

On the basis of the lighting effects it is possible to estimate the savings in driving costs that can be attained by means of lighting. The most important savings are the accident costs. Calculations are based on the following values of reduction of night-time accidents:

- motorways and semi-motorways 20 %
- other roads only for motor traffic 25 %
- all-purpose roads 30 %

1.2 Objects to be lighted

Road lighting may be warranted, feasible and worthwhile without additional studies due to location, traffic volume or accidents.

1.2.1 Sections which are lighted on the basis of their location

For example:

- public roads and streets in built-up areas
- movable bridges, ferry and ship terminals and road sections in conjunction with these
- tunnels
- motorways, if the distance between two lighted sections is $\leq$ 1500 m
- on two-lane highways unlit sections shorter than 500 m are not allowed

1.2.2 Sections which are lighted on the basis of the traffic volume

For road lighting based on traffic flow, the starting point is the average personal injuries and fatality accident rate for each road class. On semi-motorways and other highways, the savings obtained in time costs are also considered.

The profitability of road lighting in terms of traffic economy is analysed by comparing the average annual savings in total costs of road traffic with the combined influence of lighting costs and the costs of column collisions. The traffic flow required to make road lighting profitable is obtained by performing the analysis after half of the service life (t) of the road lighting system has passed (t is usually 20 years), cf. formula (1).

$$KVL = \frac{10^8 \times [K_v + b \times n \times Onk_p (1 + r_1/100)^{t/2}] \times HK}{365 \times b \times [1{,}1\ p \times d \times g \times Onk \times (1 + r_2/100)^{t/2}] + Aik_s} \quad (1)$$

where

KVL	is the average daily traffic flow (vehicles/d)
K_v	annual costs of road lighting (FIM/km x a), according to formula (3)
b	traffic growth factor
n	number of columns (columns/km)
ONK_p	costs of a column collision (FIM/collision)
r_1	annual growth in costs of column collisions (%)
HK	benefit-cost ratio
t	service life of lighting system (a)
p	proportion of night-time traffic
d	reduction in night-time accidents due to road lighting

g	personal injuries and fatality accident rate on the road section (accidents/10^8 vehicle km), according to publication TIEL 703614
Onk	costs of a personal injuries and fatality accident (FIM), according to publication TIEL 703614
r_2	annual growth in costs of personal injuries and fatality accidents (%)
Aik_s	savings in time costs (FIM/vehicle km), according to formula (2), multiplied by 1.1 to include material damages

$$Aik_s = p \times Aik \times (1/v_1 - 1/v_2)\,(1 + r_3/100)^{t/2} \qquad (2)$$

where

p	is the proportion of night-time traffic
Aik	the price of traffic time (FIM/h), according to publication TIEL 703614
r_3	annual growth in value of time in traffic(%)
v_1	night-time speed before road lighting
v_2	night-time speed after installation of road lighting
$1/v_1 - 1/v_2$	savings in time (h/vehicle km)

Calculated figures for different functional classes of roads are indicated in table 1.

Table 1
Profitable traffic volumes from traffic economics point of view

Road Category	ADT (veh / d)	
Motorway - central reserve > 12 m - central reserve < 12 m Semi-motorway	 40 000 18 000 13 000	
Roads of the basic network	Junction density (pc/km)	
	2	5
Other main roads - cars only - all-purpose	 8 000 6 000	 5 000 4 000
Other highways - all-purpose	 5 000	 3 000

1.2.3 Sections which are lighted on the basis of accidents

If the night-time accident density exceeds the value indicated in table 2, road lighting will be worthwhile.

