

**DEVELOPMENT OF A GUIDELINE FOR DESIGNING
ECONOMICAL AND EFFECTIVE RETROFIT LED
STREET LIGHTING SYSTEM FOR SRI LANKA**

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Degree of Master of Science

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Sri Lanka

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree
Master of Science in Electrical Installation

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

May 2021

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Master thesis under my supervision.

Signature of the supervisors:

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Prof. N.K. Wickramarachchi

Signature of the supervisors:

Date:

Dr. W.D.A.S. Rodrigo

DEDICATION

I dedicate my M.Sc. research dissertation to my beloved parents and my husband for their support given throughout my life.

ACKNOWLEDGMENT

First I would like to express my sincere gratitude to my research supervisors Prof. N. K. Wickramarachchi and Dr. W. D.A.S. Rodrigo (Department of Electrical Engineering, University of Moratuwa) for their continuous guidance and assistance to fruitful the research.

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I'm also grateful to all the staff members of Colombo Municipal Council (CMC), Regional Center for Lighting (RCL) and Road Development Authority (RDA) for the support they have given to gather necessary information.

Specially I would like to give my heartiest gratitude for my family members for staying behind me in every single step of my life.

L. W. N. Muthuransi

ABSTRACT

Nowadays most of the conventional type street lights are been converting to LEDs (Light Emitting Diodes). But there are no proper criteria or standardize methods to replace these conventional type street lamps to LEDs. Only energy saving aspect is garnering more attraction by the governments. But quality aspects like glare, uniformity ratios and color rendering should also be addressed. Otherwise it will not meet the safety and visibility needs of the road users which is the utmost objective of street light designing.

The objective of this thesis is develop a guideline for designing economical and effective retrofit LED street lighting system for Sri Lanka. According to EN 13201-2:2015 'Road lighting - Part 2: Performance requirements standard, lighting classes were defined by a set of photometric requirements aiming at the visual needs of road users by considering the road categories, number of lanes and street light installation patters in Sri Lanka. Then minimum wattage/ lumen output, ideal light distribution type, luminaire mounting height, overhang and slope angle which should be used when replacing conventional type luminaires were decided for all road categories through a computer simulation process.

It was noticed that pay-back period is long due to the cost of LED luminaire and arm modification. Also when we are trying to meet the standard luminance and illumination levels to a road which is having very poor lighting conditions, the cost becomes high. The prices of the LED luminaires are gradually decreasing and therefore lower price levels can be expected in the future and it will reduce these long payback periods. Though these projects have somewhat higher pay-back periods, they are still viable due to energy saving and maintenance cost saving compared to conventional type street lights.

Hence when implementing these kinds of public projects investment cost should not be the only reason that should be considered. The safety of road users, upgrade the quality of life by promotion of business activities during the night hours should also be addressed.

Keywords: LED, Street Light, Retrofit, EN 13201, Lighting Class, Dialux 4.12 Software, Pay-back, Net Present Value

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LIST OF ABBREVIATIONS

Abbreviation	Description
LED	Light Emitting Diode
CEB	Ceylon Electricity Board
GWh	Giga Watt hour
RCL	Regional Center for Lighting
CFL	Compact Fluorescent Lamp
ADB	Asian Development Bank
LECO	Lanka Electricity Company (Pvt) Ltd
CRI	Colour Rendering Index
CT	Colour Temperature
HPS	High Pressure Sodium
NPV	Net Present Value
RDA	Road Development Authority
PUCSL	Public Utility Commission of Sri Lanka
kWh	kilo Watt hour
W	Watt
cd	candela
m	meter
lm	lumen
L	Luminance or brightness
L_{av}	Average luminance
U _o	Overall Uniformity
U _l	Longitudinal Uniformity
TI	Threshold Increment
SR	Surround Ratio
CIE	Commission Internationale de l'Eclairage
IES	Illuminating Engineering Society
ANSI	American National Standards Institute
BIS	Bureau of Indian Standards

IESNA

Illuminating Engineering Society of North
America

PHP

Hypertext Preprocessor

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1. INTRODUCTION

1.1 Background

Providing economical and qualitative street lighting for public is a challenge for the public authorities specially in developing countries. Well-designed street lighting system will provide a safe drive for the motorists by giving facility to see the road signs and hazards. It will allow pedestrians to see the hazards, identify the other people around and improve the sense of security [1]. It also enhances the night time appearance of the area. On the other hand, poorly designed street lighting systems can lead to energy wastage and it won't meet the expected benefits of street lighting mentioned above.

LED (Light Emitting Diode) is one of the latest technologies introduced to the becoming popular in street lighting due to its improved efficiency and life time when compared with conventional light sources such as fluorescent, sodium vapour, mercury vapour and metal halide. The cost of LED lighting is typically higher than other conventional lighting sources. But considering only its energy saving aspect, most people find it more economical to going for LEDs in street lighting nowadays. But when designing a lighting solution for streets, operational concerns like energy usage, light output, durability; and performance concerns like illumination levels, glare, uniformity ratios and color rendering should be addressed. Economical, effective and human friendly street lighting design incorporates efficient lighting technologies, minimum energy usage, good light distribution and optimum pole height while serving the safety of road users.

1.2 Problem Statement

1.2.1 Current situation of street lights in Sri Lanka

Some common observations about street lights in Sri Lanka can be listed as; [2]

Most of the time indoor type fluorescent bulbs and low quality, indoor type switches are used to switch on-off the street lights and majority of street lights on roads are badly maintained. Low light levels and very low uniformity ratios in light distribution are creating difficult situations for both motorists and pedestrians. Also

there is no evenness in types of luminaire used, mounting height and overhang creating further reduction in uniformity ratios.

➤ Data from street light survey which was done in 2010-2012 period with the cooperation of Regional Center for Lighting (RCL) in Ceylon Electricity Board was obtained to get an idea on light condition of Sri Lankan roads.

a) Road: By road (Katuwana road)

Road width: 10feet

Luminaire: 20W Compact Fluorescent Lamp (CFL)

Span: 27m

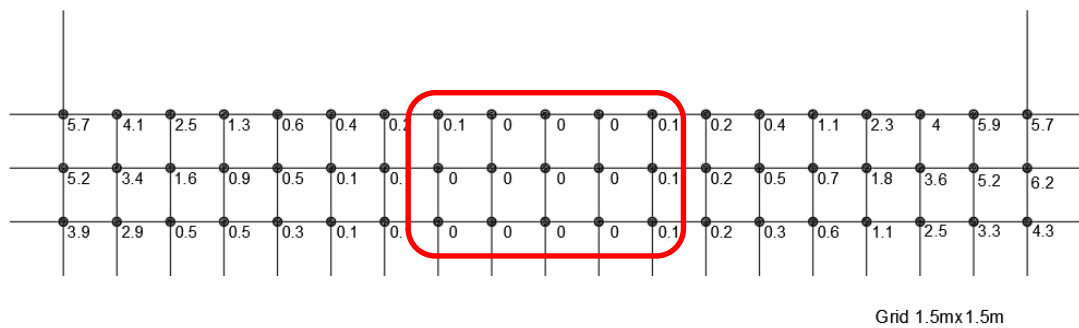


Figure 1.1: Lux level measurements with 20W CFL luminaire

Average illumination level : 1.5 lux
 Minimum illumination level : 0 lux
 Maximum illumination level : 6.2 lux
 Overall uniformity : 0

As it is clearly seen from Figure 1.1, the illumination level in between two light poles is zero. It leads to an inadequate uniformity level on road which is zero. This is an inappropriate situation as uniformity levels (longitudinal uniformity and overall uniformity) have a direct impact on visibility level [3].

b) Road: By road (Katuwana road)

Road width: 4.3m

Luminaire: Fluorescent(36W)

Span: 48m

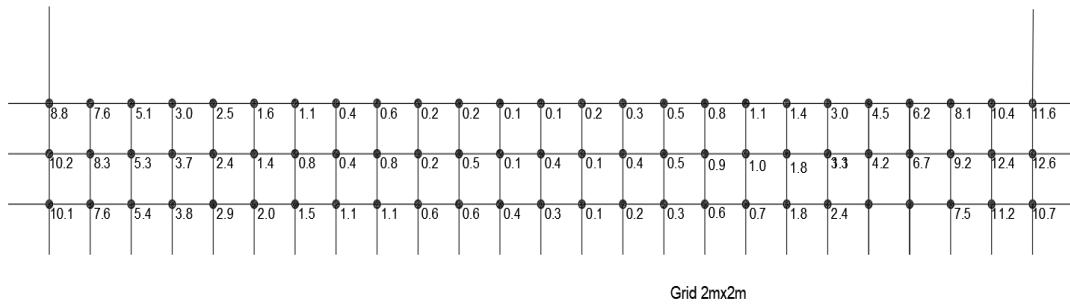


Figure 1.2: Lux level measurements with 36W fluorescent luminaire

Average illumination level : 3.29 lux
 Minimum illumination level : 0.1 lux
 Maximum illumination level : 12.6 lux
 Overall uniformity : 0.03

Here also overall uniformity level is very low on road surface. So it will not provide the adequate visual conditions to the road users.

- c) Road: B452 Katuwana road
- Road width: 15feet
- Luminaire: Sodium vapour
- Span: 31.5m

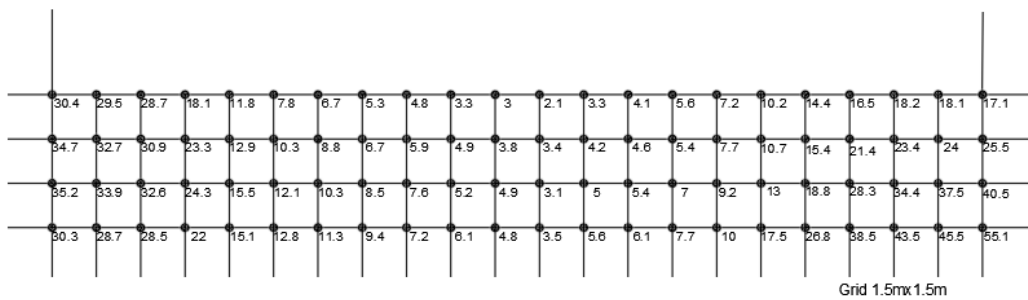


Figure 1.3: Lux level measurements with sodium vapour luminaire

Average illumination level : 16.1 lux
 Minimum illumination level : 2.1 lux
 Maximum illumination level : 55.1 lux
 Overall uniformity : 0.13

Average illumination level on road with sodium vapour luminaire is 16.1lux and it is quite good lighting level. But the overall uniformity has become very low due to low illumination level in between two poles.

d) Road: By road (Katuwana)

Road width: 4.2m

Luminaire: 9W LED

Span: 40m

According to the data in Figure 1.4, the illumination levels on road surface can be calculated.

Average illumination level : 0.6 lux
 Minimum illumination level : 0 lux
 Maximum illumination level : 2.1 lux
 Overall uniformity : 0

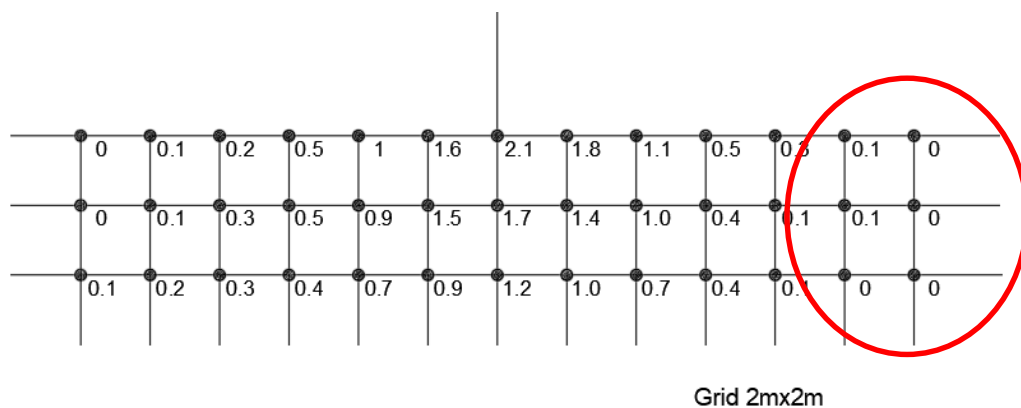


Figure 1.4: Lux level measurements with 9W LED luminaire

This road is illuminated with 9W LED luminaire. According to calculated data, overall uniformity has become zero and therefore the light conditions on this road is also not acceptable. Therefore, illuminating a road with just a LED won't cater the requirement.

e) Road: By road (Katuwana)

Road width: 4.2m

Luminaire: 12W LED

Span: 40m

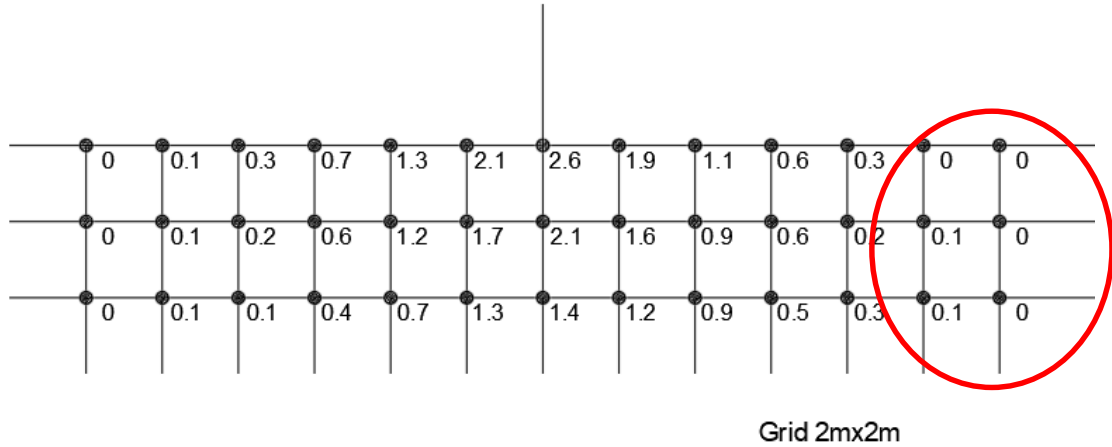


Figure 1.5: Lux level measurements with 12W LED luminaire

Average illumination level : 0.7 lux
Minimum illumination level : 0 lux
Maximum illumination level : 2.6 lux
Overall uniformity : 0

When compared to previous situation (Figure 1.4), the average illumination level has been increased with higher wattage used. But still uniformity level is zero due to the incorrect selection of light distribution type and may be low mounting height.

➤ Illumination levels were measured for selected two roads which are in Colombo area.

f) AC16 road from Thotalaga junction (in Panchikawatta)

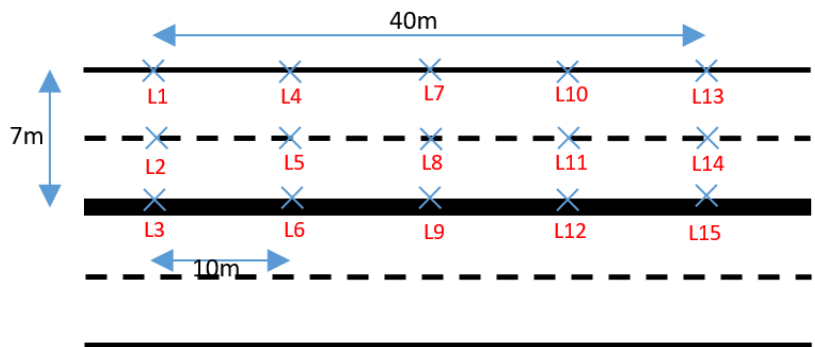
Number of lanes: 4 lanes

Installation pattern: Median

Luminaire: 140W/ 13900lm LED luminaire

Span: 40m

Mounting height: 13m



Figure

level measurements with 140W LED luminaire

1.6: Lux

L1 :19 lux	L4 :13 lux	L7 :10 lux	L10 :13 lux	L13 :19 lux
L2 :23 lux	L5 :15 lux	L8 :11 lux	L11 :15 lux	L14 :23 lux
L3 :28 lux	L6 :18 lux	L9 :12 lux	L12 :18 lux	L15 :28 lux

$$\text{Average Lux level on road} = \frac{L1 + L2 + L3 + \dots + L15}{15} = 17.8\text{lux}$$

g) Deans road- Town hall, Colombo 01

Road type: 4 lane road

Installation pattern: Median

Luminaire: 250W Sodium vapour luminaire

Span: 40m

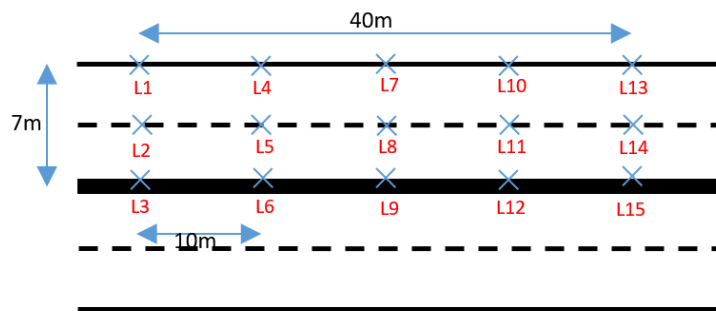


Figure 1.7: Lux level measurements

L1 :42 lux	L4 :21 lux	L7 :8.6 lux	L10 :21 lux	L13 :42 lux
L2 :55 lux	L5 :24 lux	L8 :8.31 lux	L11 :24 lux	L14 :55 lux
L3 :63 lux	L6 :26 lux	L9 :8.19 lux	L12 :26 lux	L15 :63 lux

$$\text{Average Lux level on road} = \frac{L1 + L2 + L3 + \dots + L15}{15} = 32.47 \text{ lux}$$

1.2.2 Problem Statement

Currently most of the conventional type street lights are been converting to LEDs. Only energy saving aspect is garnering more attraction by the governments. But quality aspects like glare, uniformity ratios and color rendering should not be compromised.

There are no proper criteria or standardize method to replace these conventional type street lamps to LEDs. Some common practices in the field are use 120W LED street lights to replace 250W sodium vapour lamps, use 60W LED street lights to replace 125W mercury vapour lamps and use 15W, 18W, 20W indoor type LED bulbs for minor roads without considering light output or efficacy of LED luminaires.

Inadequate lighting levels and very low uniformity ratio are the main problems associated with street lighting projects due to wrongly selected luminaires, distribution type and mounting positions. Also too much of light will waste energy. The initial cost of implementing a LED retrofit street lighting project is comparatively high due to the cost of LED luminaires. Project financing become difficult due to long payback periods. But if not designed properly, it will not meet the expectations of this kind of project such as energy saving, and will not meet the safety and visibility needs of the road users. Therefore, designing economical and effective LED retrofit project is a challenge.

1.3 Objectives of the Research

Development of a guideline for designing economical and effective retrofit LED street lighting system for Sri Lanka is the ultimate objective of this research.

As the final outcome of the research, a simplified and practical method which someone can use as a rule of thumb to decide the minimum wattage/ lumen output, light distribution type, mounting height of the luminaire, slope angle and overhang of the LED street lights to replace the conventional type street lights by considering the

road class (Class A/ Class B/ Secondary-Minor roads), number of lanes (1 lane/ 2 lane/ 4 lanes/ 6 lanes) and installation pattern (single side/ staggered/ opposite) will be presented.

1.4 Chapter Summary

The thesis is ordered as follow to achieve the objectives discussed in section 1.3.

First chapter gives a brief introduction on importance of street lights, background of LED technology, condition of street lights in Sri Lanka and problems associated with not having a standardize method to replace the conventional type street light with LED.

Second chapter review the literatures related to road lighting, terms and definitions, international standards for roadway lighting, different standards used in other south Asian countries for roadway lighting and international standards practicing in Sri Lanka for roadway lighting.

Chapter 3 is the methodology. It describes the design steps to obtain the optimum street light design.

Chapter 4 includes a detailed discussion on how to do the analysis to determine luminance value, uniformity (overall and longitudinal), threshold of increment, surround ratio and minimum illumination level considering the road conditions for different road classes.

Chapter 5 presents how to do the economic analysis for a retrofit project to check the viability of such project. In includes the simple payback calculation and net present value analysis for selected roads.

Chapter 6 provides a detailed discussion on results and observations obtained throughout the research.

Chapter 7 is the conclusion.

2. LITERATURE SURVEY AND PRESENT ROAD LIGHTING STANDARDS

2.1 Literature Survey

In 2015 Rosaria Ciriminna, Lorenzo Albanese, Francesco Meneguzzo and Mario Pagliaro has shown the positive side of LED street light conversions through their study- 'LED Street Lighting: A Looking Ahead Perspective' [4]. LED street lights emit light efficiently in downward direction, therefore reduce the light loss. Also high intensity discharge lamps take significant time to ignite. But LED come to its full brightness in no time. The average life time of LED is much longer due to technology advances compared to conventional technologies. When compared to high pressure sodium which is having colour rendering value around 25-30, LEDs have high CRI values more than 80.

Michael Jackett and William Frith has shown there is an impact of road lighting to the night time crashes in their research in 2013 [5].

'Demand-side management for municipal street lighting' which was published in July 2012, prepared for Asian Development Bank (ADB) and Ministry of Power and Energy, Sri Lanka has introduced some guidelines on how to initiate a street light project [2]. Two pilot projects have been done, one in Homagama area which is in CEB territory and second pilot project is in LECO territory. Based on the BS/EN 13201 street lighting standard, those selected roads have been classified. According to that analysis, selected Class A roads are under ME5 road class, Class B roads are under ME6 and Class C roads are under S5 road lighting class. To determine Class A road luminance levels, it has been assumed those roads have mixed traffic and motorized traffic, slow moving vehicles, and possibly cyclists and pedestrians and traffic flow is under 7000 vehicles per day and under 3 intersections per kilometer. Class B road conditions were assumed similar to the Class A, but no parked vehicles and significant activity on the verges. For Class C roads it has been assumed lower speed with normal levels of pedestrians and cyclists, no parked vehicles and no traffic calming [2]. As the next step, site conditions like roadway way width, carriageways type (single/dual), positions of street lighting poles and mounting

heights have been gathered. Considering the performance of luminaires like wattages, efficacy, life time, lumen depreciation factor, Colour Rendering Index (CRI), Colour Temperature (CT), ballasts and control gear, range of luminaires have been selected for these pilot projects. Then after thorough analysis they have selected 250W high pressure sodium vapour (HPS), 150W HPS and 2 x 14W T5 fluorescent type luminaires for Class A, Class B and Class C respectively. But that analysis is not mentioned in the report. As the final step, by using street lighting design software, they have identified the optimal street lighting pole spacing for particular situation and located new street light poles and luminaries accordingly. These pilot projects were done some times back in a time that LED luminaires were not popular. But today fluorescent type light fixtures and other conventional type light sources are fade away from the market and LED products are coming gradually. Still there is no proper standard on how to choose most appropriate LED luminaire, considering the situation/ road type.