Table 2
Night-time accident density

Road cate	Accident density acc. / km x a
Motorway - central reserve > 12 m - central reserve < 12 m	 2,4 1,1
Semi-motorway	1,0
Other main road	0,6
Other highway	0,5

1.2.4 Sections which are lighted on the basis of special reasons

For example:

- two-lane roads if the volume of pedestrians and cyclists necessitates need of the separate pedestrian and bicycle way but this can not be constructed during the next 5 years.
- in the main direction channelised and signal controlled intersections
- separate pedestrian and bicycle ways alongside the main road if distance between road edge and luminaire row is more than the mounting height.
- pedestrian underpasses on the lighted roads
- traffic schemes at the end of motorways

1.3 Rehabilitation of road lighting

This chapter emphasizes the importance of rehabilitation of obsolete and uneconomic installations. It is possible to reach higher luminance values in spite of lower consumption of electricity. Impact costs also will be taken into account. There will be good cost-benefit ratios and short amortisation periods.

1.4 Periodic reduction of road lighting

This chapter deals with aspects which shall be carefully considered when designing reduction or switching of road lighting. Both on rural and urban sections, periods, effects, savings and environmental aspects will be investigated throughout.

2 PERFORMANCE REQUIREMENTS FOR LIGHTING PARAMETERS

Requirements for motor traffic is based on luminance concept in accordance with recommendations of CIE. Illuminance concept is used on conflict areas and for pedestrian and bicycle traffic.

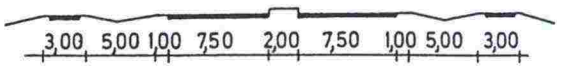
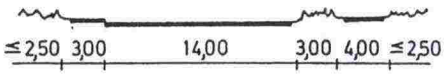
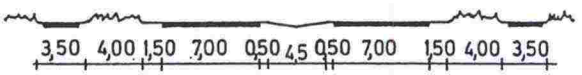
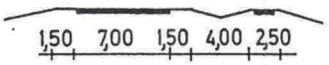
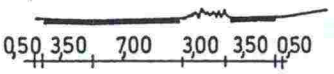
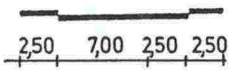
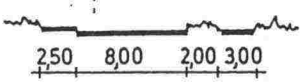
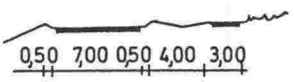
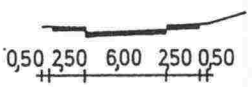
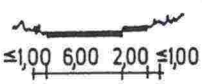
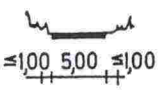
Quality criteria and choice of lighting class is indicated in tables 3 and 4 and figures 1 and 2. Values are for dry road surface. On a wet surface overall uniformity U_o shall be at least 0,15.

Table 3
Lighting requirements for motor traffic and conflict areas

Lighting class	Luminance			Glare		Illuminance		
	Average value	Uniformity				Average	Outside of carriage way	Uniformity
		Overall	Longitudinal					
	L_m cd/m²	U_o	U_l	G	TI %	E_{min}	E_{min} lx	U_o
A1	≥ 2,0	≥ 0,4	≥ 0,6	≥ 5	≤ 8	≥ 30	10	≥ 0,4
A2	≥ 1,5	≥ 0,4	≥ 0,6	≥ 5	≤ 10	≥ 20	7	≥ 0,4
A3	≥ 1,0	≥ 0,4	≥ 0,6	≥ 5	≤ 10	≥ 15	4	≥ 0,4
A4	≥ 1,0	≥ 0,4	≥ 0,4	≥ 5	≤ 15	≥ 15	4	≥ 0,4
A5	≥ 0,5	≥ 0,4	≥ 0,4	≥ 5	≤ 20	≥ 10	2	≥ 0,4

Table 4
Lighting requirements for pedestrian traffic

Lighting class	Illuminance						Discomfort glare	
	Horizontal		Semicylindrical		Hemispherical			
	E_h (lx)		E_{sc} (lx)		E_{hs} (lx)			
	Average	min	Average	min	Average	min		
K1	20	3	10...16	2,7	8...12	2	H(m)	$LA^{0.25}$
K2	15	3	8...12	2,7	6...9	2	< 4,5	< 3000
K3	10	3	6...8	0,8	3...5	2	4,5...6	< 4000
K4	5	1	2...5	0,8	1...2,5	0,6	> 6	< 5000
K5	2	0,3	1...2	0,8	0,5...1	0,3		