Chandana S. Kulasooryage, Satish S. Namasivayam and Lanka Udawatta has done a research on energy efficiency and optimality of LED based street lighting system in 2015 [6]. They have done a pilot project in Galle road from Bambalapitiya junction to Kollupitiya junction to find the most suitable LED replacement for existing 250W HPS street lamps. The ME5 road lighting class with minimum illumination level of 7.5lux and average luminance value of 0.5cd/m² as per British Standards has been selected for this road. Lighting design software RealityTM has been used for simulations [6]. It was found that 111W LED can be used to replace the existing 250W HPS for this road. Then simple payback period and Net Present Value (NPV) for the period of twelve years has been calculated for different scenarios. According to that calculations it was disclosed that CFL bulb replacement is not economical as the NPV figure becomes negative. Therefore, they have suggested not to replace existing CFL by LED equivalent to achieve energy saving. But due to the new import regulations, laws has been imposed to limit the import of CFL in to Sri Lanka. Also government is encouraging the provincial councils and local government to replacing inefficient street lamps with efficient LED street lamps through 'National program on energy demand side management, efficient energy use and energy conservation –

The presidential task force on demand side management'. Hence this is the high time to implement a guideline on designing economical, effective and human friendly retrofit LED street lighting system in Sri Lanka.

Huaizhou Jin, Shangzhong Jin, Liang Chen, Songyuan Cen, and Kun Yuan has done a research on lighting performance of LED street lights with different color temperatures. As per the international standards, it is recommended to have intensity levels between 0.3cd/m^2 and 2cd/m^2 to have proper adaptation of lights at night time under mesopic conditions [7]. Though the blue LEDs have higher efficacy, through this research they have identified blue LEDs will harm the eye's dark adaption and color perception abilities. Also fog penetration of blue LEDs is low creating inconvenience situation for motorists. Therefore, they are recommending to have warm colour (colour temperature 3000K) for street lighting designs.

Ö Güler and S Onaygil has done a research to find the relation of luminance uniformity and visibility level in road lighting in 2002-time period. Visibility level for different type of installation patterns like single side, opposite, staggered, twin central has been measured for different light distribution types (cut-off, non-cut-off and semi cut-off) by changing the uniformity levels. Uniformity levels have been varied by changing the luminaire mounting position and span. Finally, it has been revealed that uniformity ratios should be according to recommended values to have a proper visibility level. Also luminaires with non-cut-off light distribution type leads to disability glare which adversely affect to visual conditions [3].

Life cycle cost analysis can be used to determine the feasibility of LED conversion project [8]. Jeong Tai Kim and Taeyon Hwang has done a test project in South Korea in 2016 to analyze the energy saving that can be achieved by replacing existing high pressure sodium luminaires with LED. They have disclosed 69% energy saving can be achieved with this high pressure sodium to LED conversion and can be increased up to 77% by using dimming controllers which are sensitive to pedestrian movements.

As LED luminaires are incorporated with electronic drivers, the effect from LEDs to power network and power quality is a problem that should be addressed properly. A

Gil-de-Castroa, A Moreno-Munoz, A Larssonb , JJG de la Rosac and MHJ Bollen has done a research to study the power quality changes with LED and high pressure sodium lamps [9]. When high pressure sodium lamps are connected to electronic ballasts, the total harmonic distortion current has been decreased rather than using electromagnetic ballasts. Also they have discovered the total harmonic distortion current of LED lamps is lower than HPS with electronic ballasts.

2.2 Road Lighting Standards

2.2.1 Terms and definitions

Luminance or brightness (L)

Luminance or brightness means luminous flux per unit projected area of a surface in a given direction. It measures the amount of light emitted or reflected from a surface and incident upon the eye. Visual brightness depends on the reflective properties of the surface material.

Measured unit is candela per square meter (cd/m^2)

Average luminance (L_{av})

Luminance of the road surface is averaged over the carriageway [10]. This value depends on luminous flux of the luminaire, light distribution of the luminaires, pole spacing, installation pattern, mounting height, overhang, slope and reflection properties of the road surface.

Overall Uniformity (U_o)

Overall uniformity is the ratio of the minimum luminance on the road surface to the average luminance.

Longitudinal Uniformity (U_l)

Longitudinal uniformity is the ratio of the minimum to the maximum luminance [11] along a line or lines parallel to the run of the road. Usually this is measured along a line at the middle of a lane.

Threshold Increment (TI)

Disability glare occurs when the light scatters within the eye by reducing the contrasts of the retinal image. Veiling luminance means the luminance superimposed over the eye's retina due to this stray light. Disability glare occurs for the motorists

due to the illuminance or lighting level on their eye and the direction of light comes from the luminaires. This disability glare decreases as a function of the average road luminance. TI means the percentage increase in the luminance difference needed to make the object equally visible in the presence of glare as in the absence of glare.

Surround Ratio (SR)

Sufficient lighting in the surrounding of the road creates a proper adaptation of the eye. SR is the ratio that measures the amount of light falling on the surrounds as a proportion of that falling on the road.

2.2.2 International standards for roadway lighting

Some commonly used roadway lighting standards in the world are CIE 115-2010: Lighting of Roads for Motor and Pedestrian Traffic published by International Commission on Illumination or Commission Internationale de l'Eclairage (CIE); BS/EN 13201-2 Road: Lighting—Part 2: Performance Requirements and IES/ANSI RP-8-00: American National Standard Practice for Roadway Lighting published by Illuminating Engineering Society of North America (IESNA) [12].

2.2.3 Standards used in other south Asian countries for roadway lighting

Based on the above international standards, many countries have defined lighting levels to be maintained on their roads considering the road conditions.

In India, BIS 1981 standard, roads have been classified according to the traffic density of the road [13]. Then for each category, they have recommended mounting height and levels of illumination (Refer Table 2.1 and Table 2.2).

Nepal Road Standard-2070 published by Ministry of Physical Infrastructure & Transport-Government of Nepal has defined mounting heights, illumination levels and uniformity level to be maintained on roads. According to that, mounting height is expecting to be at least 9m and 10m to 15m height is usually preferable. Recommended level of illumination is 30lux on important high speed roads and 15lux on other main roads. The ratio of minimum to average illuminations is 0.4 [14].

Table 2.1: Road classification in India according to BIS 1981

Group	Description
A1	For very important routes with rapid and dense traffic where the only considerations are the safety and speed of the traffic and the comfort of drivers
A2	For main roads with considerable mixed traffic like main city streets, arterial roads and thoroughfares
B1	For secondary roads with considerable traffic such as local traffic routes and shopping streets
B2	For secondary roads with light traffic
C	For residential and unclassified roads not included in the previous groups
D	For bridges and flyovers
E	For towns and city centers
F	For roads with special requirements such as roads near airports and railways

Adopted from Bureau of Indian Standards. 1981. Indian Standard, code of practice for lightning of public thoroughfares, IS 1944-7: 1981 (R2003). New Delhi, India [13].

Table 2.2: Recommended levels of illumination and mounting height of luminaires according to BIS 1981

Type of Road	Road characteristics	Average level of illumination on road surface in Lux	Ratio of minimum/Average illumination	Type of luminaire preferred	Min:Max (%)	Mounting height of luminaire
A-1	Important traffic routes carrying fast traffic	30	0.4	Cut-off	33	9 to 10 meters
A-2	Main roads carrying mixed traffic like city main roads/streets, arterial roads, throughout ways	15	0.4	Cut-off	33	9 to 10 meters
B-1	Secondary roads with considerable traffic such as local traffic routes and shopping streets	8	0.3	Cut-off or semi-cut-off	20	7.5 to 9 meters
B-2	Secondary roads with light traffic	4	0.3	Cut-off or semi-cut-off	20	7.5 to 9 meters

Adopted from Bureau of Indian Standards. 1981. Indian Standard, code of practice for lightning of public thoroughfares, IS 1944-7: 1981 (R2003). New Delhi, India [13].

2.2.4 International standards practicing in Sri Lanka for roadway lighting

Road development Authority (RDA) is the responsible authority for developing and maintaining of national highway system which includes Class A, B and expressways. According to the 'LED Road Lighting Specification in National Highways' published by RDA, they have adopted British standards: EN TR 13201-1-2014 – Guidelines on selection of lighting classes to define lighting levels for Sri Lankan roads.

Recommended lighting levels by RDA for main national highways [15];

- Average luminance- minimum maintained (L) : 1.5 cd/m²
- Overall uniformity ratio- minimum (U₀) : 0.4
- Longitudinal uniformity ratio- minimum (U_l) : 0.7
- Threshold increment (TI) <= 10%
- Minimum surrounds ratio (SR) : 0.5

2.2.5 EN 13201-2:2015 'Road lighting - Part 2: Performance requirements

A lighting class is defined by a set of photometric requirements aiming at the visual needs of certain road users in certain types of road areas and environment [10];

The main idea of presenting lighting classes is to make it easier to define and produce suitable lighting conditions on roads. The lighting classes have been defined by considering vehicle speed, traffic volume and composition, number of intersections per kilometer, parked vehicles, luminance level in surrounding, navigation difficulty, visual guidance and traffic control.

The ME classes are intended for motorized traffic. The CE classes are for conflict areas such as complex road intersections and roundabouts. The S classes are intended for road areas lying separately or along the carriageway of a traffic route, residential roads, pedestrian streets, parking areas, schoolyards etc. [10]

Table 2.3: ME series of lighting classes

Class	Luminance of the road surface of the carriageway for the dry road surface condition			Disability glare	Lighting of surroundings
	L in cd/m ² (Minimum maintained)	U0 (Minimum)	U1 (Minimum)	TI in % (Maximum)	SR (Minimum)
ME1	2.0	0.4	0.7	10	0.5
ME2	1.5	0.4	0.7	10	0.5
ME3a	1.0	0.4	0.7	15	0.5
ME3b	1.0	0.4	0.6	15	0.5
ME3c	1.0	0.4	0.5	15	0.5
ME4a	0.75	0.4	0.6	15	0.5
ME4b	0.75	0.4	0.5	15	0.5
ME5	0.5	0.35	0.4	15	0.5
ME6	0.3	0.35	0.4	15	No requirement

Adopted from Technical Committee CEN/TC 169 "Light and Lighting", "EN 13201-2:2003 Road lighting - Part 2: Performance requirements," European Committee for Standardization, 2003.

Table 2.4: CE series of lighting classes

Class	Horizontal illuminance	
	E in lux (Minimum maintained)	U0 (Minimum)
CE0	50	0.4
CE1	30	0.4
CE2	20	0.4
CE3	15	0.4
CE4	10	0.4
CE5	7.5	0.4

Adopted from Technical Committee CEN/TC 169 "Light and Lighting", "EN 13201-2:2003 Road lighting - Part 2: Performance requirements," European Committee for Standardization, 2003.

Table 2.5: S series of lighting classes

Class	Horizontal illuminance	
	E in lux (Minimum maintained)	E_{min} in lux (Minimum)
S1	15	5
S2	10	3
S3	7.5	1.5
S4	5	1
S5	3	0.6
S6	2	0.6

Adopted from Technical Committee CEN/TC 169 "Light and Lighting", "EN 13201-2:2003 Road lighting - Part 2: Performance requirements," European Committee for Standardization, 2003.

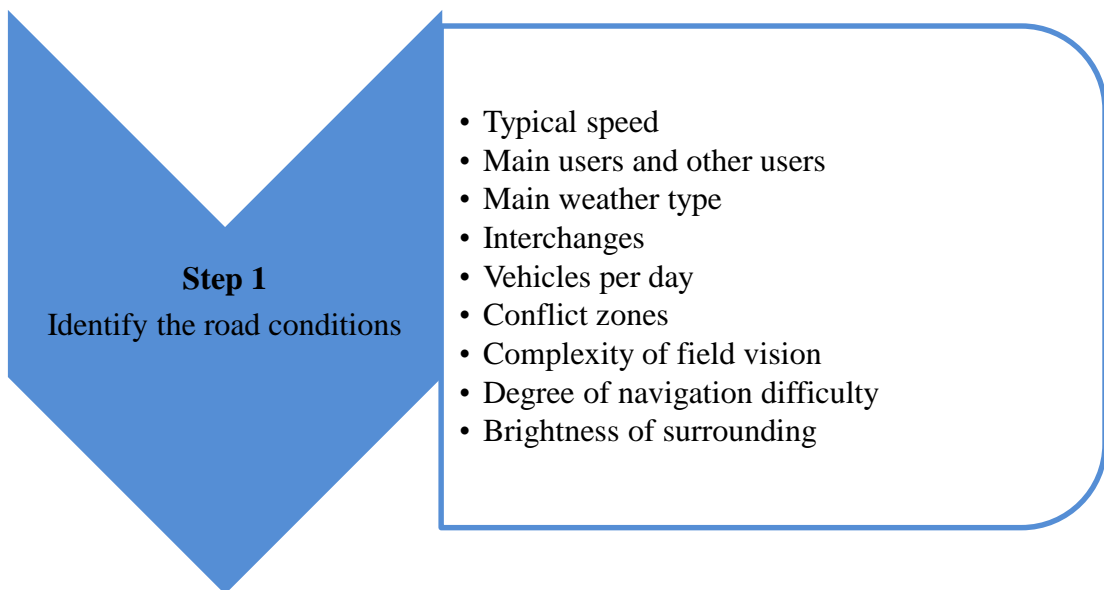
3. METHODOLOGY

Street lighting design is an advance procedure which involves numerous factors that need to be addressed while serving the utmost purpose of safety of road users.

Succeeding correct and acceptable illuminance and luminance values while achieving the highest possible energy saving with the least investment cost is really a challenge. Implementing LED retrofit street lighting system is more difficult than designing a new project as it is difficult to balance the investment and saving through energy consumption.

In this chapter the procedure which was followed to decide the wattage/ lumen output, light distribution type, luminaire mounting height, overhang and slope angle of the LED street lights to replace the conventional type street lights by considering the road class (Class A/ Class B/ Secondary-Minor roads) [16], number of lanes (1 lane/ 2 lane/ 4 lanes/ 6 lanes) and installation pattern (single side/ staggered/ opposite) will be discussed.

3.1 Step 1- Identify the road conditions



First step is to identify the road conditions of Class A, Class B and minor roads. As the lighting classes in EN 13201-2 standards, have been defined by considering vehicle speed, traffic volume and composition, intersection density, parked vehicles, ambient luminance, difficulty of navigation, visual guidance and traffic control, it is

needed to identify the road conditions for each type of road. Refer appendix A for ‘Field survey form’ which someone can use to gather necessary data to identify the road conditions when doing a retrofit type street light project.

Here, six cases have been identified according to the proposed road classification (Refer Figure 3.1). The detailed analysis for each case is mentioned in chapter 4. According to that analysis the minimum maintained average luminance, minimum overall uniformity ratio, minimum longitudinal uniformity ratio, threshold increment, minimum surrounds ratio, average illumination level and minimum illumination level were decided.

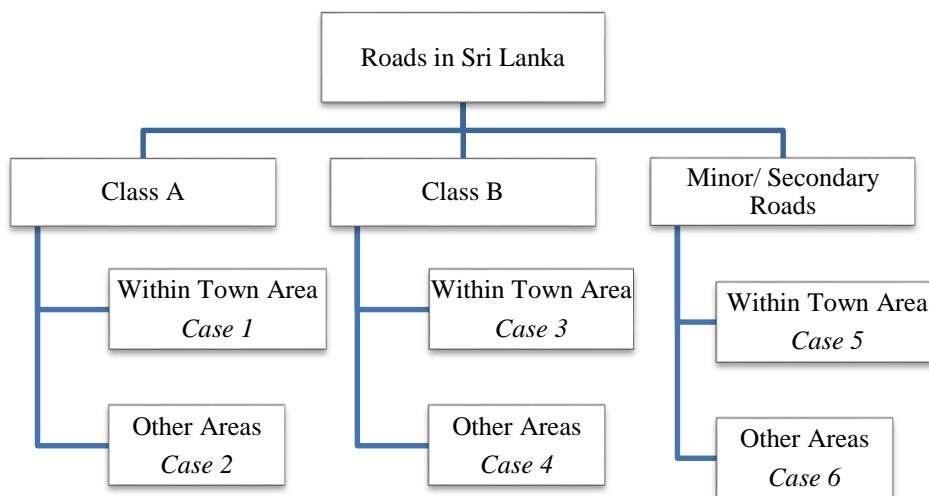
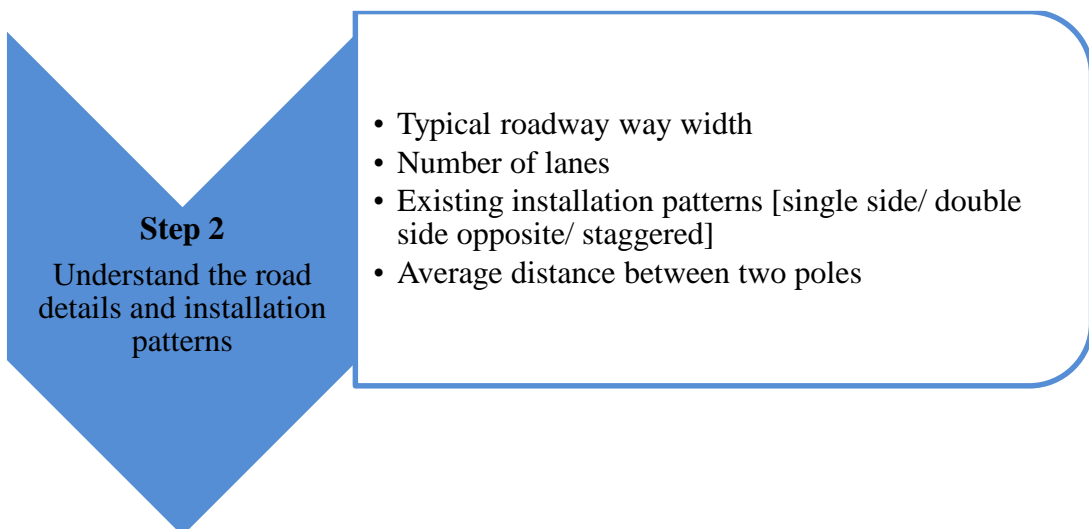


Figure 3.1: Road classification done to identify the different road conditions

3.2 Step 2-Understand the road details and installation patterns



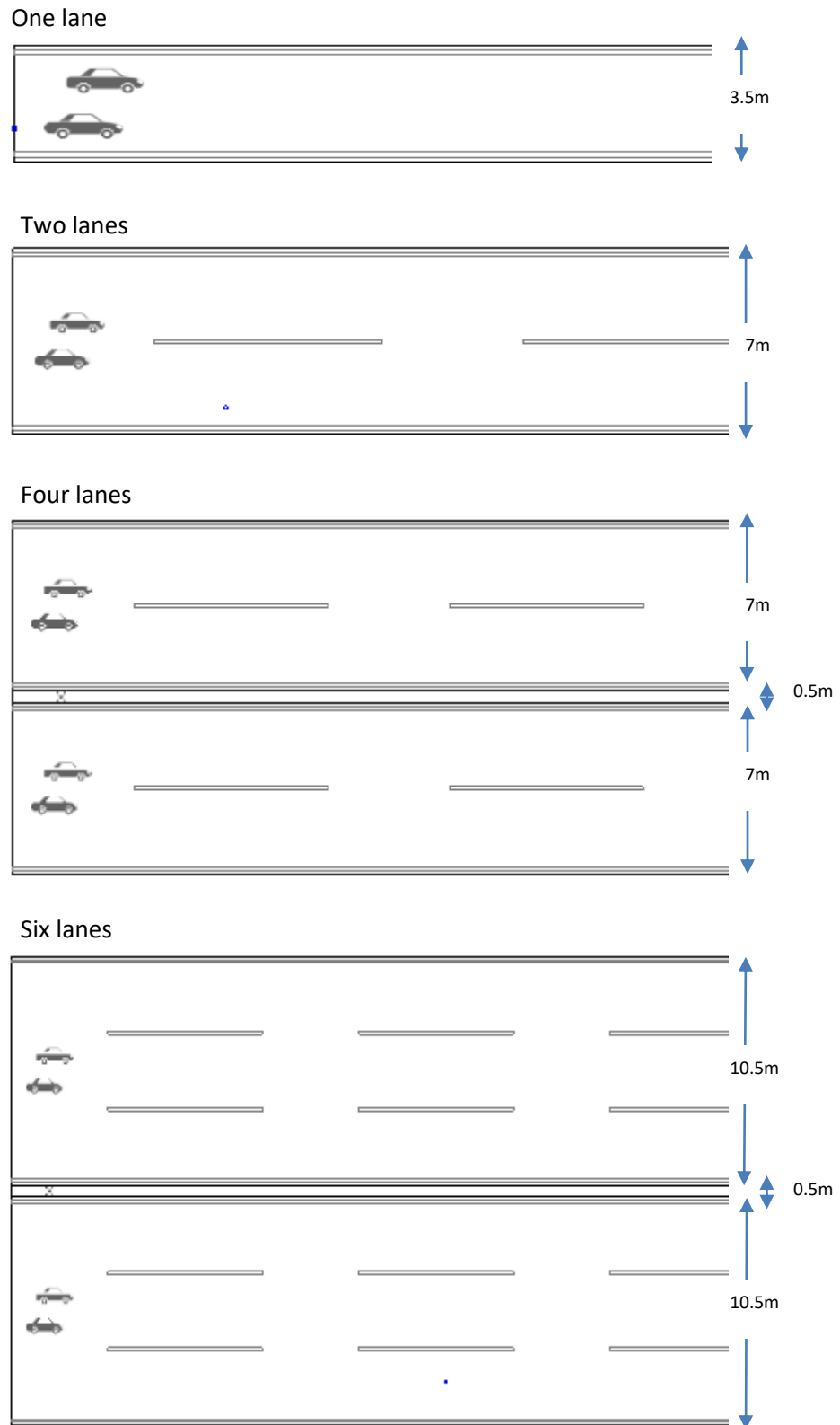


Figure 3.2: Considered road widths for simulations

In Sri Lanka, the width of the roads is not standardized and typical width of one lane is 3.5m. Kerb width was considered as 0.5m. The width of different types of roads considered for simulations are illustrated in Figure 3.2.

For Class A and B roads; one lane, two lanes, four lanes and six lanes were considered. For minor roads only one and two lanes were simulated.

In Sri Lanka, we can find single side, double side and staggered type street light installation patterns. Pole spacing is typically 30m to 40m span and therefore simulations were done for both 30m and 40m pole spacing in single side and double side installation patterns. For staggered type it was simulated for 60m pole spacing (refer figure 3.3, 3.4 and 3.5).

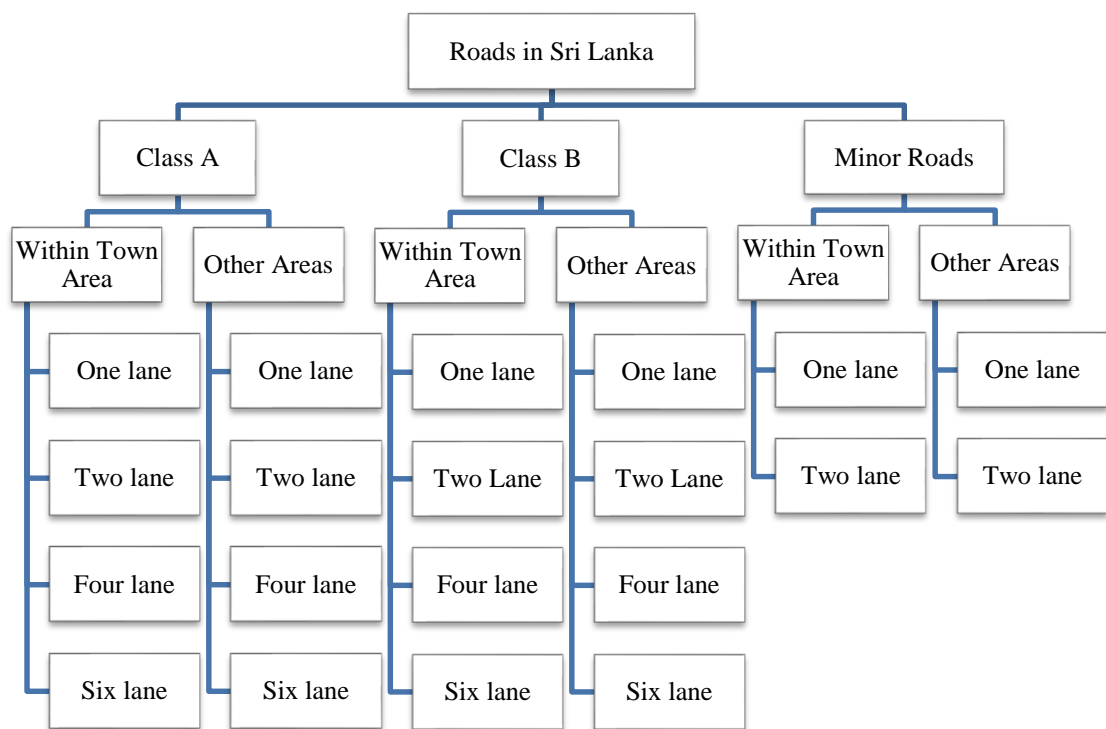


Figure 3.3: Road classification

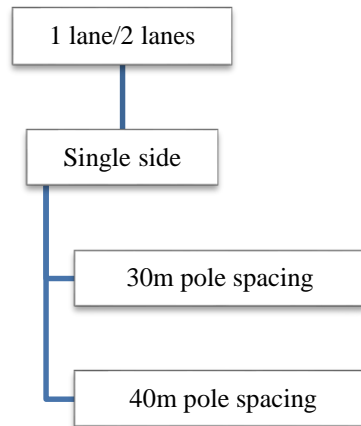


Figure 3.4: Sub classification for one lane and two lane roads

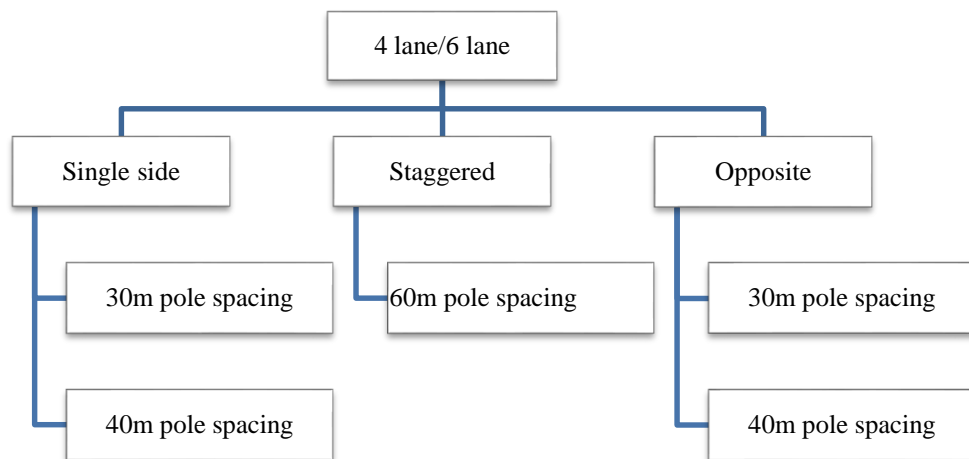
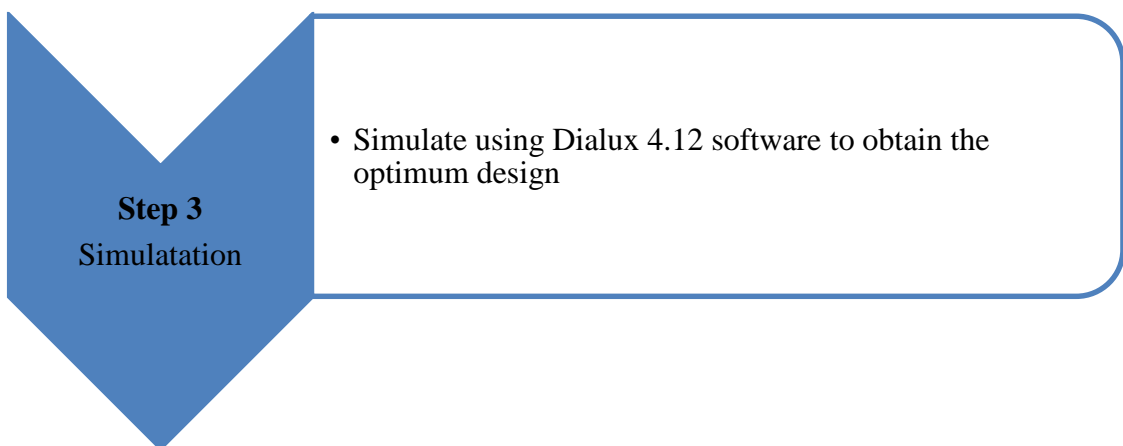


Figure 3.5: Sub classification for four lane and six lane roads

3.3 Step 3- Simulation



3.3.1 Software used for simulations

DIALux is one of the leading software for lighting design in all over the world. It is available free of charge. It has the facility to plan, calculate and visualize light for indoor and outdoor areas like buildings, individual rooms, sports lighting and street lighting [17]. Dialux 4.12 software is used for the simulations and it offers the facility to do street light designs based on either BS/EN 13201-2 standard or IES/ANSI RP-8-00 standard.

3.3.2 Feeding data, photometric files

Computer based simulations were done for each identified scenario according to the road classification (Figure 3.3, Figure 3.4 and Figure 3.5). As the initial step, configuration of road in the software was done. For that number of lanes, lane width and installation pattern for the selected scenario should be entered (Figure 3.6).

For the simulation purpose, photometric files from brand- Philips were obtained. Light distribution pattern is an important factor when selecting a luminaire. There are five types of light distribution types (Figure 3.7). For one simulation all five light distribution types were used as it is needed to identify the best fit light distribution pattern for minimum lumen output.

3.3.3 Optimization procedure

The objective is to find the luminaire with minimum lumen output which is suitable for the selected road category and installation pattern. Therefore, the lumen output of all five light distribution patterns changed in to a minimum value. Refer Figure 3.8.

Dialux 4.12 software has the facility to obtain the optimum value by changing pole distance, mounting height, overhang and slope angle for a given installation pattern. Therefore, mounting height was varied from minimum 6m to 13m. For one lane and two lane roads tried to get the optimum between 6m to 10m and for four lane and six lane roads between 6m to 13m. Overhang was varied from 0 to 2.5m and slope angle from 0° to 15° and simulation were carried out for that certain lumen output (Figure 3.9)

Lumen output of all five light distribution patterns were gradually increased and same procedure was followed until the software gives an optimum design for the selected road type and installation pattern (Figure 3.10).

Figure 3.6: Configure the road in the software- Example: Class A within town area, two lanes

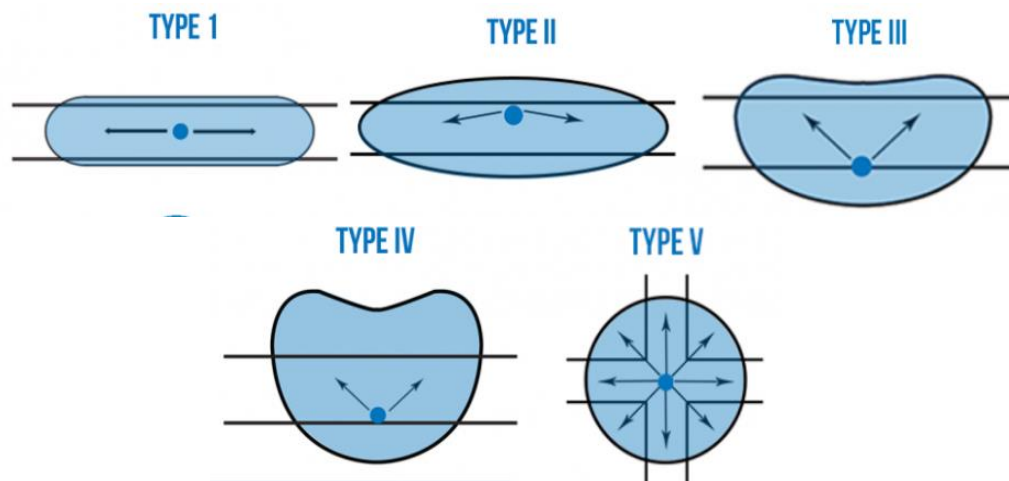


Figure 3.7: Light distribution types

Source: "PREMISE," [Online]. Available: <https://www.premised.com/iesna-light-distribution-types-what-do-they-mean/>. [Accessed 23 September 2020]. [18]

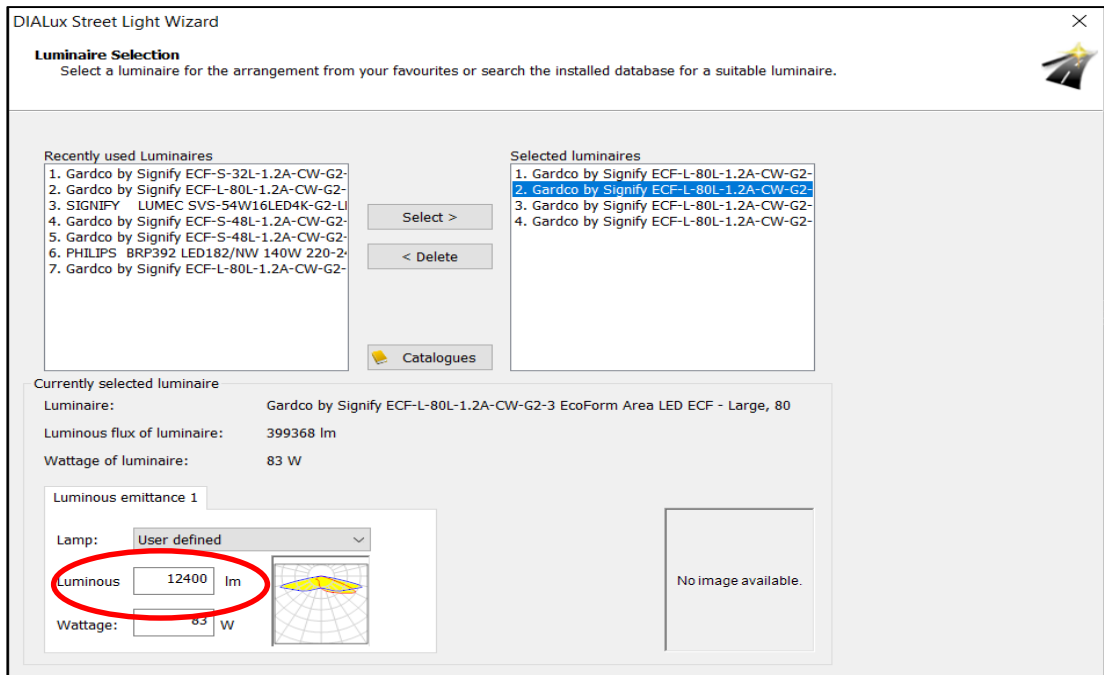


Figure 3.8: Changing the lumen output of all five light distribution types into a minimum value

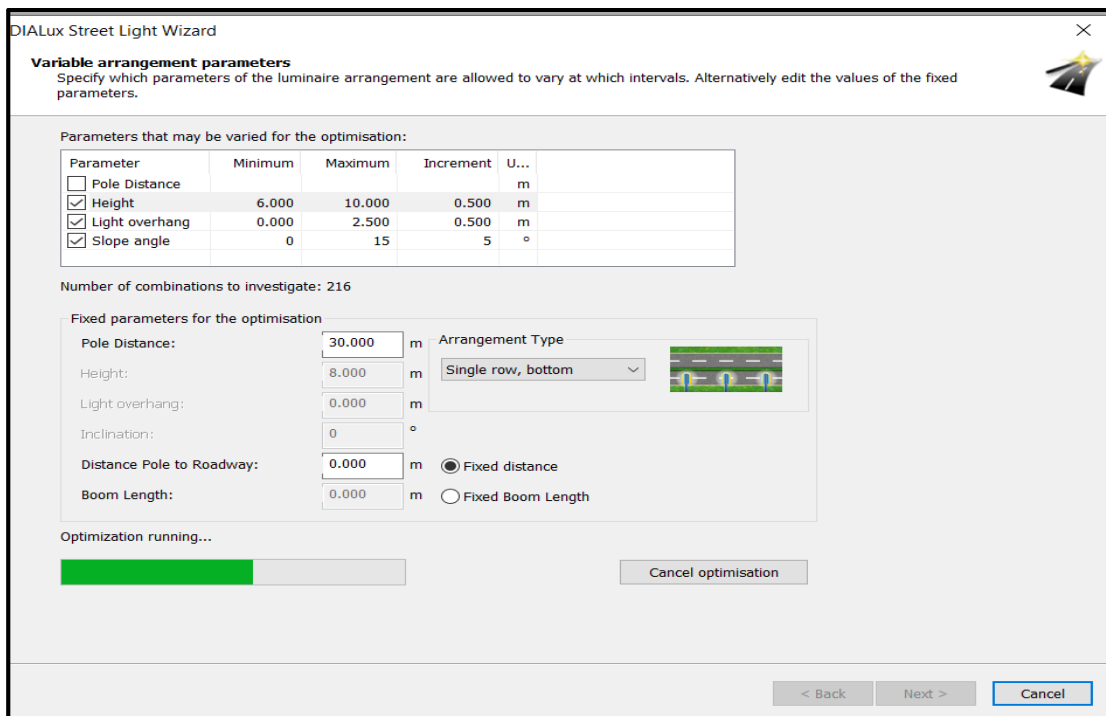


Figure 3.9: Simulation for Class A, within town area, two lane, 30m pole spacing, single side installation

Positioning suggestions
Select a suggested luminaire arrangement for implementation.

Classification of the arrangement variants:
Suitable: 1, largely suitable: 0, inadequate d: 359

Distance [m]	Height [m]	Overhan [m]	Slope angle [°]	Type	Lm [cd/m ²]	U0	UI	TI [%]	SR
☑ Suitable variants (all target values met)									
30.000	10.000	2.000	0	(1)	1.50	0.70	0.84	10	0.66
☒ Inadequate variants									
30.000	6.000	2.500	0	(1)	2.08	0.34	0.47	26	0.38
30.000	6.000	2.500	5	(1)	1.91	0.27	0.48	26	0.42
30.000	6.000	2.500	10	(1)	1.72	0.20	0.45	26	0.45
				Target ...	1.50	0.40	0.70	10	0.50

If you want to implement a positioning suggestion, select it in the list and subsequently complete the wizard. Else simply cancel the wizard.

Immediately Calculate Created Street.
 Save set values for further optimisations.

CSV Export

Figure 3.10: Optimum design for Class A, within town area, two lane, 30m pole spacing, single side installation

3.3.4 Final result

According to the road classification in figure 3.3, 3.4, 3.5 and road condition analysis, 232 different combinations were identified. For each combination, the procedure discussed in this chapter was followed to obtain the optimum design. As the final result, a chart was developed which includes

- Minimum wattage/ lumen output
- Light distribution type
- Luminaire mounting height
- Overhang
- Slope angle

of the LED street lights to replace the conventional type street lights by considering

- Road class (Class A/ Class B/ Secondary-Minor roads)
- Number of lanes (1 lane/ 2 lane/ 4 lanes/ 6 lanes)
- Installation pattern (single side/ staggered/ opposite)

Refer Appendix B for summarized output.

3.3.5 Developing a database

XAMPP is a free, open-source, cross-platform which works on Windows, Mac and Linux operating systems. It makes an offline local server or localhost within the computer. 'Sublime Text 2' is a code editor which supports many computer languages. Programme was written using PHP (Hypertext Preprocessor) which is a language used for web development applications.

An interface was developed using XAMPP to make it easy to find the results in Appendix B.

For Class A and Class B Road Category	Click Here!
For Secondary/ Minor Road Category	Click Here!

Figure 3.11: Interface for road type selection

<u>Project for Class A & B</u>	
Road category	: <input type="text" value="Select"/> ▾
Town area/ Other areas	: <input type="text" value="Select"/> ▾
Number of lanes	: <input type="text" value="Select"/> ▾
Installation pattern	: <input type="text" value="Select"/> ▾
Number of junctions per km	: <input type="text" value="Select"/> ▾
Vehicles per day	: <input type="text" value="Select"/> ▾
Conflict area or not?	: <input type="text" value="Select"/> ▾
<input type="button" value="Submit"/>	

Figure 3.12: Developed interface for Class A and Class B roads

Project for Secondary/ minor roads

Town area/ Other areas : ▾

Number of lanes : ▾

Installation pattern : ▾

Figure 3.13: Interface for secondary/ minor roads

Minimum Lumen Output (lm)	: 33,000
Average Illumination Level on Road (lux)	: 27
Lighting Distribution Pattern	: Type IV
Luminaire Mounting Height (m)	: 10.5
Overhang (m)	: 2.5
Slope Angle (degree)	: 0

Figure 3.14: Output results
 Example- for Class A, within town area; 4 lanes, 30m pole spacing

4. ANALYSIS OF ROAD CONDITIONS

4.1 Assumptions Used for the Road Condition Analysis

4.1.1 Assumptions used for the road condition analysis for class A and B

When analyze the Class A and B roads in town areas and in other areas, assumptions mention in Table 4.1 were made.

For town areas, typical speed was taken below 60 km/h and for roads not within town areas it was taken more than 60 km/h. Traffic calming areas were taken into consideration only for roads within town area. In town areas number of interchanges quantity is taken more than three per kilometer and in other areas it was simulated for any quantity. Parked vehicles were taken care for town areas and for other areas it was not.

Table 4.1: Assumptions for analysis of Class A and Class B roads

	Parameter	Description	Values	Town area [Case 1 & 3]	Other areas [Case 2 & 4]
i)	Typical speed	How high is the typical speed of the main user in the street? Main users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic <i>Typical speed of the main user?</i>	High [>60 km/h]		✓
			Medium [Between 30-60km/h]	✓	
			Low [Between 5-30km/h]		
			Walking speed (<5km/h)		
ii)	Main weather type	Enter typical weather	Dry	✓	✓
			Wet		
iii)	Traffic calming areas	Have traffic calming areas taken into consideration?	Yes	✓	
			No		✓

iv)	Interchanges	How the street connects to other streets and the frequency of interchanges/junctions	<3 per km		✓
		<i>Enter the frequency of simple junctions</i>	>= 3 per km	✓	✓
v)	Parked vehicles	Do parked vehicles have to be taken into consideration?	Yes	✓	
			No		✓
vi)	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification is made <i>Brightness of surrounding is?</i>	Low (Rural environment)		✓
			Medium (City environment)	✓	
			High (Inner-city environment)		

4.1.2 Assumptions used for the road condition analysis in minor roads

Face recognition is very much important for this type of minor roads as these roads are used by lot of pedestrians and need to feel the sense of safety for them. Parked vehicles were not considered. Typical speed was taken between 5-30 km/h.

4.1.3 Considered number of vehicles for the analysis

For Class A roads within town areas, all vehicle conditions were considered (less than 7,000, 7,000-15,000, 15,000-25,000 and more than 25,000). Class A other area roads and class B town area roads vehicles were considered below 25,000 per day.

Table 4.2: Vehicles per day considered for analysis

	Parameter	Values	Case 1	Case 2	Case 3	Case 4
i)	<i>How many vehicles are there per day?</i>	Less than 7000	✓	✓	✓	✓
		Between 7000 and 15000	✓	✓	✓	✓
		Between 15000 and 25000	✓	✓	✓	
		More than 25000	✓			

4.2 Road Condition Analysis through Dialux 4.12 software

As discussed in chapter 3 step 1- Identify road conditions; minimum maintained average luminance, minimum overall uniformity ratio, minimum longitudinal uniformity ratio, threshold increment, minimum surrounds ratio, average illumination level and minimum illumination level need to be decided depending on the road conditions like vehicle speed, traffic volume and composition, intersection density, parked vehicles, ambient luminance, difficulty of navigation, visual guidance and traffic control.