Functional class	Cross-section	Traffic	Speed limit	Junctions	Lighting class
Main streets Downtown		M+E(Pp+Jk)	50	At-grade	A2 + K3
					A2 + K3
					A1 + K2
Suburb		M+E(Pp+Jk)	80 60	Interch. At-grade	A2 + K3 A3 + K4
		M+Pp+Ejk	50	At-grade	A4 + K4
Collector streets Downtown		M+E(Pp+Jk)	50	At-grade	A3 + K4
		M+Pp+Ejk			A3 + K4
Suburb		M+E(Pp+Jk)	60	At-grade	A4 + K5
		M+Pp+Ejk	50		A5 + K5
Local streets Downtown		M+Pp+Ejk	50	At-grade	A4 + K4
Suburb		M+Pp+Ejk	40	At-grade	A5 + K5
		M+Pp+Jk	30		A5

M= motor traffic Jk=pedestrian trafficPp= bicycle traffic E= separated traffic

Figure 1 Lighting classes for streets

Functional class	Cross-section	Traffic	Running speed	Junctions	Lighting class	
					Light env	Dark env
Motorways	2 x 12,50 / 7,50 + 15,00	M	≥ 80	Interch.	A2	A3
	2 x 12,50 / 7,50 + 4,50	M				
	12,50 / 7,50	M				
Main roads	2 x 9 / 7 + 4,50	M+Pp+Jk	≥ 60	At-grade	A1	A2
				Interch.	A2	A3
		M+E(Pp+Jk)			A2 + K3	A3 + K4
	17,50 / 14,50	M+Pp+Jk	≥ 60	At-grade	A1	A2
		M+E(Pp+Jk)			A2 + K3	A3 + K4
	10,50 / 7,50	M+Pp+Jk	≥ 60	At-grade	A4	A4
	8 / 7	M+E(Pp+Jk)			A4 + K4	A5 + K5
Other roads	8 / 7	M+Pp+Jk	< 60	At-grade	A4	A5
		M+E(Pp+Jk)			A5 + K5	A5 + K5
	7 / 6	M+Pp+Jk	< 60	At-grade	A5	A5
	4...6	M+Pp+Jk	< 40		A5	A5
	DOCKS				A1	A2

M= motor traffic Jk=pedestrian traffic Pp= bicycle traffic E= separated traffic

Figure 2 Lighting classes for public roads

Table 5
Lighting classes for pedestrian areas

STREET OR AREA	LIGHTING CLASS
PEDESTRIAN STREETS	
Downtown - Pedestrians only - Service traffic permitted	 K 3 K 1
Suburb - Pedestrians only - Service traffic permitted	 K 3 K 2
Built-Up Areas (Countryside) - Pedestrians only - Service traffic permitted	 K 3, K 4 K 3
WOONERF - Busy - Less activities	 K 3 K 4, K 5
PEDESTRIAN AREAS IN DOWNTOWN, SQUARES AND PLAZAS	K 2, K 3
PARKING AREAS	K 4
MAIN HIKING ROUTES	K 3, K 4
SEPARATE PEDESTRIAN AND BICYCLE WAYS - Busy - Less trafficked	 K 4 K 5

3. LIGHTING EQUIPMENT

3.1 General

3.2 Lamps

In this chapter the types of light sources, the properties of different types of lamps and their use on roads and other areas of different functions are presented.

3.3 Luminaires

In accordance with the code, the luminous intensity distribution properties and the luminous intensity distribution classes must be measured and defined in accordance with the methods of the CIE. Luminaires are presented in accordance with the purpose, type of lamp and structure. Advice for choice of luminaire is submitted.