Dialux 4.12 software gives the facility to do the road condition analysis and depending on the entered data lighting class is determined. Hence appropriate luminance and illuminance levels for the roads can be decided based on road conditions.

4.2.1 Case 1: Class A roads within town area

Table 4.3 shows the detailed analysis for Class A roads in town areas. Those data were fed in to the Dialux 4.12 software and lighting class was determined.

Table 4.3: Road condition analysis for Class A within town area roads

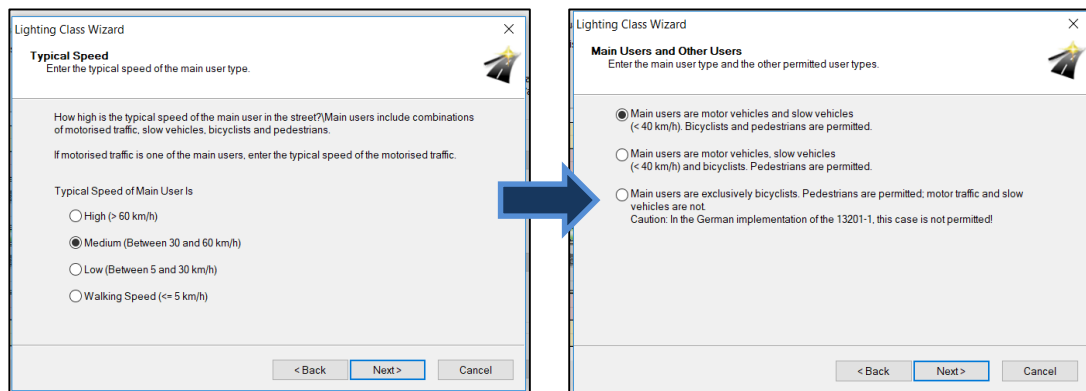
	Parameter	Description	Values	For normal situation	For conflict area
a	Typical speed	<i>Typical speed of the main user?</i>	High [>60 km/h]		
			Medium [Between 30-60km/h]	✓	✓
			Low [Between 5-30km/h]		
			Walking speed (<5 km/h)		

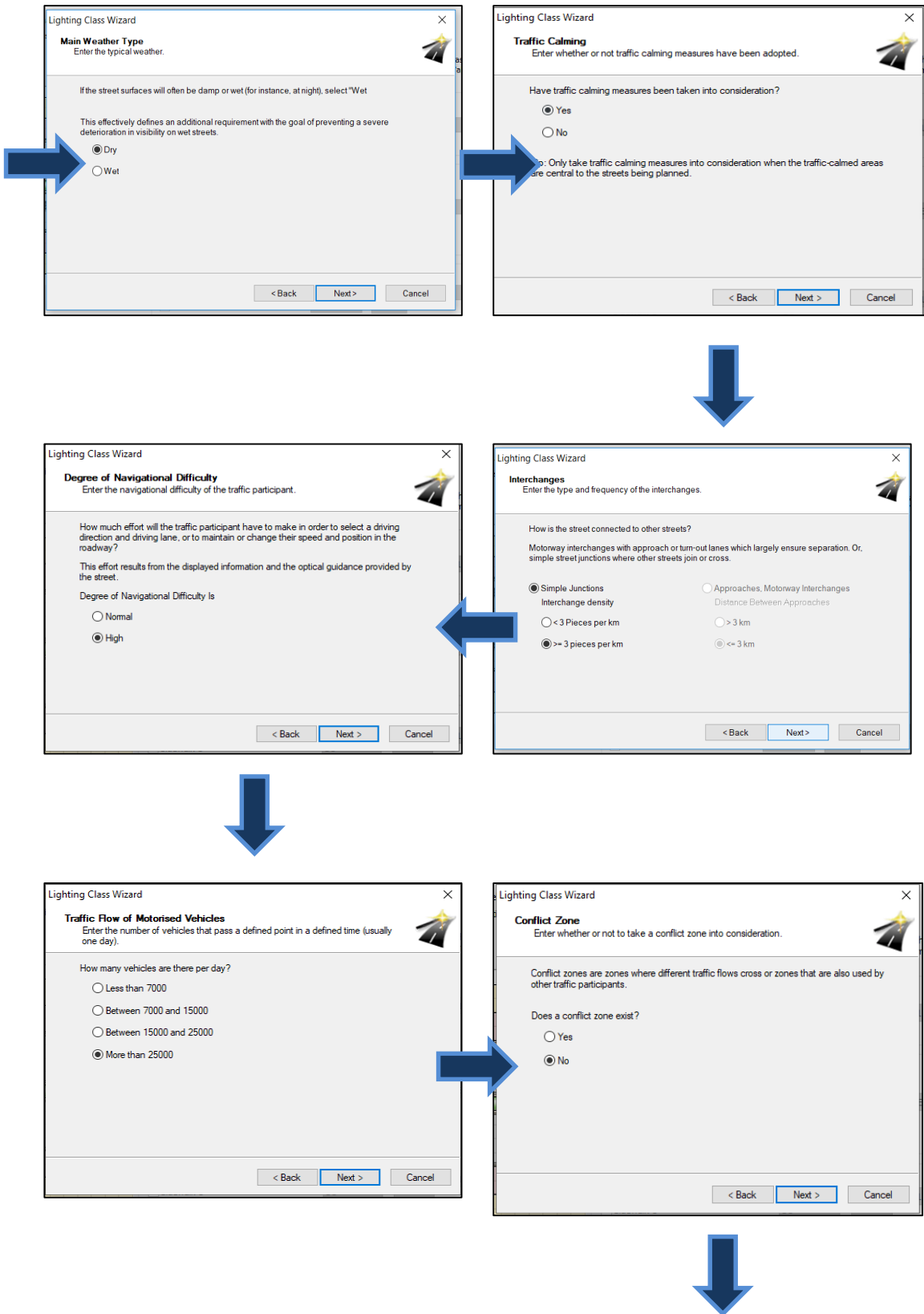
	Parameter	Description	Values	For normal situation	For conflict area
b	Main users and other users	Main users and other permitted users	Main users are motor vehicles are motor vehicles and slow vehicles <40km/h. Bicyclists and pedestrians are permitted		
			Main users are motor vehicles and slow vehicles <40km/h and bicyclists. Pedestrians are permitted	✓	✓
c	Main weather type	Enter typical weather	Dry	✓	✓
			Wet		
d	Traffic calming areas	Have traffic calming areas taken into consideration?	Yes	✓	✓
			No		
e	Interchanges	How the street connects to other streets and the frequency of interchanges/junctions <i>Enter the frequency of simple junctions</i>	<3 per km		
			>= 3 per km	✓	✓
f	Degree of navigation difficulty	How much of effort will the traffic participant have to make in order to select a driving direction and driving lane, or to maintain or change their speed and position in the roadway? <i>Degree of navigation difficulty is?</i>	Normal		
			High	✓	✓

	Parameter	Description	Values	For normal situation	For conflict area
g	Vehicles per day	How many vehicles are there per day?	< 7000	✓	✓
			Between 7000 and 15000	✓	✓
			Between 15000 and 55000	✓	✓
			>25000	✓	✓
h	Conflict zones	Conflict zones are the zones where different traffic flows cross or zones that are also used by other traffic participants	Yes	✓	
		Does a conflict zone exist?	No		✓
i	Parked vehicles	Do parked vehicles have to be taken into consideration?	Yes	✓	✓
			No		
j	Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit buildings) within the field of vision? Complexity of field vision is	Normal		
			High	✓	✓

	Parameter	Description	Values	For normal situation	For conflict area
k	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification is made Brightness of surrounding is	Low (Rural environment)		
			Medium (City environment)	✓	✓
			High (Inner-city environment)		
1	Traffic flow for bicyclist		Normal		
			High	✓	✓
Determined road lighting class				ME2	ME2

4.2.1.1 Road condition analysis through the Dialux 4.12 software





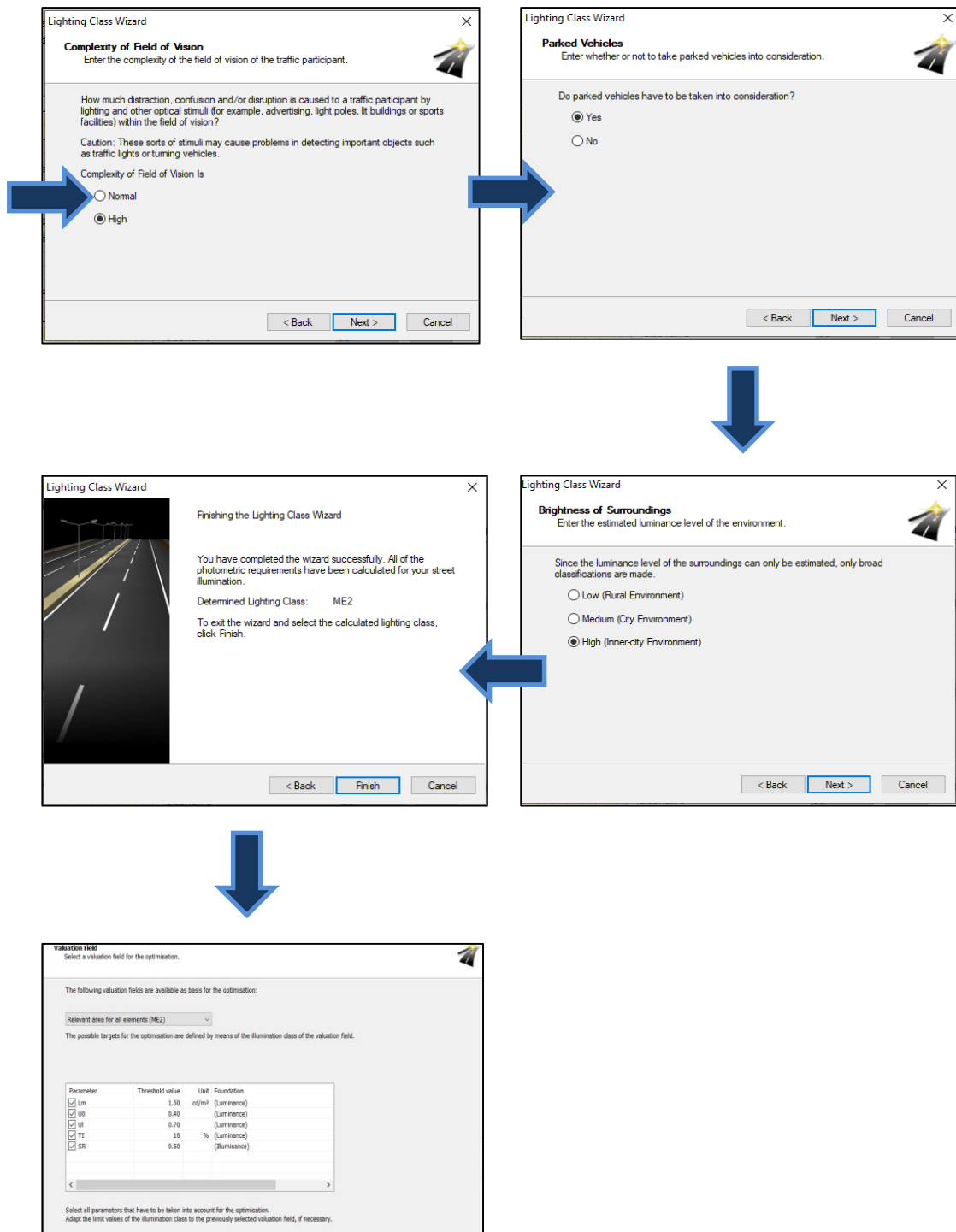


Figure 4.1: Road condition analysis through the software

Hence, according to the EN 13201-1 standard; Class A roads within town area needs to have below luminance values and uniformity ratios.

- Average luminance -minimum maintained (L) :1.5 cd/m²
- Overall uniformity ratio- minimum (U0) : 0.4
- Longitudinal uniformity ratio-minimum (UI) : 0.7
- Minimum surrounds ratio (SR) : 0.5
- Threshold increment (TI) <= 10 %

4.2.2 Case 2- Class A roads in other areas

Table 4.4 shows the detailed analysis for Class A roads in other areas. Number of vehicles were simulated for below 25,000 per day.

Table 4.4: Road condition analysis for Class A other area roads

		Value	For normal situation				For conflict area			
			Junctions <3 per km		Junctions >=3 per km		Junctions <3 per km		Junctions >=3 per km	
Parameter	Vehicles	< 15000	15000 - 25000	< 15000	15000 - 25000	< 15000	15000 - 25000	< 15000	15000 - 25000	
a	Typical speed	High [>60 km/h]	✓	✓	✓	✓	✓	✓	✓	✓
		Medium [Between 30-60km/h]								
		Low								
		Walking speed								
b	Main users and other users	All other users are permitted	✓	✓	✓	✓	✓	✓	✓	✓
		Other users are not permitted								
c	Main weather type	Dry	✓	✓	✓	✓	✓	✓	✓	✓
		Wet								
d	Interchanges	<3 per km	✓	✓			✓	✓		
		>= 3 per km			✓	✓			✓	✓

e	Vehicles per day	< 7000	✓		✓		✓		✓	
		7000 - 15000	✓		✓		✓			✓
		15000 - 25000		✓		✓		✓		✓
		More than 25000								
f	Conflict zones	Yes					✓	✓	✓	✓
		No	✓	✓	✓	✓				
g	Complexity of field vision	Normal	✓	✓	✓	✓				
		High								
h	Parked vehicles	Yes								
		No	✓	✓	✓	✓				
i	Degree of navigation difficulty	Normal	✓	✓	✓	✓				
		High								
j	Brightness of surrounding	Low (Rural environment)	✓	✓	✓	✓				
		Medium (City environment)								
		High (Inner-city environment)								
Determined road lighting class			ME5	ME4a	ME4a	ME3b	ME3b	ME2	ME3b	ME2

As per EN 13201-1 standard; Class A roads in other areas should be maintained Table 4.5 and Table 4.6 luminance values and uniformity ratios.

Table 4.5: Luminance values and uniformity ratios for Class A other area roads(without conflict areas)

Condition		Lighting class	L	U0	U1	SR	TI
Junctions <3 per km	Vehicles <15000	ME5	0.5	0.35	0.4	0.5	15%
	Vehicles 15000-25000	ME4a	0.75	0.4	0.6	0.6	15%
Junctions >=3 per km	Vehicles <15000	ME4a	0.75	0.4	0.6	0.6	15%
	Vehicles 15000-25000	ME3b	1	0.4	0.6	0.5	15%

Table 4.6: Luminance values and uniformity ratios for Class A other area roads(with conflict areas)

Condition		Lighting class	L	U0	U1	SR	TI
Junctions <3 per km	Vehicles <15000	ME3b	1	0.4	0.5	0.6	15%
	Vehicles 15000-25000	ME2	1.5	0.4	0.6	0.5	10%
Junctions >=3 per km	Vehicles <15000	ME3b	1	0.4	0.5	0.6	15%
	Vehicles 15000-25000	ME2	1.5	0.4	0.6	0.5	10%

4.2.3 Case 3: Class B roads within town area

The typical speed in town areas is less than 60km/h. Number of vehicles were considered below 25,000 per day. Table 4.5 shows the detailed analysis for Class B within town area roads.

Table 4.7: Road condition analysis for Class B within town area roads

	Parameter	Values	For normal situation	For conflict area
a	Typical speed	High [>60 km/h]		
		Medium [Between 30-60km/h]	✓	✓
		Low [Between 5-30km/h]		
		Walking speed (<5km/h)		

b	Main users and other users	Main users are motor vehicles and slow vehicles <40km/h. Bicyclists and pedestrians are permitted		
		Main users are motor vehicles, slow vehicles <40km/h and bicyclists. Pedestrians are permitted	✓	✓
c	Main weather type	Dry	✓	✓
		Wet		
d	Traffic calming areas	Yes	✓	✓
		No		
e	Interchanges	<3 per km		
		>= 3 per km	✓	✓
f	Degree of navigation difficulty	Normal	✓	✓
		High		
g	Vehicles per day	Less than 7000	✓	✓
		Between 7000 and 15000	✓	✓
		Between 15000 and 25000	✓	✓
		More than 25000		
h	Conflict zones	Yes		✓
		No	✓	
i	Complexity of field vision	Normal	✓	
		High		

j	Parked vehicles	Yes	✓	
		No		
k	Brightness of surrounding	Low (Rural environment)		
		Medium (City environment)	✓	
		High (Inner-city environment)		
l	Traffic flow for bicyclist	Normal	✓	
		High		
Road Lighting Class			ME3c	ME2

Hence, according to the EN 13201-1 standard; Class B roads within town area needs to have below luminance values and uniformity ratios.

Areas without conflict areas

- Average luminance -minimum maintained (L) :1 cd/m²
- Overall uniformity ratio- minimum (U0) : 0.4
- Longitudinal uniformity ratio-minimum (UI) : 0.5
- Minimum surrounds ratio (SR) : 0.5
- Threshold increment (TI) <= 15 %

Areas with conflict areas

- Average luminance -minimum maintained (L) :1.5 cd/m²
- Overall uniformity ratio- minimum (U0) : 0.4
- Longitudinal uniformity ratio-minimum (UI) : 0.7
- Minimum surrounds ratio (SR) : 0.5
- Threshold increment (TI) <= 10 %

4.2.4 Case 4- Class B roads in other areas

Typical speed was taken more than 60km/h. Number of vehicles were considered below 15,000 per day.

Table 4.8: Road condition analysis for Class B other area roads

	Parameter	Values	For normal situation		For conflict area		
			Juncti ons <3 per km	Juncti ons >=3 per km	Juncti ons <3 per km	Junctions >=3 per km	
a	Typical speed	High [>60 km/h]	✓	✓	✓	✓	✓
		Medium [Between 30- 60km/h]					
		Low [Between 5- 30km/h]					
		Walking speed (<5km/h)					
b	Main users and other users	All other users (slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	✓	✓	✓	✓	✓
		Other users are not permitted					
c	Main weather type	Dry	✓	✓	✓	✓	✓
		Wet					
d	Intercha nges	<3 per km	✓		✓		
		>= 3 per km		✓		✓	✓
e	Vehicle s per day	Less than 7000	✓	✓	✓	✓	
		Between 7000 and 15000	✓	✓	✓		✓
		Between 15000 and 25000					
		More than 25000					

f	Conflict zones	Yes			✓	✓	✓
		No	✓	✓			
g	Comple xity of field vision	Normal	✓	✓			
		High					
h	Parked vehicles	Yes					
		No	✓	✓			
i	Degree of navigati on difficult y	Normal	✓	✓			
		High					
j	Brightn ess of surroun ding	Low (Rural environment)	✓	✓			
		Medium (City environment)					
		High (Inner-city environment)					
Road Lighting Class			ME5	ME4a	ME3b	ME3b	ME2

As per EN 13201-1 standard; Class B roads in other areas should be maintained below luminance values and uniformity ratios.

Table 4.9: Luminance values and uniformity ratios for Class B other area roads(without conflict areas)

Condition	Lighting class	L	U0	U1	SR	TI
Junctions <3 per km	ME5	0.5	0.35	0.4	0.5	15%
Junctions >=3 per km	ME4a	0.75	0.4	0.6	0.6	15%

Table 4.10: Luminance values and uniformity ratios for Class B other area roads(with conflict areas)

Condition		Lighting class	L	U0	UI	SR	TI
Junctions <3 per km	Vehicles <15000	ME3b	1	0.4	0.6	0.5	15%
Junctions >=3 per km	Vehicles <7000	ME3b	1	0.4	0.6	0.5	15%
	Vehicles 7000-15000	ME2	1.5	0.4	0.7	0.6	10%

4.2.5 Case 5: Secondary/ minor roads within town area

Table 4.11: Road condition analysis for minor roads in town areas

	Parameter		Values	
a	Typical speed	Typical speed of the main user	High [>60 km/h]	
			Medium [Between 30-60km/h]	
			Low [Between 5-30km/h]	✓
			Walking speed (<5km/h)	
b	Main users and other users	Main users and other permitted users	All other users (motor vehicles, slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	✓
			Other users are not permitted	
c	Traffic calming areas	Have traffic calming areas taken into consideration?	Yes	
			No	✓
d	Parked vehicles	Do parked vehicles have to be taken into consideration?	Yes	
			No	✓
e	Degree of navigation difficulty	Degree of navigation difficulty is	Normal	✓
			High	

f	Traffic flow for bicyclist		Normal	✓
			High	
g	Complexity of field vision	Complexity of field vision is	Normal	✓
			High	
h	Identification of persons	The criminality risk for the viewed traffic area is given in comparison to the criminality risk for the extended surroundings	Normal	✓
			High	
		Face recognition of people is	Required	✓
			Not required	
i	Brightness of surrounding	Brightness of surrounding is	Low (Rural environment)	
			Medium (City environment)	✓
			High (Inner-city environment)	
Road Lighting Class				S5

Hence, according to the EN 13201-1 standard; minor roads in town areas need to have below illumination levels.

- Average illumination level (E_m) > 3 lux
- Minimum illumination level (E_{min}) > 0.6 lux

4.2.6 Case 6: Secondary/ minor roads in other areas

Table 4.12: Road condition analysis for minor roads in other areas

	Parameter		Values	
a	Typical speed	Typical speed of the main user	High [>60 km/h]	
			Medium [Between 30-60km/h]	
			Low [Between 5-30km/h]	✓
			Walking speed (<5km/h)	
b	Main users and other users	Main users and other permitted users	All other users (motor vehicles, slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	✓
			Other users are not permitted	
c	Traffic calming areas	Have traffic calming areas taken into consideration?	Yes	
			No	✓
d	Parked vehicles	Do parked vehicles have to be taken into consideration?	Yes	
			No	✓
e	Degree of navigation difficulty	Degree of navigation difficulty is	Normal	✓
			High	
f	Traffic flow for bicyclist		Normal	✓
			High	
g	Complexity of field vision	Complexity of field vision is	Normal	✓
			High	

h	Identification of persons	The criminality risk for the viewed traffic area is given in comparison to the criminality risk for the extended surroundings	Normal	✓
			High	
		Face recognition of people is	Required	✓
			Not required	
i	Brightness of surrounding	Brightness of surrounding is	Low (Rural environment)	✓
			Medium (City environment)	
			High (Inner-city environment)	
Road Lighting Class				S6

As per EN 13201-1 standard; minor roads in other areas need to have below illumination levels.