3.4 Road surface

For the calculation of the luminance pavement reflection properties and surface classes are defined in accordance with the R-scale of the CIE. This scale is better suited for Finnish pavements (coarse mineral aggregate, soft bitumen) than the N- and C-scales. Dry and wet conditions will be examined in lighting calculations. Visibility of road markings will be treated also.

3.5 Columns

The code is based on the domestic SFS-standard and on the European EN-standards and includes the following data for lighting columns:

- definitions and dimensions
- materials and surface protection
- electrical compartments and devices
- loading and dimensioning
- column types and their selection

Above mentioned performance requirements are valid both for the conventional rigid columns and for the modern columns with passive safety.

Detachable or yielding columns must be used in side installations on Finnish highways when ADT exceeds 3 000 veh / d and speed limit is higher than 50 km / h. Columns with passive safety are not needed beyond guard rails.

3.6 Foundation

For the foundation of the columns different fixing and foundation methods as well as the selection of these methods are presented.

There are of course typical drawings for the manufacture and installation of the columns and foundations available, but the present design and specifications determine more and more performance requirements. Manufacturers have their opportunities to develop relevant products.

3.7 Electrical devices

The electrical devices must be in accordance with both the security and constructional regulations of the Electrical Inspectorate. Supplementary information and special regulations of the local electricity distribution utility must be observed.

This chapter comprises:

- the fundamental principles
- the distribution system
- earthing
- the sets of equipment and installations

4. PRINCIPLES OF ROAD LIGHTING

4.1 General

By the principles of lighting is meant the placing of the lighting equipment on road sections, in junctions, rest areas, tunnels and on bridges with regard to the cross-section and the alignment of the road so that traffic safety can be improved within the limits of the required values of lighting parameters and with a minimum of annual costs.

At the same time attention must be paid to improving the level of service and driving comfort, public discipline and security as well as the road environment.

To attain these objectives basic solutions and examples are presented in the most extensive chapter of the code.

4.2 Lighting arrangements

This chapter contains:

- general principles regarding the placing of luminaires and lighting columns
- main types of lighting arrangements
- factors that affect the mounting height
- actors that determine the length of the bracket
- adjustment of lighting columns
- structure type of column and its location in the cross-section

4.3 Visual guidance and aesthetics

The design principles from the viewpoint of visual guidance and aesthetics. Aesthetic factors that are considered in the design are described; example figures.

4.4 Roads

At the beginning of the chapter, all roads are given common factors by means of which type of lighting arrangements is chosen. Then the selection factors which depend on the object are described as well as the forming of adaption zones grouped in accordance with the road type:

- undivided roads
- dual carriageways
- footpaths and cycleways
- low traffic roads

4.5 Junctions and similar areas

As above the common design principles as well as the design principles which are due to the type of junction are described:

- intersections
- interchanges
- low traffic junctions
- parking, rest and service areas
- pedestrian crossings
- docks and harbour areas
- bus stops
- railway level crossings

4.6 Bridges

Although the bridge is part of the road, some additional directives are needed.

Short tunnels are discussed in this chapter.

4.7 Tunnels for motor traffic

In this chapter the basis of design, the dimensioning with regard to the lighting engineering and the lighting equipment are described. The Finnish code is based on the CIE recommendations and on the draft European standards.

This chapter contains:

- nighttime lighting
- daytime lighting
  * basics
  * access zone luminance
  * threshold zone luminance
  * transition zone luminance
  * interior zone luminance
  * exit zone luminance
  * uniformity

* flicker
- emergency lighting
- lighting equipment
- electrical devices

4.8 Traffic signs

The relationship between the location of traffic signs, cross-section, road alignment, reflective film and lighting is proved.

The principles of lighting as well as the dimensioning and equipment are presented.

4.9 Periodic reduction of lighting

For control of the lighting this chapter contains

- the principles of reduction
  Special attention must be paid to the profitability of this measure
- control methods

4.10 Urban roads

This chapter gives additional advise for lighting design of public roads which are going through communities and small towns.

There are different elements of outdoor lighting, each performing a specific function. Many of these elements are covered by previous chapters. Often they will compete with each other as they will have been independently designed and installed. The purpose of this chapter is to show how the lighting design for an area can be approached in a coordinated way, integrating the solutions from existing guides and codes of practice.

The chapter includes following items:

- grounds and objectives
- performance requirements
- lighting equipment
- planning and design
- common principles in several figures

5. DESIGN METHODS

5.1 General

In this chapter the aids and methods - by means of which a solution that fulfills the requirements is designed using the principles and lighting arrangements described in the preceding chapters - are described.

5.2 Dimensioning of lighting parameters

This chapter explains the calculation of luminance, glare and illumination.

A data processing method, the softwares of which are improved Finnish modifications of the CIE version, are almost exclusively used in the design.

The information required in the file is defined in the code. The Finnish National Road Administration sees to the surface reflection properties. The manufacturers of luminaires must supply the luminous intensity distribution tables measured at the Technical Research Centre of Finland.

The directions for use as well as the output of the softwares are described.

By varying the geometry solutions which meet the requirements are looked for. Highway authorities always make the comparison by means of the abovementioned softwares.

The Centre of Technical Development of the Finnish Road Administration has precalculated and documented a large amount of performance tables (documentation tables) for the most common cross-sections and pavements. The files which are being supplemented continually have been sent to the district offices for the practical design.

5.3 Foundations of columns

This chapter gives guidelines for dimensioning of pier, slab, rock and pile foundation. Settlement of subgrade and the effect of frost are considered.

5.4 Dimensioning of the electrical network

Directives by means of which the electrical network can be planned considering the loading data and installation method. In this chapter the design of the network and the dimensioning principles (thermal rating, voltage decrease and zero conditions) are dealt with.

5.5 Cost calculation

At the different stages of the road keeping data on the costs of the installation and maintenance of lighting are needed. The details are needed:

- when the necessity of lighting is evaluated
- when the priority of projects is defined
- when the implementation program is worked out
- when the lighting arrangements and structures are compared
- in cost estimates
- in budgets

The calculation method, accuracy and units vary in accordance with the circumstances.

At the engineering the comparison of solutions that are equal from viewpoint of lighting performance is made by means of cost calculation which is based on the unit-prices of completed, important parts.

The construction costs K_rFIM/road metre are calculated from the formula (3).

$$K_r = \frac{m \times H_p + n \times H_v + S \times H_{sj}}{S} \qquad (3)$$

m = number of columns in the cross-section
n = number of luminaires in the cross-section
H_p = price of column and foundation, FIM/piece
H_v = price of luminaire and first lamp, FIM/piece
H_{sj} = price of electrical distribution installations, FIM/road metre (suspended wire and cable grouped according to the lighting arrangement and mounting height)
S = spacing, m

The annual operating and maintenance costs K_{kk} FIM/m × a are calculated from the formula (4).

$$K_{kk} \frac{t_1 \times n \times P_i \times H_e + \frac{n \times H_1}{t_2} + 0{,}15 \times n \times (H_1 + H_{ly}) + m \times c}{S} \qquad (4)$$

Where

t_1 is annual burning time, h
t_2 life time of the lamp, a
m number of columns in the cross-section
n number of luminaires in the cross-section
P_i the effect of the lamp with control gears, kW (or the total effect of lamps in the same luminaire)
H_e price of energy, FIM/kWh

H_1 unit-price of lamp when changed by group, FIM/piece
H_{ly} additional price when lamps are changed one by one, FIM/piece
C fixed costs, FIM/column
S spacing, m

The annual cost K_v FIM/m × a is calculated from the formula (5).

$$K_v^{v(t/2)} = \alpha_t \times K_r + \beta_t \times K_{kk} \qquad (5)$$

where α_t is capital recovery factor
β_t growth factor of operating and maintenance costs

If the service life of the lighting is 20a, the calculable interest 7,5 % and the annual increase in the maintenance costs 4 %, formula (5) assumes the form (6)

$$K_u = 0{,}098\ K_r + 1{,}48\ K_{kk} \qquad (6)$$

6. LIGHTING PLANS

6.1 General

Implementation of road lighting requires usually three plans of different level. They have their own goals and accuracy.