- Average illumination level (Em) > 2 lux
- Minimum illumination level (Emin) > 0.6 lux

5. ECONOMIC ANALYSIS

Converting the conventional type street light to LED has several benefits which includes increase energy efficiency and less maintenance due to longer lifespan. The prices of the LED luminaires are gradually decreasing with the advancement in LED technology and therefore lower price levels can be expected in the future. But still it requires a considerable financial investment due to comparatively high prices of LED in the market. Therefore, proper financial analysis is needed.

5.1 Scenario 1- Class A Road Within Town Area

Colombo 10 Deans road from Vinayalankara mawatha to round-about was selected for the economic analysis. This is a Class A road in Colombo town area. 250W sodium vapour luminaire are installed. According to the final output derived in chapter 3, the light levels related to ME2 road lighting class should be maintained. A luminaire with minimum lumen output of 19,500lm and type 2 light distribution type will satisfy that requirement. If the efficacy is 150 lm/W, the selected luminaire will consume 130W. According to Public Utility Commission of Sri Lanka (PUCSL) electricity tariff for street lighting is Rs. 17/ kWh [19]. Energy consumption for 22 number of luminaires were considered and simple payback calculation is shown in Table 5.2. Calculated simple payback period is 5.6 years. Then Net Present value was calculated using discount factor of 10%. That calculation is shown in Table 5.3.

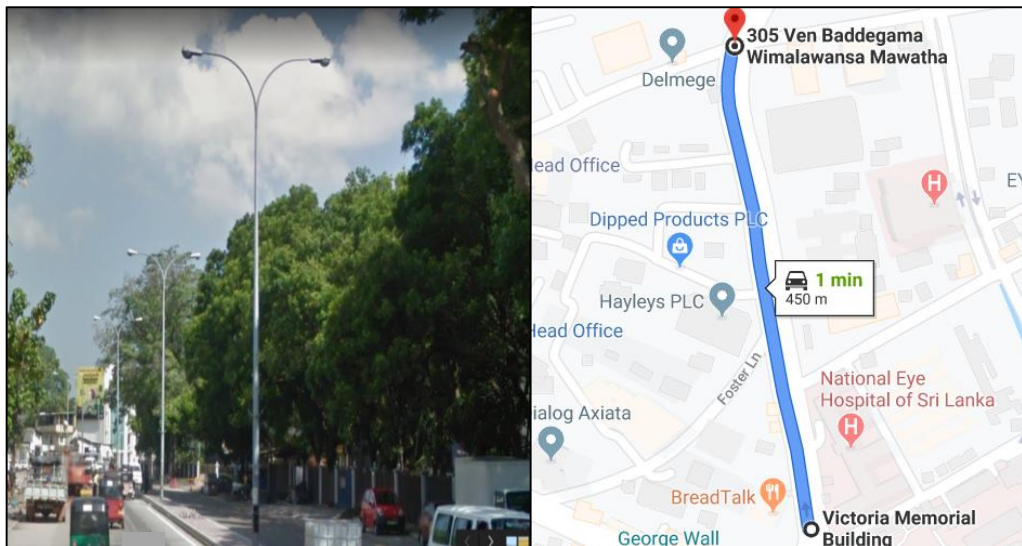


Figure 5.1: Selected road for scenario 1

Table 5.1: Collected details for scenario 1

Road class	Class A
Area	Within town limits
Number of lanes	4
Distance between two poles	40m
Luminaire Arrangement	Median
Existing luminaire type	250W Sodium vapour
Mounting height	13m

Table 5.2: Simple pay-back calculation for scenario 1

	Details	Unit	250W Sodium Vapour	130W LED
1	Lamp wattage	W	250	130
2	Ballast loss	W	25	0
3	Consumption of one luminaire	W	275	130
4	Number of luminaires		22	22
5	Total system consumption	W	6,050	2,860
6	No of working days	Days	365	365
7	No of working hours per day	Hours	12	12
8	Total burning hours per year	Hours	4380	4380
9	Lamp life	Hours	25,000(around 5 years)	50,000(around 10 years)
10	Luminaire cost	LKR	20,000.00	44,000.00
11	Cost for bracket	LKR		10,500.00
12	Total energy consumption per year	kWh	26,499	4,468
13	Electricity tariff for street lighting: Rs. 17/ kWh			
14	Total energy cost per year	LKR	450,483.00	212,955.60
15	Total energy cost saving per year	LKR		237,527.40
16	Initial investment+ 10% project management cost			569,250.00
17	Simple payback period		5 years and 7 months	

Table 5.3: NPV calculation for scenario 1

Year	0	1	2	3	4	5	6	7	8	9	10
Investment	-1,318,900.00										
Energy Saving		237,527.40	237,527.40	237,527.40	237,527.40	237,527.40	237,527.40	237,527.40	237,527.40	237,527.40	237,527.40
Maintenance cost saving						62,700.00					62,700.00
Net Cash Flow	-1,318,900.00	237,527.40	237,527.40	237,527.40	237,527.40	300,227.40	237,527.40	237,527.40	237,527.40	237,527.40	300,227.40
Discount Factor	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
Present Value	-1,318,900.00	215,934.00	196,303.64	178,457.85	162,234.41	186,417.59	134,078.02	121,889.11	110,808.29	100,734.80	115,750.66
Net Present Value	203,708.38										

5.2 Scenario 2- Class B Road Within Town Area

B79 Wariyapola-Chilaw road from Wariyapola town clock tower was selected. The gathered data are mentioned in Table 5.4. According to the Appendix B results, 68W LED luminaire was selected to replace the existing 125W mercury vapour luminaires. Therefore, it is possible to save 77W from one luminaire and total energy saving per year is 337kWh. Applying electricity tariff for street lighting (Rs.17/kWh), annually it will save Rs. 5,733.42

Energy consumption for 15 number of luminaires were considered and simple payback calculation is shown in Table 5.5. Calculated simple payback period is 6.6 years.

Then Net Present value was calculated using discount factor of 10%. That calculation is shown in Table 5.6.

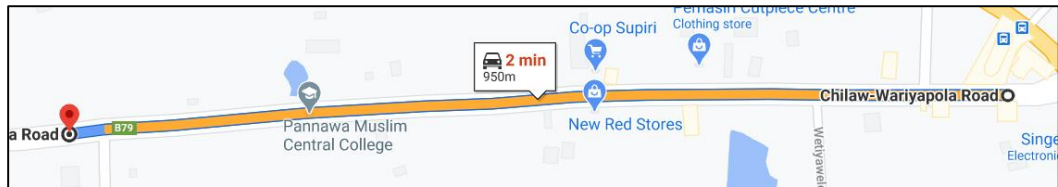


Figure 5.2: Selected road for scenario 2

Table 5.4: Collected details for scenario 2

Road class	Class B
Area	Within town limits
Number of lanes	2
Distance between two poles	35-40m
Luminaire Arrangement	Single side
Existing luminaire type	125W Metal halide
Mounting height	6m

Table 5.5: Simple pay-back calculation for scenario 2

	Details	Unit	125W Mercury Vapour	68W LED
1	Lamp wattage	W	125	68
2	Ballast loss	W	20	0
3	Consumption of one luminaire	W	145	68
4	Number of luminaires		15	15
5	Total system consumption	W	2,175	1,020
6	No of working days	Days	365	365
7	No of working hours per day	Hours	12	12
8	Total burning hours per year	Hours	4380	4380
9	Lamp life	Hours	20,000(around 4 years)	50,000(around 10 years)
10	Luminaire cost	LKR	20,000.00	24,000.00
11	Cost for bracket	LKR		10,500.00
12	Total energy consumption per year	kWh	9,527	4,468
13	Electricity tariff for street lighting: Rs. 17/ kWh			
14	Total energy cost per year	LKR	161,950.50	75,949.20
15	Total energy cost saving per year	LKR		86,001.30
16	Initial investment+ 10% project management cost			569,250.00
17	Simple payback period		6 years and 8 months	

Table 5.6: NPV calculation for scenario 2

Year	0	1	2	3	4	5	6	7	8	9	10
Investment	-569,250.00										
Energy Saving		86,001.30	86,001.30	86,001.30	86,001.30	86,001.30	86,001.30	86,001.30	86,001.30	86,001.30	86,001.30
Maintenance cost saving					80,250.00	-45,000.00			80,250.00		-45,000.00
Net Cash Flow	-569,250.00	86,001.30	86,001.30	86,001.30	166,251.30	41,001.30	86,001.30	86,001.30	166,251.30	86,001.30	41,001.30
Discount Factor	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
Present Value	-569,250.00	78,183.00	71,075.45	64,614.05	113,551.87	25,458.58	48,545.49	44,132.27	77,557.46	36,472.95	15,807.78
Net Present Value	6,148.90										

5.3 Scenario 3- Minor Road Not Within Town Area

As scenario 3, Delkanda- Meegahawatta minor road about 300m was selected. Normally these types of roads have no uniformity in type of luminaires. Here 36W fluorescent luminaires, different types of CFL bulbs and LED bulbs have been installed.

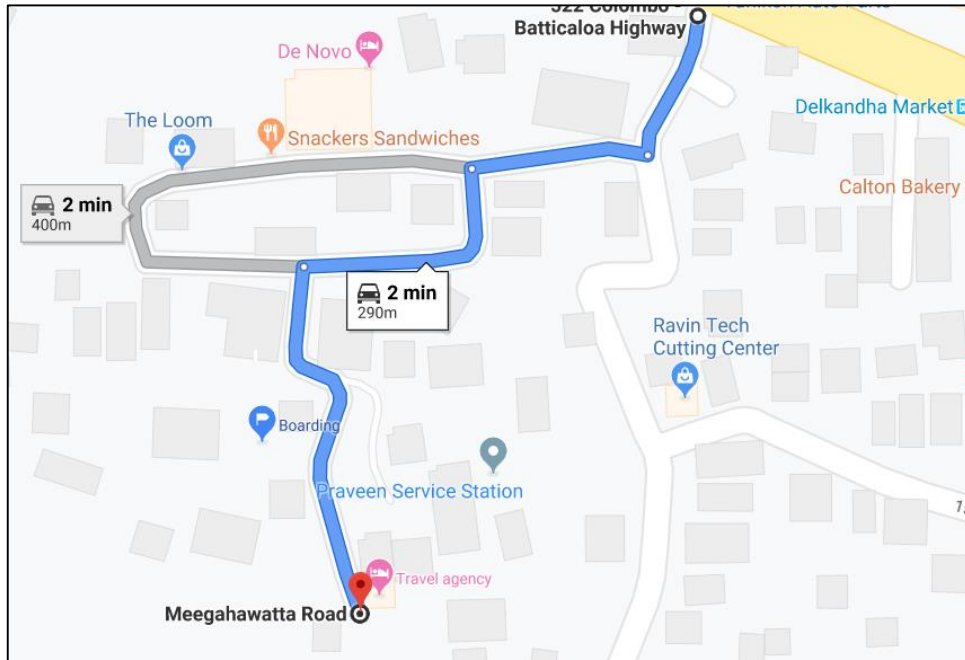


Figure 5.3: Selected road for scenario 3

Table 5.7: Collected details for scenario 3

Road class	Minor roads
Area	Not within town limits
Number of lanes	1
Distance between two poles	Not uniform (30m to 40m)
Luminaire Arrangement	Single side
Existing luminaire type	36W fluorescent/ CFL/LED bulbs
Mounting height	6m

Table 5.8: Simple pay-back calculation for scenario 3

	Details	Unit	36W Fluorescent	11W LED
1	Lamp wattage	W	36	11
2	Ballast loss	W	4	0
3	Consumption of one luminaire	W	40	11
4	Number of luminaires		7	7
5	Total system consumption	W	280	77
6	No of working days	Days	365	365
7	No of working hours per day	Hours	12	12
8	Total burning hours per year	Hours	4380	4380
9	Lamp life	Hours	10,000(around 2 years)	50,000(around 10 years)
10	Luminaire cost	LKR	1,500.00	4,000.00
11	Cost for bracket	LKR		0.00
12	Total energy consumption per year	kWh	1,226	337
13	Electricity tariff for street lighting: Rs. 17/ kWh			
14	Total energy cost per year	LKR	20,848.80	5,733.42
15	Total energy cost saving per year	LKR		15,115.38
16	Initial investment+ 10% project management cost		30,800.00	
17	Simple payback period		2 years and 1 month	

Table 5.9: NPV calculation for scenario 3

Year	0	1	2	3	4	5	6	7	8	9	10
Investment	-30,800.00										
Energy Saving		15,115.38	15,115.38	15,115.38	15,115.38	15,115.38	15,115.38	15,115.38	15,115.38	15,115.38	15,115.38
Maintenance cost saving			840.00		840.00	-21,000.00	840.00		840.00		-20,160.00
Net Cash Flow	-30,800.00	15,115.38	15,955.38	15,115.38	15,955.38	-5,884.62	15,955.38	15,115.38	15,955.38	15,115.38	-5,044.62
Discount Factor	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
Present Value	-30,800.00	13,741.25	13,186.26	11,356.41	10,897.74	-3,653.89	9,006.40	7,756.58	7,443.30	6,410.40	-1,944.92
Net Present Value	43,399.54										

6. CONCLUSION

6.1 Results and Observations

Inadequate lighting levels and very low uniformity ratio are the main problems associated with street lighting projects due to wrongly selected luminaires, distribution type and mounting positions. As the initial cost of implementing a LED retrofit street lighting project is comparatively high due to the cost of LED luminaires, it is not wiser to go for higher wattages unnecessarily. It will also adversely effect to the energy saving and will be difficult to finance the project due to long payback periods.

Many leading lamp manufacturers in the world have closed down the production of conventional type lamps like sodium vapour and mercury vapour. Also due to the new import regulations, laws has been imposed to limit the import of CFL in to Sri Lanka. Meanwhile, Sri Lankan government is encouraging the provincial councils and local government to replace street lamps with efficient LED street lamps. Therefore, having a proper guideline on how to replace these existing luminaires into LED is a must.

The objective of this research was to develop a guideline for designing economical and effective retrofit LED street lighting system in Sri Lanka.

In chapter 3, the procedure which was followed to decide the optimum wattage/ lumen output, ideal light distribution type, luminaire mounting height and overhang of the LED street lights to replace the conventional type street lights by considering the road class (Class A/ Class B/ Secondary-Minor roads), number of lanes (1 lane/ 2 lane/ 4 lanes/ 6 lanes) and installation pattern (single side/ staggered/ opposite) was discussed.

According to the road condition analysis in chapter 4; vehicle speed, traffic volume and composition, number of intersection within kilometer, parked vehicles, ambient lighting level, navigation difficulty and pattern of traffic control has large impact on required lighting levels.

Class A within town area roads have the highest lighting requirement. When the number of vehicles and junctions are increased, the light level requirement also goes up. Also when areas are having conflict zones, the lighting requirement goes up.

As per the analysis, Class A and Class B roads were under ME class and minimum of maintained average luminance, minimum overall uniformity ratio, minimum longitudinal uniformity ratio, threshold increment, minimum surrounds ratio, were decided. Minor roads are under S class and therefore average and minimum illumination levels were defined.

As per the EN 13201-2:2015 'Road lighting - Part 2: Performance requirements standards, the required lighting levels according to the road class which were derived through the analysis are shown in table 6.1, table 6.2 and table 6.3.

According to the road classification done in figure 3.3, 3.4 and 3.5, two hundred and thirty-two different scenarios were identified and computer simulated using Dialux 4.12 software for optimum design. The derived final output is attached in appendix B.

The observations according to the derived final output can be listed as follow;

For the Class A and Class B roads (which are not having conflict zones)

- For one lane and two lane roads with single side installation, it is always need to go for luminaires with type 2 light distribution pattern.
- For four lane roads, despite of installation pattern is single side, double side or staggered, ideal selection is luminaires with type 2 light distribution pattern except for Class A within town area roads.
- For six lane roads (except Class A within town area) which have single side and opposite side pole installations, it is always need to go for type 2 light distribution type.
- If it is a Class A within town area road with six lanes, it is difficult to match the required lighting levels with single side 30m -40m pole spacing, or staggered 60m pole spacing. Therefore, the best option is to go for opposite type 30m installation.

For minor roads

- For minor roads with single or double lanes which are having single side pole installation, the ideal mounting height to achieve minimum lumen output is 6m and light distribution pattern is type 2.

Table 6.1: Lighting levels according to the road class for areas not having conflict zones- Class A and Class B

Road Class	Area			Lighting class	L	U0	UL	SR	TI
A	Within town area			ME2	1.5	0.4	0.7	0.5	10%
	Other areas	Junctions <3 per km	Vehicles <15000	ME5	0.5	0.35	0.4	0.5	15%
			Vehicles 15000-25000	ME4a	0.75	0.4	0.6	0.6	15%
		Junctions >=3 per km	Vehicles <15000	ME4a	0.75	0.4	0.6	0.6	15%
			Vehicles 15000-25000	ME3b	1	0.4	0.5	0.6	15%
B	Within town area (vehicles <25000)			ME3c	1	0.4	0.5	0.5	15%
	Other areas	Junctions <3 per km	Vehicles <15000	ME5	0.5	0.35	0.4	0.5	15%
		Junctions >=3 per km	Vehicles <15000	ME4a	0.75	0.4	0.6	0.6	15%

Table 6.2: Lighting levels according to the road class for areas having conflict zones- Class A and Class B

Road Class	Area			Lighting class	L	U0	UL	SR	TI
A	Within town area			ME2	1.5	0.4	0.7	0.5	10%
	Other areas	Junctions <3 per km	Vehicles <15000	ME3b	1	0.4	0.5	0.6	15%
		Or >=3 per km	Vehicles 15000-25000	ME2	1.5	0.4	0.6	0.5	10%
B	Within town area (vehicles <25000)			ME2	1.5	0.4	0.7	0.5	10%
	Other areas	Junctions <3 per km	Vehicles <15000	ME3b	1	0.4	0.6	0.5	15%
		Junctions >=3 per km	Vehicles <7000	ME3b	1	0.4	0.6	0.5	15%
			Vehicles 7000-15000	ME2	1.5	0.4	0.7	0.6	10%

Table 6.3: Lighting levels according to the road class- secondary/minor roads

Road Category	Area	Lighting class	Average illumination level (Em)	Minimum illumination level (Emin)
Secondary/Minor roads	Within town area	S5	3	0.6
	Other areas	S6	2	0.6

The final aim of street lighting design is the safety of road users. Achieving appropriate, correct and acceptable illuminance and luminance values while balancing the saving through energy consumption and investment cost is really a challenge in implementing LED retrofit street lighting system.

The payback period of a project means length of time that takes to recover the cost of an investment. It can be used as the most basis financial analysis to get an idea about when the investment reaches its break-even point. Projects with shorter payback periods usually get the attraction.

As scenario 1, Colombo 10 Deans road from Vinayalankara mawatha to round-about was selected which is a class A within town area road. Therefore, as per the analyzed road conditions, it should be maintained minimum average luminance value 1.5 cd/m^2 ; minimum overall uniformity ratio 0.4; minimum longitudinal uniformity ratio 0.7; minimum surrounds ratio 0.5 and $TI \leq 10 \%$. 250W sodium vapour luminaire are installed at 13m height and the ideal LED replacement would be 130W as per Appendix B. From one luminaire, it will be able to save 145W. If we assume 12hour burning time per day, it will save 1.74kWh per day. Then in one year it will save 635.1kWh which means Rs. 10,796.70 per year. Calculated simple payback period is 5.6 years which is a really high value. Refer Table 5.2. The reason for long payback period is the cost of LED luminaire and arm modification. But the prices of the LED luminaires are gradually decreasing and therefore lower price levels can be expected in the future. It will reduce this long payback period. NPV reflects the present value of future cash flows. These adjustments are done using the 'discount factor' which will be selected by considering the inflation. Here Net Present Value was calculated using discount factor of 10%. The sodium vapour lamp life at 50% failure was taken

as 25,000 hr. Then one lamp will last nearly 5 years. Electromagnetic ballast in combination with external ignitor is used in sodium vapour luminaires. The replacement cost of lamp, ballast and ignitor were considered for NPV calculations. Cost of one lamp, ballast and ignitor was taken as Rs. 2,000.00, Rs.3500.00 and Rs.350 respectively which are current market prices. Though the life time of LED chip is 50,000hr, the life time of LED driver is around 25,000hr. Therefore, the replacement cost of LED driver which is around Rs.3000.00 after 5 years was taken in to consideration. The calculations are shown in Table 5.3. NPV calculated was positive and therefore this project is viable.

As second scenario, Wariyapola-Chilaw road from Wariyapola town clock tower which is a class B road within town area was selected. The selected stretch is 950m. The existing 125W mercury vapour street lamps can be replaced with 68W LED luminaires. Here also calculated payback period is very long. As explained in scenario 1, one reason for this long payback period is cost of LED luminaires and modification cost of arm. The mercury vapour lamp life at 50% failure was taken as 20,000 hr and then one lamp will last nearly 4 years. So there will be a lamp replacement cost of Rs 1,500.00 after four years. Cost of ballast and ignitor was taken as Rs.3500.00 and Rs.350 respectively. The life time of LED driver is around 25,000hr and therefore, the replacement cost of LED driver which is around Rs.3000.00 after 5 years was considered. For this project also, the calculated NPV was positive and that means project is viable.

There is no consistency in type of luminaires, wattages in most of the minor/secondary type roads. Most of the time indoor type fluorescent tubes, CFL and LED bulbs are used to light up the roads. The selected road was Delkanda- Meegahawatta minor road. The selected section is about 300m. Road width was about 3.5m to 4m. 36W 4feet fluorescent luminaires, different types of CFL bulbs and LED bulbs have been installed in different mounting heights. For the calculation purpose, it was assumed only 36W fluorescent luminaires are there. Mounting height also not uniform and it was about 6m. Seven luminaires were counted in this section. The ideal replacement for this 36W fluorescent luminaire is 11W Type 2 LED luminaire. Therefore, if we replace these seven number of luminaires it will save Rs. 15,115.38 per annum. The cost of 11W LED street light is about Rs. 4,000.00 and then the

investment needed for this project is Rs. 30,8000.00. The calculated pay-back period is 2.04 years which can be considered as good pay-back period. Refer Table 5.8. The lamp life of good quality fluorescent bulb is about 10,000hr at 50% failure. So it will last about two years for 4380 burning hours. Replacement cost of one fluorescent tube is Rs. 120.00. Net Present Value was calculated using discount factor of 10%. The replacement cost of LED driver also taken into consideration. The calculated NPV was positive and that means project is viable.

Most of the time the prevailing lighting conditions on road is very poor. For an example the measured illumination level on road was 7lux right under the luminaire and it was 0lux in between two light poles in B79 Chilaw- Wariyapola road. So this type of situation won't cater the safety and visibility need of road users which is the main purpose of street light designing. Therefore, when we are trying to meet the standard luminance and illumination levels, the cost will become high and energy saving will not be highlighted. This is the second reason for having longer payback periods. Hence when implementing these kinds of public projects investment cost should not be the only reason that should be considered. The safety of road users, upgrade the quality of life by promotion of business activities during the night hours should also be addressed.

6.2 Further Improvements

According to the analysis in section 4, vehicles per day is one of the key factor to decide the lighting level of road. But during the late night time, the motor traffic and pedestrian density is low and therefore the luminance/ illuminance levels can be reduced further. For an example; in Class A-other area roads, if vehicle density goes down from 'more than 15,000' to 'below 15,000' range, then the required luminance values also goes down (refer Table 6.4).

If we consider two lane road with single side installation and 30m pole spacing, then the required lumen output goes down from 5,100lm to 3,450lm. Efficacy of 150lm/W one luminaire will save 11W energy. That means more than 30% energy saving can be achieved. Using dimmable street lights with timers will serve the purpose [8]. But when it comes to the cost of dimmable street lights, that idea will not be so economical. Therefore, use split type street light with two LED drivers and when in

late hours, switch off one part of street light using timer will further enhance the energy saving.

Table 6.4: Luminance values for Class A- other area roads

Road Class	Area		Lighting class	L	U0	UL	SR	TI
Class A	Other areas	Junctions <3 per km	Vehicles <15000 ME5	0.5	0.35	0.4	0.5	15%
			Vehicles 15000-25000 ME4a	0.75	0.4	0.6	0.6	15%

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FIELD SURVEY FORM

LED STREET LIGHT UP-LAMPING PROJECT

1) Site Details				
a) Road name				
b) Road width				
c) Number of lanes				
d) Carriageway type	Single carriageway			
	Dual carriage way			
2) Existing Luminaire Details and Mounting Details				
a) Installation pattern	Single side			
	Double side opposite			
	Staggered			
b) Average distance between two poles				
c) Type of luminaire				
d) Existing wattage				
e) Mounting height				
f) Arm length				
g) Distance from pole to road edge				
3) Identify the Road Conditions				
Parameter	Description	Value		
Typical speed	How high is the typical speed of the main user in the street? Mai users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic	Typical speed of the main user	High [>60 km/h]	
			Medium [Between 30-60km/h]	
			Low [Between 5-30km/h]	
		Walking speed (<5km/h)		
Main users and other users		Enter main user type and other user	All other users (slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	

		permitted user types	Other users are not permitted	
Main whether type		Enter typical whether	Dry	
			Wet	
Interchanges	How the street connects to other streets and the frequency of interchanges/Junctions	Enter the frequency of simple junctions	<3 per km	
			>= 3 per km	
Vehicles per day		How many vehicles are there per day?	Less than 7000	
			Between 7000 and 15000	
			Between 15000 and 55000	
			More than 25000	
Conflict zones	Conflict zones are the zones where different traffic flows cross or zones that are also used by other traffic participants	Does a conflict zone exist?	Yes	
			No	
Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit buildings) within the field of vision?	Complexity of field vision is	Normal	
			High	
Parked vehicles		Do parked vehicles have to be taken into consideration?	Yes	
			No	
Degree of navigation	How much of effort will the traffic participant have to make in order to	Degree of navigation difficulty is	Normal	

ion difficul ty	select a driving direction and driving lane, or to maintain or change their speed and position in the roadway?		High	
Brightn ess of surroun ding	Since the luminance level of the surrounding can only be estimated, only broad classification are made	Brightness of surroundin g is	Low (Rural environment)	
			Medium (City environment)	
			High (Inner-city environment)	

GUIDELINE TO DESIGN ECONOMICAL, EFFECTIVE AND HUMAN FRIENDLY RETROFIT LED STREET LIGHTING SYSTEM

1. Guideline to select best fit LED street light luminaire according to road category, number of lanes and installation pattern

Below charts will help to understand the minimum lumen output of a street light luminaire that should be used to replace the existing conventional street light according to the road category, number of lanes and installation pattern.

Simulations are based on BS/EN 13201 road lighting standards. Maintenance factor is considered as 0.7. Width of one lane is taken as 3.5m. The analysis part of the road conditions is shown in section 2.

Assumptions: For roads within town are: junctions within kilometre >=3

CLASS A ROADS

Road Category	Area			Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Minimum Wattage (considering efficacy as 150lm/W)	Average illumination level on road (lux)	Lighting Distribution Pattern	Luminaire Mounting Height (m)	Overhang (m)	Slope (deg)
Class A	Within town area			ME2	1 lane	Single side- 30m pole spacing	9,000	60	16	Type 2	8.5	1	0
						Single side- 40m pole spacing	15,000	100	16	Type 2	10	1	5
					2 lanes	Single side- 30m pole spacing	12,400	83	18	Type 2	10	2	0
						Single side- 40m pole spacing	19,500	130	18	Type 2	12	1	0
					4 lanes	Single side- 30m pole spacing	33,000	220	27	Type 4	10.5	2.5	0
						Single side- 40m pole spacing	60,000	400	27	Type 4	13	0.5	10
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	9,300	62	20	Type 2	11	0.5	0
					6 lanes	Opposite- 40m pole spacing	25,500	170	24	Type 4	13	0.5	5
						Single side- 30m pole spacing	-	-	-	-	-	-	-
	Single side- 40m pole spacing	-	-	-		-	-	-	-				
	Staggered- 60m pole spacing	-	-	-		-	-	-	-				
	Opposite- 30m pole spacing	12,200	81	20		Type 2	10	1	0				
	Other areas	Junctions <3 per km	Vehicles <15000	ME5	1 lane	Single side- 30m pole spacing	2,300	15	6	Type 2	6	1	0
						Single side- 40m pole spacing	3,800	25	6	Type 2	7.5	0.5	5
					2 lanes	Single side- 30m pole spacing	3,450	23	6	Type 2	7.5	1	0
						Single side- 40m pole spacing	5,000	33	6	Type 2	8	1	5
					4 lanes	Single side- 30m pole spacing	6,850	46	7	Type 2	12	1	0
						Single side- 40m pole spacing	9,500	63	7	Type 2	11.5	0.5	5
						Staggered- 60m pole spacing	6,250	42	7	Type 2	10.5	0	0,5
Opposite- 30m pole spacing						2,900	19	7	Type 2	7	0	0	
6 lanes					Opposite- 40m pole spacing	4,000	27	6	Type 2	8	0	0	
					Single side- 30m pole spacing	9,950	66	8	Type 3	10.5	2	0	
	Single side- 40m pole spacing	13,500	90	8	Type 3	11	2.5	0					
	Staggered- 60m pole spacing	8,300	55	7	Type 2	11.5	1	0					
	Opposite- 30m pole spacing	4,000	27	6	Type 2	8.5	0	5					
				Opposite- 40m pole spacing	5,400	36	7	Type 2	8.5	0	5		

Road Category	Area		Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Wattage (efficacy = 150lm/W)	Average illumination(lux)	Lighting Dist. Pattern	Mounting Height(m)	Overhang (m)	Slope (deg)	
Class A	Other areas	Junctions <3 per km	Vehicles 15000-25000	ME4a	1 lane	Single side- 30m pole spacing	3,900	26	8	Type 2	7	1.5	0
						Single side- 40m pole spacing	6,800	45	8	Type 2	9	2	0
					2 lanes	Single side- 30m pole spacing	5,100	34	10	Type 2	7.5	1.5	0
						Single side- 40m pole spacing	8,500	57	10	Type 2	9	1.5	5
					4 lanes	Single side- 30m pole spacing	10,650	71	11	Type 2	12	1	5
						Single side- 40m pole spacing	15,000	100	11	Type 2	11.5	0.5	10
						Staggered- 60m pole spacing	9,250	62	10	Type 2	12	1.5	0
						Opposite- 30m pole spacing	4,450	30	10	Type 2	8	0	0
						Opposite- 40m pole spacing	6,200	41	10	Type 2	10	0	0
						Single side- 30m pole spacing	14,900	99	12	Type 3	10.5	2	0
					6 lanes	Single side- 40m pole spacing	21,000	140	12	Type 3	11.5	2	0
						Staggered- 60m pole spacing	14,550	97	11	Type 3	11.5	0.5	0
						Opposite- 30m pole spacing	6,000	40	10	Type 2	8.5	0	5
						Opposite- 40m pole spacing	8,300	55	10	Type 2	9.5	0	5
						Single side- 30m pole spacing	3,900	26	8	Type 2	7	1.5	0
	Other areas	Junctions >=3 per km	Vehicles <15000	ME4a	1 lane	Single side- 30m pole spacing	3,900	26	8	Type 2	7	1.5	0
						Single side- 40m pole spacing	6,800	45	8	Type 2	9	2	0
					2 lanes	Single side- 30m pole spacing	5,100	34	10	Type 2	7.5	1.5	0
						Single side- 40m pole spacing	8,500	57	10	Type 2	9	1.5	5
					4 lanes	Single side- 30m pole spacing	10,650	71	11	Type 2	12	1	5
						Single side- 40m pole spacing	15,000	100	11	Type 2	11.5	0.5	10
						Staggered- 60m pole spacing	9,250	62	10	Type 2	12	1.5	0
						Opposite- 30m pole spacing	4,450	30	10	Type 2	8	0	0
						Opposite- 40m pole spacing	6,200	41	10	Type 2	10	0	0
						Single side- 30m pole spacing	14,900	99	12	Type 3	10.5	2	0
					6 lanes	Single side- 40m pole spacing	21,000	140	12	Type 3	11.5	2	0
						Staggered- 60m pole spacing	14,550	97	11	Type 3	11.5	0.5	0
						Opposite- 30m pole spacing	6,000	40	10	Type 2	8.5	0	5
						Opposite- 40m pole spacing	8,300	55	10	Type 2	9.5	0	5
						Single side- 30m pole spacing	5,400	36	11	Type 2	7	0.5	5
Other areas	Junctions >=3 per km	Vehicles 15000-25000	ME3b	1 lane	Single side- 40m pole spacing	9,000	60	11	Type 2	9	2	0	
					Single side- 30m pole spacing	6,750	45	13	Type 2	7.5	1.5	0	
				2 lanes	Single side- 40m pole spacing	11,000	73	13	Type 2	9	1.5	5	
					Single side- 30m pole spacing	14,200	95	15	Type 2	12	1	5	
				4 lanes	Single side- 40m pole spacing	20,000	133	15	Type 2	11.5	0.5	10	
					Staggered- 60m pole spacing	12,500	83	13	Type 2	12	1.5	0	
					Opposite- 30m pole spacing	5,900	39	13	Type 2	8	0	0	
					Opposite- 40m pole spacing	8,500	57	14	Type 2	10	0	0	
					Single side- 30m pole spacing	20,000	133	16	Type 3	10.5	2	0	
					Single side- 40m pole spacing	30,000	200	16	Type 3	12	1	0	
				6 lanes	Staggered- 60m pole spacing	19,400	129	14	Type 3	11.5	0.5	0	
					Opposite- 30m pole spacing	8,000	53	13	Type 2	8.5	0	5	
					Opposite- 40m pole spacing	11,000	73	13	Type 2	9.5	0	5	

CLASS B ROADS

Road Category	Area		Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Minimum Wattage (considering efficacy as 150lm/W)	Average illumination level on road (lux)	Lighting Distribution Pattern	Luminaire Mounting Height (m)	Overhang (m)	Slope (deg)				
Class B	Within town area		ME3c	1 lane	Single side- 30m pole spacing	4,900	33	11	Type 2	6.5	1.5	0				
					Single side- 40m pole spacing	9,000	60	12	Type 2	8	0	10				
				2 lanes	Single side- 30m pole spacing	6,750	45	13	Type 2	7.5	1.5	0				
					Single side- 40m pole spacing	10,200	68	12	Type 2	9	1.5	0				
				4 lanes	Single side- 30m pole spacing	14,200	95	15	Type 2	12	1	5				
					Single side- 40m pole spacing	19,900	133	15	Type 2	11.5	0.5	10				
					Staggered- 60m pole spacing	12,300	82	13	Type 2	11	0.5	0				
					Opposite- 30m pole spacing	5,850	39	13	Type 2	7.5	0	0				
				6 lanes	Opposite- 40m pole spacing	8,000	53	13	Type 2	9	0	0				
					Single side- 30m pole spacing	19,900	133	16	Type 3	10.5	2	0				
					Single side- 40m pole spacing	29,000	193	16	Type 3	12	2	0				
					Staggered- 60m pole spacing	17,150	114	13	Type 2	12	0	5,10				
				Other areas	Junctions <3 per km	Vehicles <15000	ME5	1 lane	Single side- 30m pole spacing	2,300	15	6	Type 2	6	1	0
									Single side- 40m pole spacing	3,800	25	6	Type 2	7.5	0.5	5
	2 lanes	Single side- 30m pole spacing	3,450					23	6	Type 2	7.5	1	0			
		Single side- 40m pole spacing	5,000					33	6	Type 2	8	1	5			
	4 lanes	Single side- 30m pole spacing	6,850					46	7	Type 2	12	1	0			
		Single side- 40m pole spacing	9,500					63	7	Type 2	11.5	0.5	5			
		Staggered- 60m pole spacing	6,250					42	7	Type 2	10.5	0	0,5			
		Opposite- 30m pole spacing	2,900		19	7		Type 2	7	0	0					
	6 lanes	Opposite- 40m pole spacing	4,000		27	6		Type 2	8	0	0					
		Single side- 30m pole spacing	9,950		66	8		Type 3	10.5	2	0					
		Single side- 40m pole spacing	13,500		90	8		Type 3	11	2.5	0					
		Staggered- 60m pole spacing	8,300		55	7		Type 2	11.5	1	0					
		Opposite- 30m pole spacing	4,000		27	6		Type 2	8.5	0	5					
	Junctions >=3 per km	Vehicles <15000	ME4a		1 lane	Single side- 30m pole spacing		3,900	26	8	Type 2	7	1.5	0		
				Single side- 40m pole spacing		6,800	45	8	Type 2	9	2	0				
				2 lanes	Single side- 30m pole spacing	5,100	34	10	Type 2	7.5	1.5	0				
Single side- 40m pole spacing					8,500	57	10	Type 2	9	1.5	5					
4 lanes				Single side- 30m pole spacing	10,650	71	11	Type 2	12	1	5					
				Single side- 40m pole spacing	15,000	100	11	Type 2	11.5	0.5	10					
				Staggered- 60m pole spacing	9,250	62	10	Type 2	12	1.5	0					
	Opposite- 30m pole spacing	4,450		30	10	Type 2	8	0	0							
Opposite- 40m pole spacing	6,200	41		10	Type 2	10	0	0								

					6 lanes	Single side- 30m pole spacing	14,900	99	12	Type 3	10.5	2	0
						Single side- 40m pole spacing	21,000	140	12	Type 3	11.5	2	0
						Staggered- 60m pole spacing	14,550	97	11	Type 3	11.5	0.5	0
						Opposite- 30m pole spacing	6,000	40	10	Type 2	8.5	0	5
						Opposite- 40m pole spacing	8,300	55	10	Type 2	9.5	0	5

SECONDARY/ MINOR ROADS

Road Category	Area	Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Minimum Wattage (considering efficacy as 100lm/W)	Lighting Distribution Pattern	Luminaire Mounting Height (m)	Overhang (m)	Slope
Secondary/Minor roads	Within town area	S5	1 lane	Single side- 30m pole spacing	1,250	12.5	Type 2	6	0	0,5
				Single side- 40m pole spacing	1,650	16.5	Type 2	6	0	0
			2 lanes	Single side- 30m pole spacing	1,350	13.5	Type 2	6	1.5	0
				Single side- 40m pole spacing	1,800	18.0	Type 2	6	1.5	0
	Other areas	S6	1 lane	Single side- 30m pole spacing	850	8.5	Type 2	6	0	0,5
				Single side- 40m pole spacing	1,110	11.1	Type 2	6	0	0
			2 lanes	Single side- 30m pole spacing	900	9.0	Type 2	6	1.5	0
				Single side- 40m pole spacing	1,250	12.5	Type 2	6	0.5	0

CLASS A ROADS-CONFLICT AREAS

Road Category	Area			Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Minimum Wattage (considering efficacy as 150lm/W)	Average illumination level on road (lux)	Lighting Distribution Pattern	Luminaire Mounting Height (m)	Overhang (m)	Slope
Class A	Within town area			ME2	1 lane	Single side- 30m pole spacing	9,000	60	16	Type 2	8.5	1	0
						Single side- 40m pole spacing	15,000	100	16	Type 2	10	1	5
					2 lanes	Single side- 30m pole spacing	12,400	83	18	Type 2	10	2	0
						Single side- 40m pole spacing	19,500	130	18	Type 2	12	1	0
					4 lanes	Single side- 30m pole spacing	33,000	220	27	Type 4	10.5	2.5	0
						Single side- 40m pole spacing	60,000	400	27	Type 4	13	0.5	10
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	9,300	62	20	Type 2	11	0.5	0
					6 lanes	Opposite- 40m pole spacing	25,500	170	24	Type 4	13	0.5	5
						Single side- 30m pole spacing	-	-	-	-	-	-	-
						Single side- 40m pole spacing	-	-	-	-	-	-	-
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	12,200	81	20	Type 2	10	1	0
					Other areas	Junctions <3 per km; Junctions >=3 per km	Vehicles <15000	ME3b	1 lane	Single side- 30m pole spacing	5,400	36	11
	Single side- 40m pole spacing	9,000	60	11						Type 2	9	2	0
	2 lanes	Single side- 30m pole spacing	6,750	45					13	Type 2	7.5	1.5	0
		Single side- 40m pole spacing	11,000	73					13	Type 2	9	1.5	5
	4 lanes	Single side- 30m pole spacing	14,200	95					15	Type 2	12	1	5
		Single side- 40m pole spacing	20,000	133					15	Type 2	11.5	0.5	10
		Staggered- 60m pole spacing	12,500	83					13	Type 2	12	1.5	0
		Opposite- 30m pole spacing	5,900	39					13	Type 2	8	0	0
	6 lanes	Opposite- 40m pole spacing	8,500	57					14	Type 2	10	0	0
		Single side- 30m pole spacing	20,000	133					16	Type 3	10.5	2	0
		Single side- 40m pole spacing	30,000	200	16	Type 3	12	1	0				
Staggered- 60m pole spacing		19,400	129	14	Type 3	11.5	0.5	0					
Opposite- 30m pole spacing		8,000	53	13	Type 2	8.5	0	5					
Opposite- 40m pole spacing	11,000	73	13	Type 2	9.5	0	5						
Opposite- 40m pole spacing	-	-	-	-	-	-	-						

Road Category	Area			Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Minimum Wattage (considering efficacy as 150lm/W)	Average illumination level on road (lux)	Lighting Distribution Pattern	Luminaire Mounting Height (m)	Overhang (m)	Slope
Class A	Other areas	Junctions <3 per km; Junctions >=3 per km	Vehicles 15000-25000	ME2	1 lane	Single side- 30m pole spacing	9,000	60	16	Type 2	8.5	1	0
						Single side- 40m pole spacing	15,000	100	16	Type 2	10	1	5
					2 lanes	Single side- 30m pole spacing	12,400	83	18	Type 2	10	2	0
						Single side- 40m pole spacing	19,500	130	18	Type 2	12	1	0
					4 lanes	Single side- 30m pole spacing	33,000	220	27	Type 4	10.5	2.5	0
						Single side- 40m pole spacing	60,000	400	27	Type 4	13	0.5	10
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	9,300	62	20	Type 2	11	0.5	0
					6 lanes	Opposite- 40m pole spacing	25,500	170	24	Type 4	13	0.5	5
						Single side- 30m pole spacing	-	-	-	-	-	-	-
						Single side- 40m pole spacing	-	-	-	-	-	-	-
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	12,200	81	20	Type 2	10	1	0
					Opposite- 40m pole spacing	-	-	-	-	-	-	-	-

CLASS B ROADS-CONFLICT AREAS

Road Category	Area			Lighting class	Number of lanes	Installation pattern	Minimum Lumen output	Minimum Wattage (considering efficacy as 150lm/W)	Average illumination level on road (lux)	Lighting Distribution Pattern	Luminaire Mounting Height (m)	Overhang (m)	Slope
Class B	Within town area			ME2	1 lane	Single side- 30m pole spacing	9,000	60	16	Type 2	8.5	1	0
						Single side- 40m pole spacing	15,000	100	16	Type 2	10	1	5
					2 lanes	Single side- 30m pole spacing	12,400	83	18	Type 2	10	2	0
						Single side- 40m pole spacing	19,500	130	18	Type 2	12	1	0
					4 lanes	Single side- 30m pole spacing	33,000	220	27	Type 4	10.5	2.5	0
						Single side- 40m pole spacing	60,000	400	27	Type 4	13	0.5	10
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	9,300	62	20	Type 2	11	0.5	0
					6 lanes	Opposite- 40m pole spacing	25,500	170	24	Type 4	13	0.5	5
						Single side- 30m pole spacing	-	-	-	-	-	-	-
						Single side- 40m pole spacing	-	-	-	-	-	-	-
						Staggered- 60m pole spacing	-	-	-	-	-	-	-
						Opposite- 30m pole spacing	12,200	81	20	Type 2	10	1	0
					Opposite- 40m pole spacing	-	-	-	-	-	-	-	-
	Other areas	Junctions <3 per km	Vehicles <15000	ME3b	1 lane	Single side- 30m pole spacing	5,400	36	11	Type 2	7	0.5	5
						Single side- 40m pole spacing	9,000	60	11	Type 2	9	2	0
					2 lanes	Single side- 30m pole spacing	6,750	45	13	Type 2	7.5	1.5	0
						Single side- 40m pole spacing	11,000	73	13	Type 2	9	1.5	5