6.2 Feasibility and location study of lighting

6.2.1 Aim

In the feasibility and location study of lighting the long-term (> 15 a) objectives and program of the road and street lighting in built-up areas, towns or urban areas are described.

Its aim is to:

- coordinate the lighting of the whole area so that it forms a logical whole
- help the programming and decision-making
- be a basis and control method of subsequent plans
- present the principles of periodic reduction of the lighting

6.2.2 Working-out

The feasibility and location study of lighting is worked out on the basis of the present situation and the development plan of the road network.

The planning begins by checking the present road and street lighting. In comparing the present lighting levels to the performance requirements described in chapter 2 the following scale can be used: over-dimensioned, acceptable, insufficient or very bad.

On the basis of traffic safety investigations, traffic volume data and the functional classes indicated by the development plan for the road and street network new traffic routes as well as the need for improving the present lighting are investigated. The lighting classes and lighting arrangements of roads and streets are defined by means of the methods and principles described in chapters 2 and 3. It is to be noted that the operating costs may decrease by choosing the right kind of light source although the lighting level increases.

The projects are put in the order of priority by taking into account the installation and maintenance costs as well as the resources that are allocated each year.

The principles of reducing the road and street lighting are defined.

The feasibility and location study of lighting is worked out in co-operation with the town or municipality and the Highway Administration. Each part must consider the plan and accept it as the basis of further design. Although the preliminary engineering of lighting is equal to the road network plan it is dealt with separately.

The next step is the following-up of the plan. It is important to check that the general principle of the plan are preserved and also that the plan is still current (e.g luminaires, lamps, construction and improvement projects).

6.2.3 Contents

The feasibility and location study consists of:

- description
- map 1:10 000 - 1:20 000 where the lighting classes and lighting arrangements
  are indicated by colours and symbols
- implementation program
- periodic reduction of lighting

6.3 Preliminary engineering of urban lighting

This type of plan is needed for a restricted and specific area of a town, city or community. Preliminary engineering will be worked out mainly due to environmental reasons and for city beautification in accordance with the aspects described in chapter 4.10.

Design process of final engineering, chapter 6.5.2, can be applied. Contents of plan varies depending on the object, but includes at least:

- description
- map showing principles for location of columns and luminaires
- illustrations and cross-sections of lighted surfaces, facades, buildings, statues, trees, parks etc.
- perspective pictures and photomontages
- general drawings of equipment

6.4 Lighting data for highway design

Implementation of a highway project requires a special highway plan which must be treated in accordance with Road Act. If road lighting is needed the highway plan shall include basic information about lighting.

For example

- present problems
- proposed lighting arrangements
- effects of proposed lighting
- costs
- general drawings (usually map)

6.5 Final engineering of lighting

6.5.1 Aim

The final engineering of lighting is a plan which is based on the feasibility and location study or on the preliminary engineering or some other similar plan. The final engineering is worked out separately for each road. It is the main document of installation and describes the final result of the work. It is also the basic document of the activity planning.

6.5.2 Working-out

The final engineering consist of four different substages, the result of which is a intermediate goal or decision. This process also comprises five different technical sectors.

Before the design is started one must make sure that the project is necessary. The grounds and objectives of the project are to be considered. The decision to work out a plan is made on the basis of these, the previous design stage and a possible agreement on lighting.

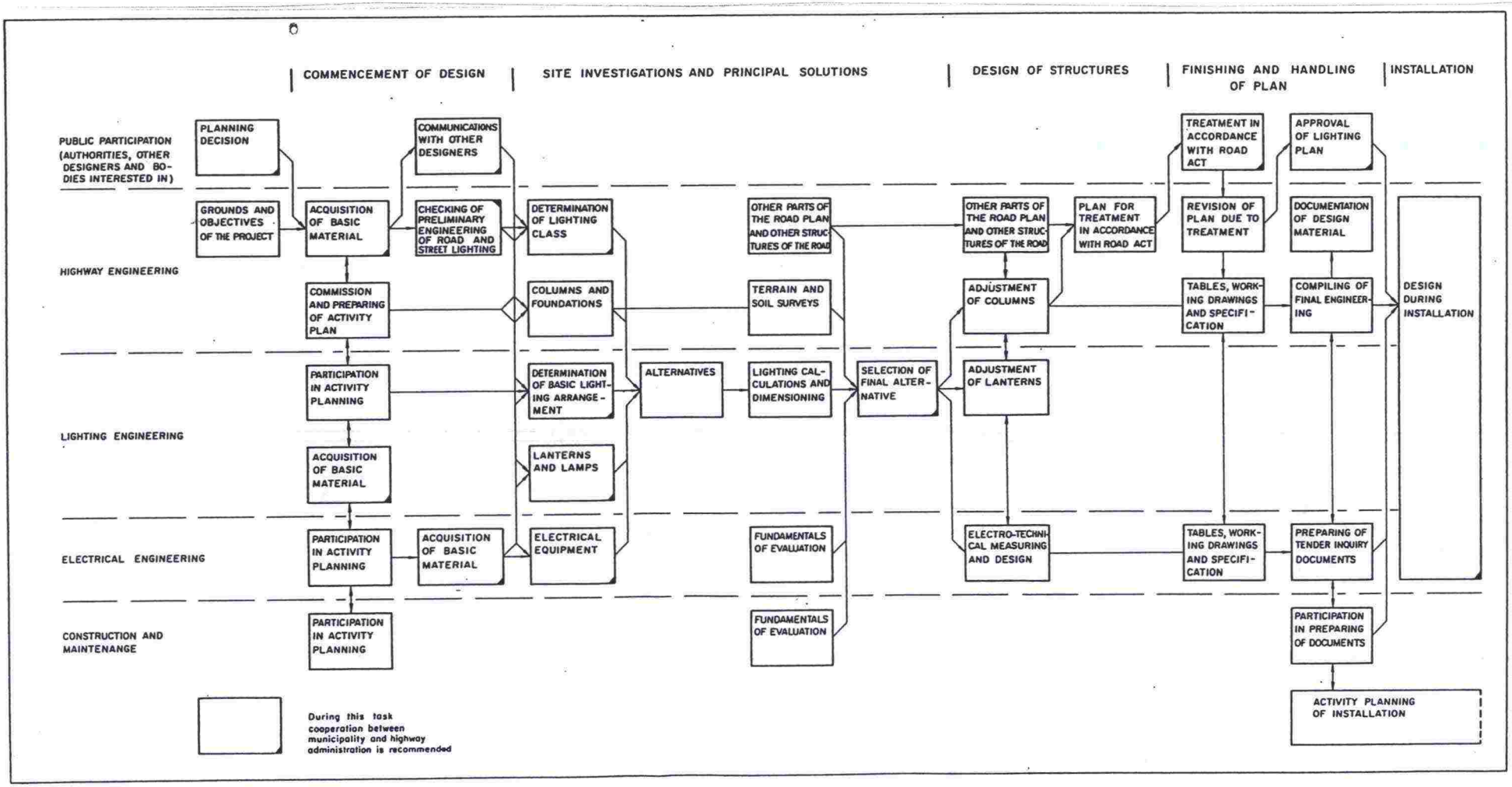


FIGURE 3. FINAL ENGINEERING OF ROAD LIGHTING

Figure 3 shows a scheme of the working-out of the final engineering for road lighting. This stage consists of four sub-stages, the most important tasks of which are:

1. Commencement of design

   After the ground and objectives have been given basic information regarding the lighting is obtained from other plans or from the present road

   - maps, longitudinal and cross-sections
   - drainage plan
   - plans for cables and equipment
   - route guidance plan
   - general drawings of bridges
   - data on present lighting
   - data on transformer stations and the supply of electricity

   After getting acquainted with the material a plan of activity can be worked out.