				4 lanes	Single side- 30m pole spacing	14,200	95	15	Type 2	12	1	5
				4 lanes	Single side- 40m pole spacing	20,000	133	15	Type 2	11.5	0.5	10
				4 lanes	Staggered- 60m pole spacing	12,500	83	13	Type 2	12	1.5	0
				4 lanes	Opposite- 30m pole spacing	5,900	39	13	Type 2	8	0	0
				4 lanes	Opposite- 40m pole spacing	8,500	57	14	Type 2	10	0	0
				6 lanes	Single side- 30m pole spacing	20,000	133	16	Type 3	10.5	2	0
				6 lanes	Single side- 40m pole spacing	30,000	200	16	Type 3	12	1	0
				6 lanes	Staggered- 60m pole spacing	19,400	129	14	Type 3	11.5	0.5	0
				6 lanes	Opposite- 30m pole spacing	8,000	53	13	Type 2	8.5	0	5
				6 lanes	Opposite- 40m pole spacing	11,000	73	13	Type 2	9.5	0	5
				1 lane	Single side- 30m pole spacing	5,400	36	11	Type 2	7	0.5	5
				1 lane	Single side- 40m pole spacing	9,000	60	11	Type 2	9	2	0
				2 lanes	Single side- 30m pole spacing	6,750	45	13	Type 2	7.5	1.5	0
				2 lanes	Single side- 40m pole spacing	11,000	73	13	Type 2	9	1.5	5
				4 lanes	Single side- 30m pole spacing	14,200	95	15	Type 2	12	1	5
				4 lanes	Single side- 40m pole spacing	20,000	133	15	Type 2	11.5	0.5	10
				4 lanes	Staggered- 60m pole spacing	12,500	83	13	Type 2	12	1.5	0
				4 lanes	Opposite- 30m pole spacing	5,900	39	13	Type 2	8	0	0
				4 lanes	Opposite- 40m pole spacing	8,500	57	14	Type 2	10	0	0
				6 lanes	Single side- 30m pole spacing	20,000	133	16	Type 3	10.5	2	0
				6 lanes	Single side- 40m pole spacing	30,000	200	16	Type 3	12	1	0
				6 lanes	Staggered- 60m pole spacing	19,400	129	14	Type 3	11.5	0.5	0
				6 lanes	Opposite- 30m pole spacing	8,000	53	13	Type 2	8.5	0	5
				6 lanes	Opposite- 40m pole spacing	11,000	73	13	Type 2	9.5	0	5
				1 lane	Single side- 30m pole spacing	9,000	60	16	Type 2	8.5	1	0
				1 lane	Single side- 40m pole spacing	15,000	100	16	Type 2	10	1	5
				2 lanes	Single side- 30m pole spacing	12,400	83	18	Type 2	10	2	0
				2 lanes	Single side- 40m pole spacing	19,500	130	18	Type 2	12	1	0
				4 lanes	Single side- 30m pole spacing	33,000	220	27	Type 4	10.5	2.5	0
				4 lanes	Single side- 40m pole spacing	60,000	400	27	Type 4	13	0.5	10
				4 lanes	Staggered- 60m pole spacing	-	-	-	-	-	-	-
				4 lanes	Opposite- 30m pole spacing	9,300	62	20	Type 2	11	0.5	0
				4 lanes	Opposite- 40m pole spacing	25,500	170	24	Type 4	13	0.5	5
				6 lanes	Single side- 30m pole spacing	-	-	-	-	-	-	-
				6 lanes	Single side- 40m pole spacing	-	-	-	-	-	-	-
				6 lanes	Staggered- 60m pole spacing	-	-	-	-	-	-	-
				6 lanes	Opposite- 30m pole spacing	12,200	81	20	Type 2	10	1	0
				6 lanes	Opposite- 40m pole spacing	-	-	-	-	-	-	-

2. Analyse the Road Conditions

To obtain the above results, following road situations were considered.

a) Class A- Within Town Area

	Parameter	Description		Values	For normal situation	For conflict area
a)	Typical speed	How high is the typical speed of the main user in the street? Mai users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic	Typical speed of the main user	High [>60 km/h]		
				Medium [Between 30-60km/h]	✓	✓
				Low [Between 5-30km/h]		
				Walking speed (<5km/h)		
b)	Main users and other users		Enter main user type and other user permitted user types	Main users are motor vehicles are motor vehicles and slow vehicles <40km/h. Bicyclists and pedestrians are permitted		
				Main users are motor vehicles are motor vehicles, slow vehicles <40km/h and bicyclists. Pedestrians are permitted	✓	✓
c)	Main weather type		Enter typical weather	Dry	✓	✓
				Wet		
d)	Traffic calming areas		Have traffic calming areas taken into consideration?	Yes	✓	✓
				No		
e)	Interchanges	How the street connect to other streets and the frequency of interchanges/Junctions	Enter the frequency of simple junctions	<3 per km		
				>= 3 per km	✓	✓
f)	Degree of navigation difficulty	How much of effort will the traffic participant have to make in order to select a driving direction and driving lane, or to maintain or change their speed and position in the roadway?	Degree of navigation difficulty is	Normal		
				High	✓	✓

g)	Vehicles per day		How many vehicles are there per day?	Less than 7000	✓	✓
				Between 7000 and 15000	✓	✓
				Between 15000 and 55000	✓	✓
				More than 25000	✓	✓
h)	Conflict zones	Conflict zones are the zones where different traffic flows cross or zones that are also used by other traffic participants	Does a conflict zone exist?	Yes	✓	
				No		✓
i)	Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit buildings) within the field of vision?	Complexity of field vision is	Normal		
				High	✓	✓
j)	Parked vehicles		Do parked vehicles have to be taken into consideration?	Yes	✓	✓
				No		
k)	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification are made	Brightness of surrounding is	Low (Rural environment)		
				Medium (City environment)	✓	✓
				High (Inner-city environment)		
l)	Traffic flow for bicyclist			Normal		
				High	✓	✓
Road Lighting Class					ME2	ME2

b) Class A- Other Areas

	Parameter	Description	Values	For normal situation				For conflict area					
				Junctions <3 per km		Junctions >=3 per km		Junctions <3 per km		Junctions >=3 per km			
				Vehicles <15000	Vehicles 15000-25000	Vehicles <15000	Vehicles 15000-25000	Vehicles <15000	Vehicles 15000-25000	Vehicles <15000	Vehicles 15000-25000		
a)	Typical speed	How high is the typical speed of the main user in the street? Mai users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic	Typical speed of the main user	High [>60 km/h]	✓	✓	✓	✓	✓	✓	✓	✓	
				Medium [Between 30-60km/h]									
				Low [Between 5-30km/h]									
				Walking speed (<5km/h)									
b)	Main users and other users		Enter main user type and other user permitted user types	All other users (slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	✓	✓	✓	✓	✓	✓	✓		
				Other users are not permitted									
c)	Main weather type		Enter typical weather	Dry	✓	✓	✓	✓	✓	✓	✓		
				Wet									
d)	Interchanges	How the street connect to other streets and the frequency of interchanges/Junctions	Enter the frequency of simple junctions	<3 per km	✓	✓			✓	✓			
				>= 3 per km			✓	✓			✓	✓	
e)	Vehicles per day		How many vehicles are there per day?	Less than 7000	✓		✓		✓		✓		
				Between 7000 and 15000	✓		✓		✓			✓	
				Between 15000 and 25000		✓		✓		✓			✓
				More than 25000									
f)	Conflict zones	Conflict zones are the zones where different traffic flows cross or zones that are also used by other traffic participants	Does a conflict zone exist?	Yes					✓	✓	✓	✓	
				No	✓	✓	✓	✓					

g)	Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit buildings) within the field of vision?	Complexity of field vision is	Normal	✓	✓	✓	✓				
				High								
h)	Parked vehicles		Do parked vehicles have to be taken into consideration?	Yes								
				No	✓	✓	✓	✓				
i)	Degree of navigation difficulty	How much of effort will the traffic participant have to make in order to select a driving direction and driving lane, or to maintain or change their speed and position in the roadway?	Degree of navigation difficulty is	Normal	✓	✓	✓	✓				
				High								
j)	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification are made	Brightness of surrounding is	Low (Rural environment)	✓	✓	✓	✓				
				Medium (City environment)								
				High (Inner-city environment)								
Road Lighting Class					ME5	ME4a	ME4a	ME3b	ME3b	ME2	ME3b	ME2

c) Class B- Within Town Area

	Parameter	Description		Values	For normal situation	For conflict area
a)	Typical speed	How high is the typical speed of the main user in the street? Mai users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic	Typical speed of the main user	High [>60 km/h]		
				Medium [Between 30-60km/h]	✓	✓
				Low [Between 5-30km/h]		
				Walking speed (<5km/h)		
b)	Main users and other users		Enter main user type and other user permitted user types	Main users are motor vehicles are motor vehicles and slow vehicles <40km/h. Bicyclists and pedestrians are permitted		
				Main users are motor vehicles are motor vehicles, slow vehicles <40km/h and bicyclists. Pedestrians are permitted	✓	✓
c)	Main weather type		Enter typical weather	Dry	✓	✓
				Wet		
d)	Traffic calming areas		Have traffic calming areas taken into consideration?	Yes	✓	✓

				No		
e)	Interchanges	How the street connect to other streets and the frequency of interchanges/Junctions	Enter the frequency of simple junctions	<3 per km		
				>= 3 per km	✓	✓
f)	Degree of navigation difficulty	How much of effort will the traffic participant have to make in order to select a driving direction and driving lane, or to maintain or change their speed and position in the roadway?	Degree of navigation difficulty is	Normal	✓	✓
				High		
g)	Vehicles per day		How many vehicles are there per day?	Less than 7000	✓	✓
				Between 7000 and 15000	✓	✓
				Between 15000 and 25000	✓	✓
				More than 25000		
h)	Conflict zones	Conflict zones are the zones where different traffic flows cross or zones that are also used by other traffic participants	Does a conflict zone exist?	Yes		✓
				No	✓	
i)	Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit buildings) within the field of vision?	Complexity of field vision is	Normal	✓	
				High		
j)	Parked vehicles		Do parked vehicles have to be taken into consideration?	Yes	✓	
				No		
k)	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification are made	Brightness of surrounding is	Low (Rural environment)		
				Medium (City environment)	✓	
				High (Inner-city environment)		
l)	Traffic flow for bicyclist			Normal	✓	
				High		
Road Lighting Class					ME3c	ME2

d) Class B- Other Areas

	Parameter	Description		Values	For normal situation		For conflict area		
					Junctions <3 per km	Junctions >=3 per km	Junctions <3 per km	Junctions >=3 per km	
a)	Typical speed	How high is the typical speed of the main user in the street? Main users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic	Typical speed of the main user	High [>60 km/h]	✓	✓	✓	✓	✓
				Medium [Between 30-60km/h]					
				Low [Between 5-30km/h]					
				Walking speed (<5km/h)					
b)	Main users and other users		Enter main user type and other user permitted user types	All other users (slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	✓	✓	✓	✓	✓
				Other users are not permitted					
c)	Main weather type		Enter typical weather	Dry	✓	✓	✓	✓	✓
				Wet					
d)	Interchanges	How the street connect to other streets and the frequency of interchanges/Junctions	Enter the frequency of simple junctions	<3 per km	✓		✓		
				>= 3 per km		✓		✓	✓
e)	Vehicles per day		How many vehicles are there per day?	Less than 7000	✓	✓	✓	✓	
				Between 7000 and 15000	✓	✓	✓		✓
				Between 15000 and 25000					
				More than 25000					
f)	Conflict zones	Conflict zones are the zones where different traffic flows cross or zones that are also used by other traffic participants	Does a conflict zone exist?	Yes			✓	✓	✓
				No	✓	✓			
g)	Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit	Complexity of field vision is	Normal	✓	✓			
				High					

		buildings) within the field of vision?							
h)	Parked vehicles		Do parked vehicles have to be taken into consideration?	Yes					
				No	✓	✓			
i)	Degree of navigation difficulty	How much of effort will the traffic participant have to make in order to select a driving direction and driving lane, or to maintain or change their speed and position in the roadway?	Degree of navigation difficulty is	Normal	✓	✓			
				High					
j)	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification are made	Brightness of surrounding is	Low (Rural environment)	✓	✓			
				Medium (City environment)					
				High (Inner-city environment)					
Road Lighting Class					ME5	ME4a	ME3b	ME3b	ME2

e) Secondary/Minor roads

	Parameter	Description	Values	Within town area	Other areas	
a)	Typical speed	How high is the typical speed of the main user in the street? Mai users include combinations of motorized traffic, slow vehicles, bicyclists and pedestrians. If motorized traffic is one of the main users, enter the typical speed of the motorized traffic	Typical speed of the main user	High [>60 km/h]		
				Medium [Between 30-60km/h]		
				Low [Between 5-30km/h]	✓	✓
				Walking speed (<5km/h)		
b)	Main users and other users		Enter main user type and other user permitted user types	All other users (motor vehicles, slow vehicles speed <40km/h, bicyclists and pedestrians) are permitted	✓	✓
				Other users are not permitted		
c)	Traffic calming areas		Have traffic calming areas taken into consideration?	Yes		
				No	✓	✓
d)	Parked vehicles		Do parked vehicles have to be taken into consideration?	Yes		

				No	✓	✓
e)	Degree of navigation difficulty	How much of effort will the traffic participant have to make in order to select a driving direction and driving lane, or to maintain or change their speed and position in the roadway?	Degree of navigation difficulty is	Normal	✓	✓
				High		
f)	Traffic flow for bicyclist			Normal	✓	✓
				High		
g)	Complexity of field vision	How much distraction, confusion or disruption is caused to traffic participants by lighting and other optical stimuli (for example advertising, light poles, lit buildings) within the field of vision?	Complexity of field vision is	Normal	✓	✓
				High		
h)	Identification of persons		The criminality risk for the viewed traffic area is given in comparison to the criminality risk for the extended surroundings	Normal	✓	✓
				High		
			Face recognition of people is	Required	✓	✓
				Not required		
i)	Brightness of surrounding	Since the luminance level of the surrounding can only be estimated, only broad classification are made	Brightness of surrounding is	Low (Rural environment)		✓
				Medium (City environment)	✓	
				High (Inner-city environment)		
Road Lighting Class					S5	S6

APPENDIX C- LIGHTING SIMULATION REPORT FOR CLASS A ROADS WITHIN
TOWN AREA

CLASS A-ROADS WITHIN TOWN AREA

Date: 03.10.2020

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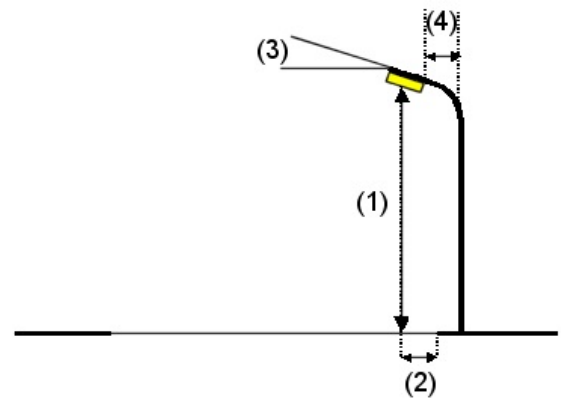
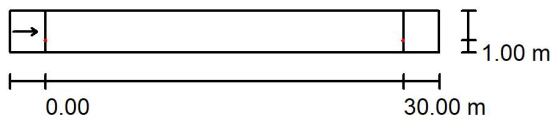
Class A-Within Town Area-1 lane-ME2 / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

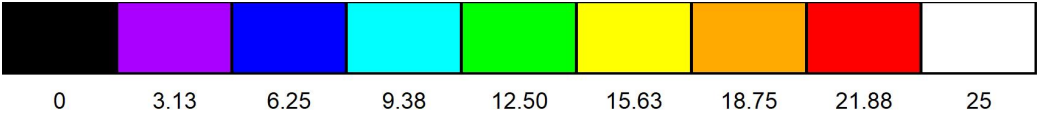
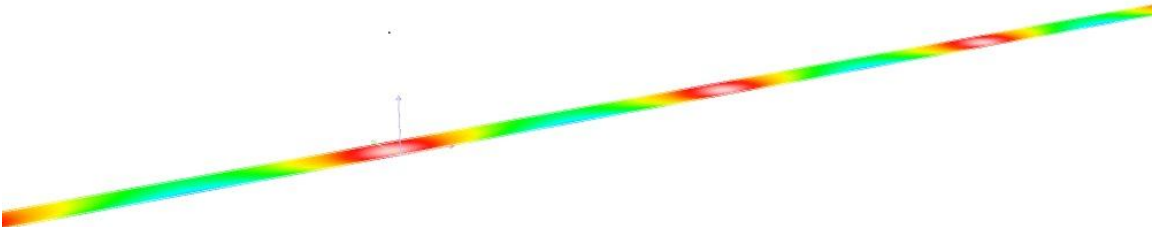
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	9000 lm	Maximum luminous intensities
Luminous flux (Lamps):	9000 lm	at 70°: 896 cd/klm
Luminaire Wattage:	60.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.600 m	No luminous intensities above 90°.
Height:	8.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.000 m	



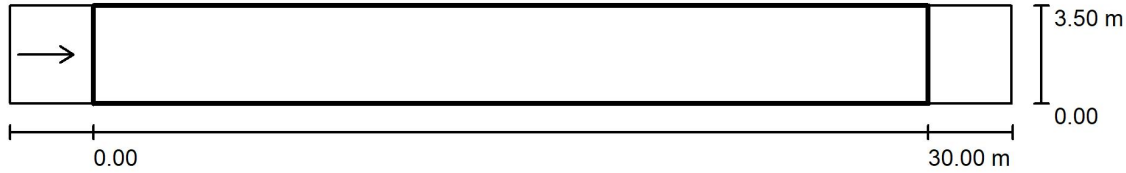
Class A-Within Town Area-1 lane-ME2 / False Color Rendering



lx



Class A-Within Town Area-1 lane-ME2 / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME2

(All lighting performance requirements are met.)

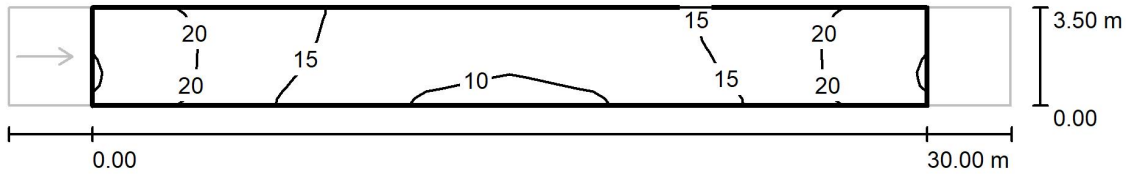
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.51	0.79	0.78	10	0.85
Required values according to class:	≥ 1.50	≥ 0.40	≥ 0.70	≤ 10	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (1 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.51	0.79	0.78	10



Class A-Within Town Area-1 lane-ME2 / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]
16

E_{min} [lx]
9.34

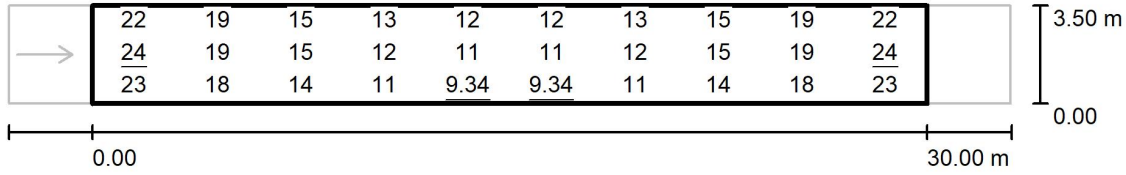
E_{max} [lx]
24

u0
0.588

E_{min} / E_{max}
0.397



Class A-Within Town Area-1 lane-ME2 / Valuation Field Roadway 1 / Value Chart (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]
16

E_{min} [lx]
9.34

E_{max} [lx]
24

u0
0.588

E_{min} / E_{max}
0.397



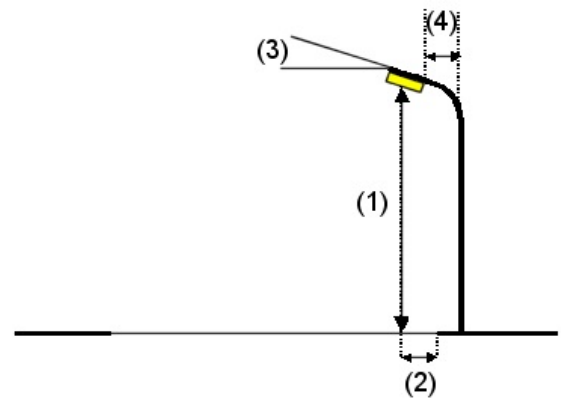
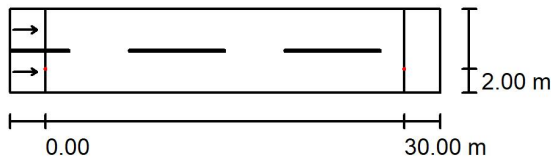
Class A-Within Town Area-2 lanes-ME2 / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

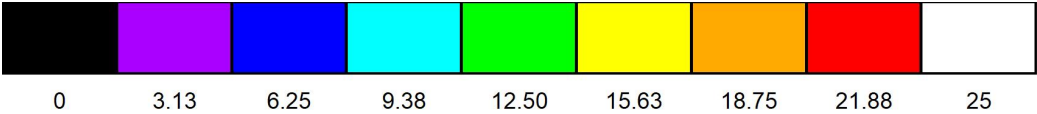
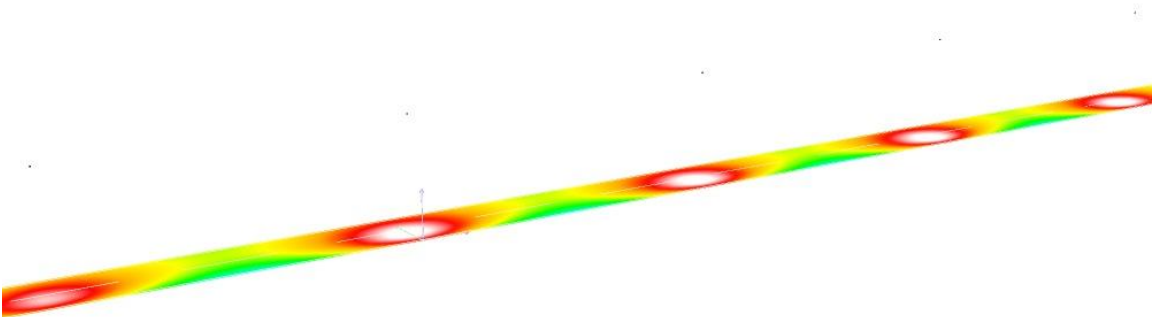
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	12400 lm	Maximum luminous intensities
Luminous flux (Lamps):	12400 lm	at 70°: 896 cd/klm
Luminaire Wattage:	83.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.100 m	No luminous intensities above 90°.
Height:	10.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	2.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	2.000 m	



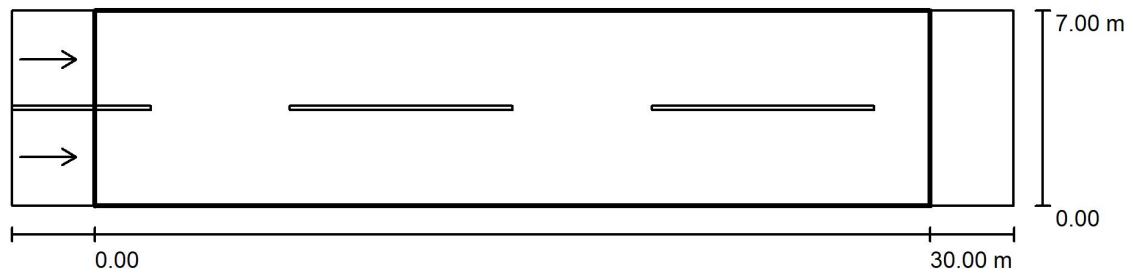
Class A-Within Town Area-2 lanes-ME2 / False Color Rendering



lx



Class A-Within Town Area-2 lanes-ME2 / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 6 Points
 Accompanying Street Elements: Roadway 1.
 tarmac: R3, q0: 0.070
 Selected Lighting Class: ME2

(All lighting performance requirements are met.)