   Because the whole planning procedure is rather long the preliminary engineering is checked so that it is up-to-date or a corresponding, short examination is worked out.

2. Site investigations and principal solutions

   A creative sub-stage of the final engineering at the beginning of which the main solutions are defined:

   - lighting class
   - lighting arrangements
   - luminaires and lamps
   - columns and foundations
   - electrical distribution devices

   By means of the above main solutions alternatives are worked out for comparison. A lighting technical dimensioning is made for each one of the alternatives. Cf. 5.2. Considering the other parts of the road e.g. footpaths and cycleways, traffic signs, signal control etc. the alternatives that are equal from the viewpoint of lighting performance are compared by means of cost calculation. Then the final choice is made. Cf. 5.5.

   Not until this sub-stage is it possible to compile lighting information for highway plan to be treated in accordance with the Road Act.

3. Design of structures

A routine sub-stage of the final engineering. At this stage the plan for the other parts of the road are dealt with and the columns and luminaires are adjusted:

- firstly, the columns are placed at the obligatory points i.e. close to the intersections, bridges, cables, pipes, culverts, manholes etc.
- then the placing is continued on the free road sections so that the spacing is as close to the theoretical value as possible
- the foundations are chosen

The electro-technical measuring and design is made simultaneously

- the cable and its cross-sections determined
- voltage decrease
- zero conditions
- selectivity of protection

At this stage at the latest lighting information must be compiled for treatment in accordance with the Road Act.

4. Finishing and treatment of the plans

When the highway plan is returned from the administrative treatment the finishing of the final engineering is continued:

- comparison to the other part of road
- working drawings are made and drawn fair
- levels are calculated
- tables are made (columns, conduits, traffic signs etc.)
- typical drawings are chosen
- specification is written
- the bill of quantities is completed
- statements of relevant authorities
- documents for the invitation of tenders are made
- the final engineering is compiled
- the design material is documented

The final engineering of lighting, which is based on the highway plan, may be agreed to by the local office of Road Administration.

The final engineering of lighting must also be sent to the local electricity distribution utility for inspection.

6.5.3 Contents

The final engineering for lighting consists of following parts:

- special specification
- general map 1:10 000 - 1:20 000
- design map 1:1 000 - 1:2 000
- typical cross-sections 1:100 - 1:200
- lists of columns
- lists of conduits
- lighting drawings of bridges 1:100 - 1:200
- list of traffic signs
- grouping table for loading
- main schemes of electric distribution boards
- special drawings
- typical drawings
- general specification

7. INSTALLATION OF ROAD LIGHTING

In this chapter the kind of management (FinnRA's own work or a contract), working-out of the activity plan and the performance of the installation are dealt with. The following matters are examined:

- acquisition
- earth works
- installation works
- quality control of installations
- inspections and examinations
- traffic schemes during construction

8. OPERATION AND MAINTENANCE OF ROAD LIGHTING

This chapter deals with:

- responsibility of maintenance
- control of lighting
- items of follow-up and maintenance
  * luminance, pavement and depreciation of luminous flux
  * temperature changes, dirtying and aging of luminaires
  * aging of control gears and voltage fluctuation
- maintenance measures
  * changing of lamps and cleaning of luminaires
  * maintenance of other structures and electrical devices
  * care of surface protection
- maintenance of high mast lighting
- maintenance of tunnel lighting
- maintenance equipment
- traffic schemes during maintenance works