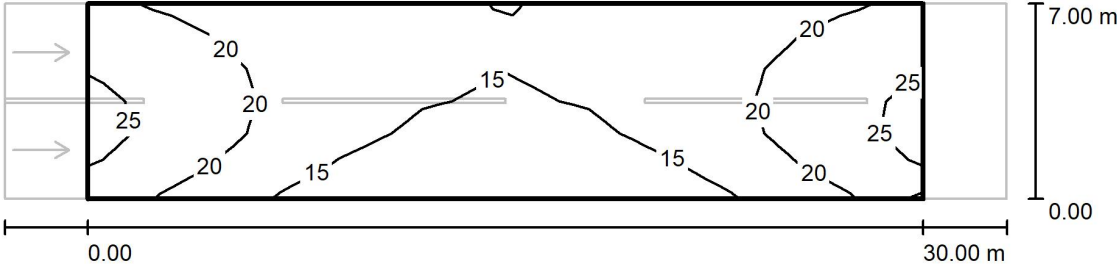
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.50	0.70	0.84	10	0.66
Required values according to class:	≥ 1.50	≥ 0.40	≥ 0.70	≤ 10	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.50	0.70	0.90	8
2	Observer 2	(-60.000, 5.250, 1.500)	1.57	0.70	0.84	10



Class A-Within Town Area-2 lanes-ME2 / Valuation Field Roadway 1 / Isolines (E)

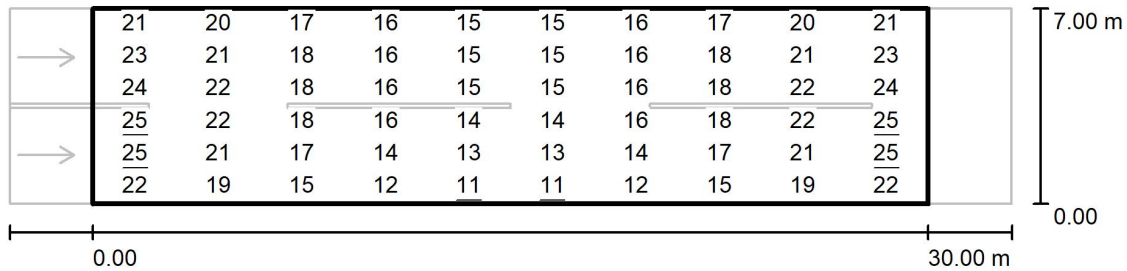


Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
18	11	25	0.601	0.431

Class A-Within Town Area-2 lanes-ME2 / Valuation Field Roadway 1 / Value Chart (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
18	11	25	0.601	0.431



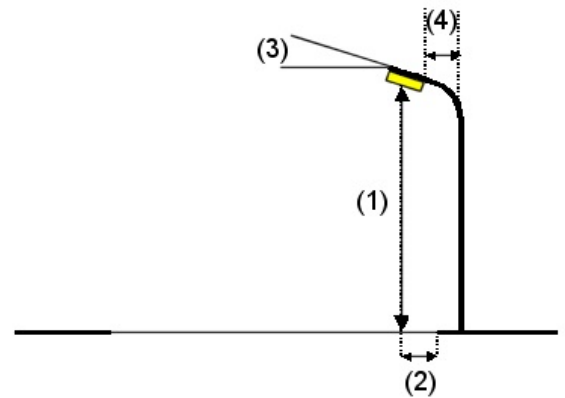
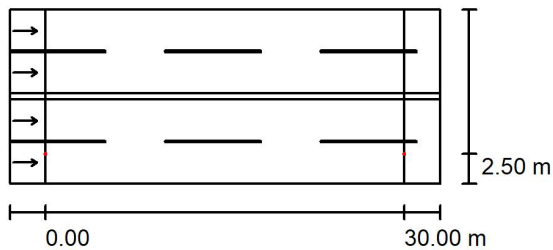
Class A-Within Town Area-4 lanes-ME2-Single side / Planning data

Street Profile

- Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
- Median 1 (Width: 0.500 m, Height: 0.000 m)
- Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

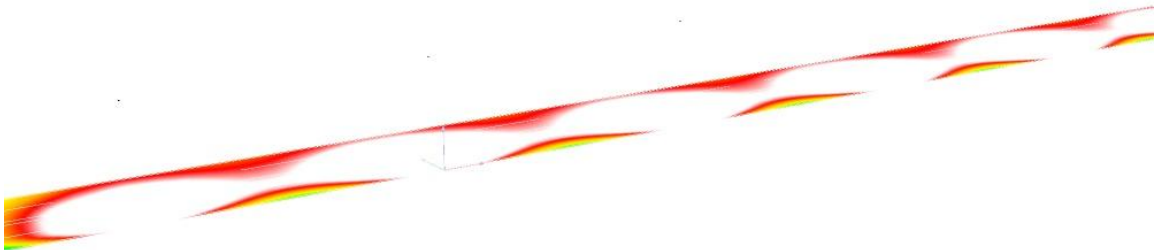
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-4 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 4 OPTIC, No Shield	
Luminous flux (Luminaire):	33000 lm	Maximum luminous intensities
Luminous flux (Lamps):	33000 lm	at 70°: 641 cd/klm
Luminaire Wattage:	220.0 W	at 80°: 94 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.600 m	No luminous intensities above 90°.
Height:	10.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	2.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	2.500 m	

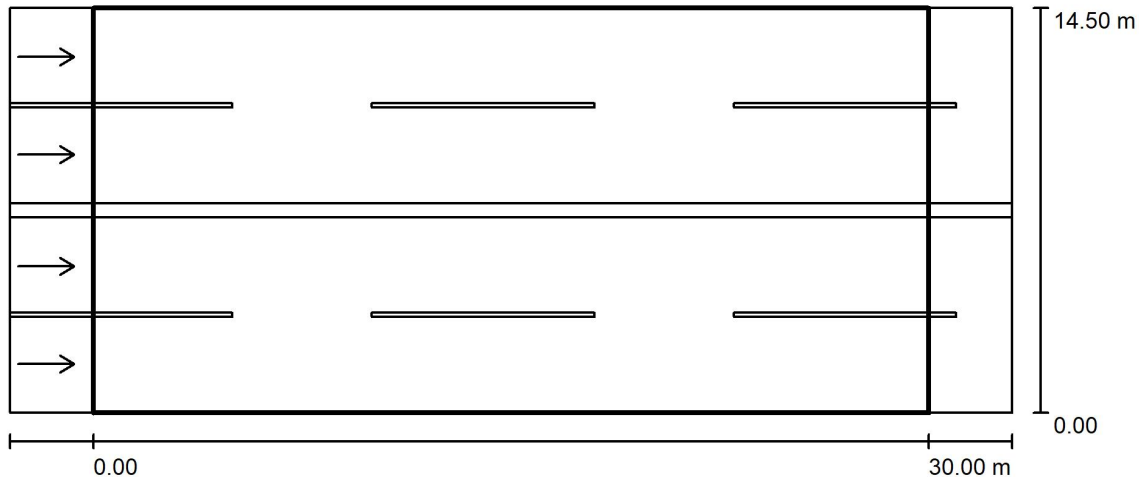


Class A-Within Town Area-4 lanes-ME2-Single side / False Color Rendering



lx

Class A-Within Town Area-4 lanes-ME2-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME2

(All lighting performance requirements are met.)

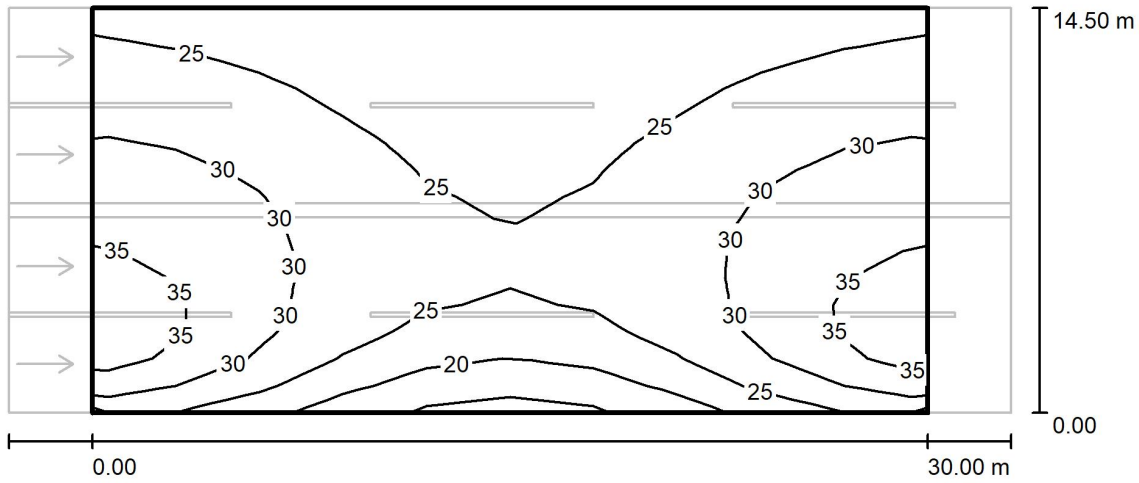
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.51	0.53	0.71	10	0.53
Required values according to class:	≥ 1.50	≥ 0.40	≥ 0.70	≤ 10	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.51	0.57	0.76	6
2	Observer 2	(-60.000, 5.250, 1.500)	1.58	0.55	0.71	10
3	Observer 3	(-60.000, 9.250, 1.500)	1.66	0.53	0.78	10
4	Observer 4	(-60.000, 12.750, 1.500)	1.72	0.53	0.81	7



Class A-Within Town Area-4 lanes-ME2-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

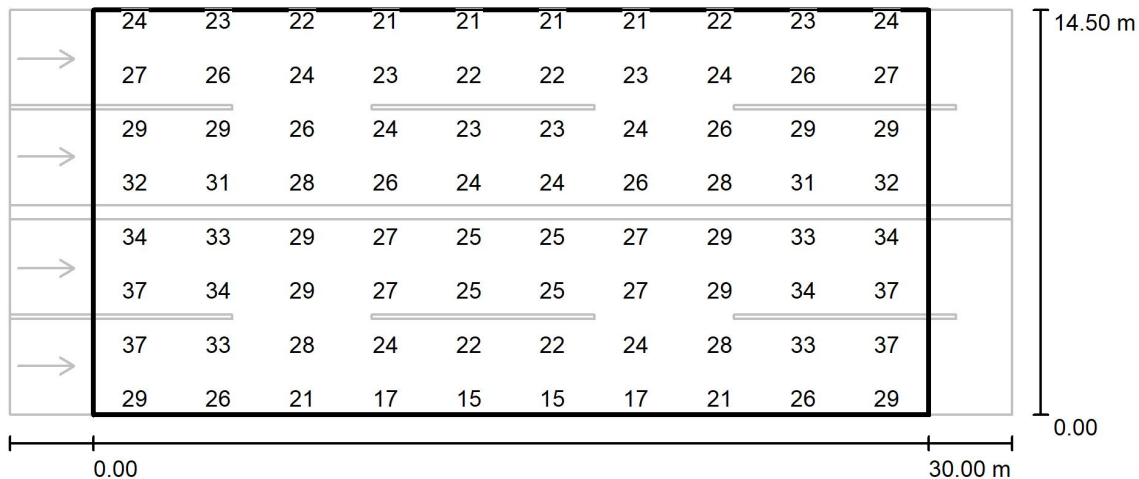


Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
27	15	38	0.548	0.387

Class A-Within Town Area-4 lanes-ME2-Single side / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
27	15	38	0.548	0.387

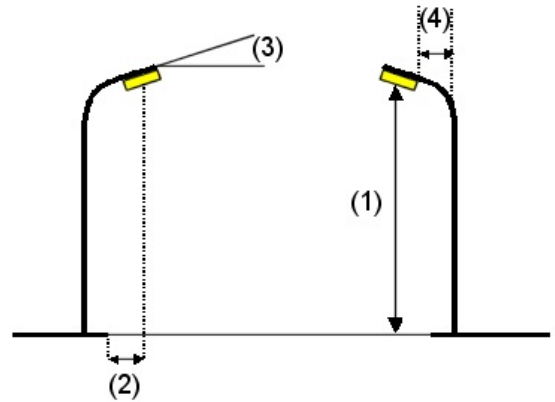
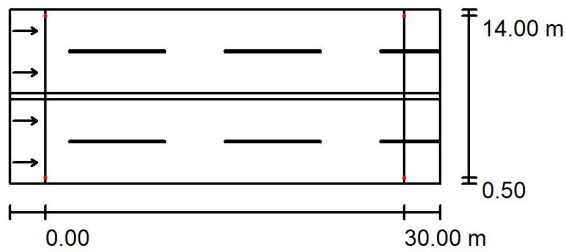
Class A-Within Town Area-4 lanes-ME2-Opposite / Planning data

Street Profile

- Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
- Median 1 (Width: 0.500 m, Height: 0.000 m)
- Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

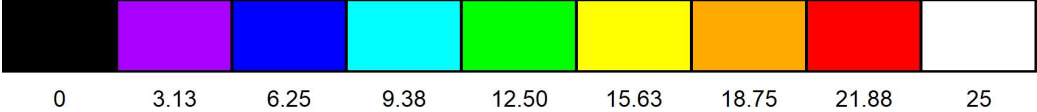
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	9300 lm	Maximum luminous intensities
Luminous flux (Lamps):	9300 lm	at 70°: 896 cd/klm
Luminaire Wattage:	62.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, opposing	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	11.100 m	No luminous intensities above 90°.
Height:	11.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.500 m	



Class A-Within Town Area-4 lanes-ME2-Opposite / False Color Rendering



Class A-Within Town Area-4 lanes-ME2-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME2

(All lighting performance requirements are met.)

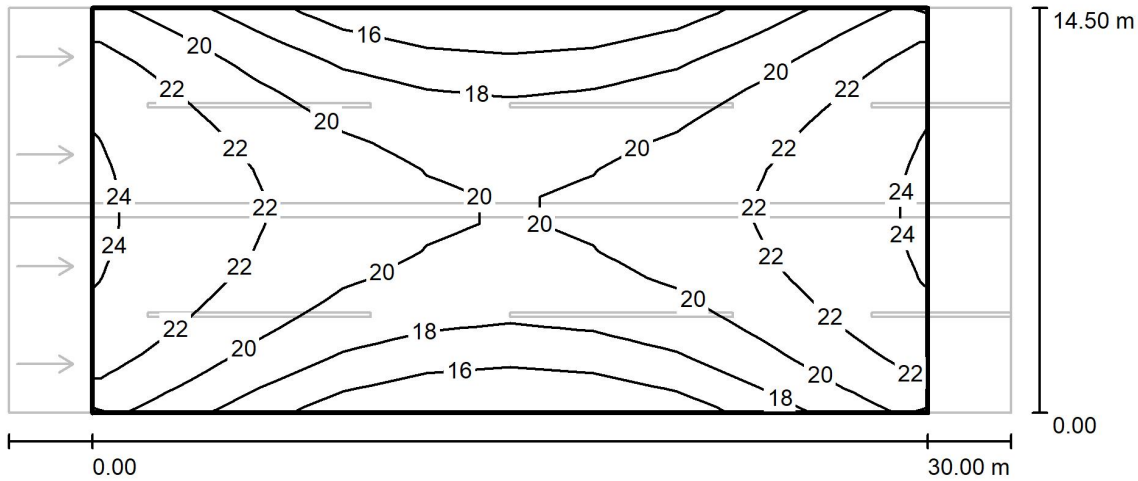
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.50	0.63	0.92	10	0.51
Required values according to class:	≥ 1.50	≥ 0.40	≥ 0.70	≤ 10	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.50	0.63	0.93	8
2	Observer 2	(-60.000, 5.250, 1.500)	1.52	0.71	0.92	10
3	Observer 3	(-60.000, 9.250, 1.500)	1.52	0.71	0.92	10
4	Observer 4	(-60.000, 12.750, 1.500)	1.50	0.63	0.93	8



Class A-Within Town Area-4 lanes-ME2-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

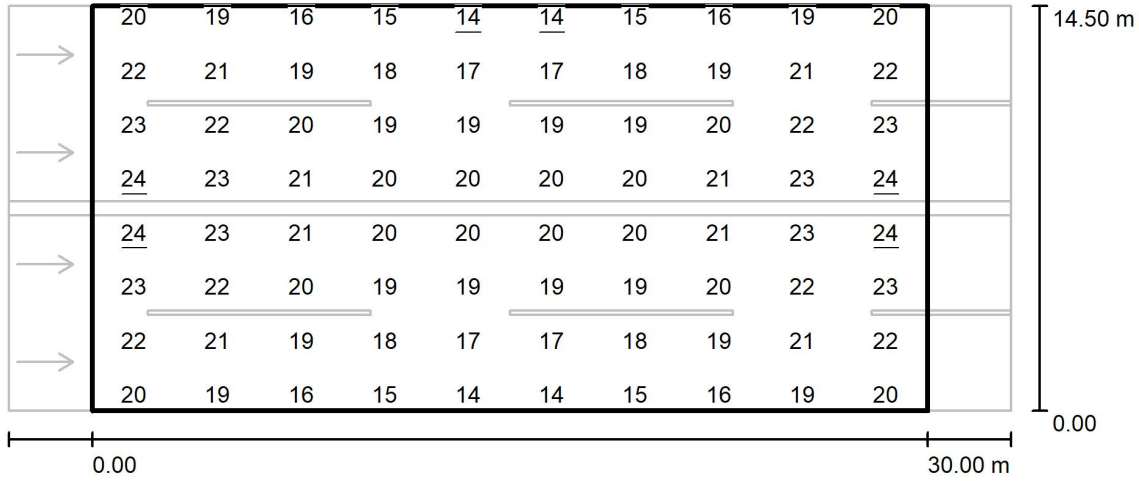


Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
20	14	24	0.707	0.592

Class A-Within Town Area-4 lanes-ME2-Opposite / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Grid: 10 x 15 Points

E_{av} [lx]
20

E_{min} [lx]
14

E_{max} [lx]
24

u0
0.707

E_{min} / E_{max}
0.592



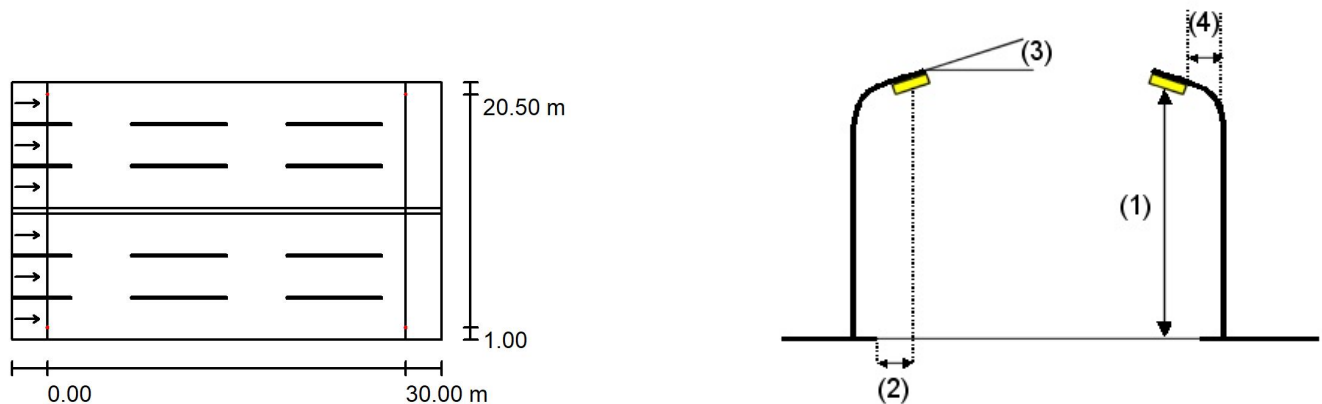
Class A-Within Town Area-6 lanes-ME2-Opposite / Planning data

Street Profile

- Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
- Median 1 (Width: 0.500 m, Height: 0.000 m)
- Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

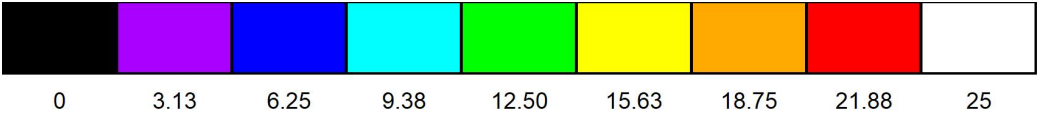
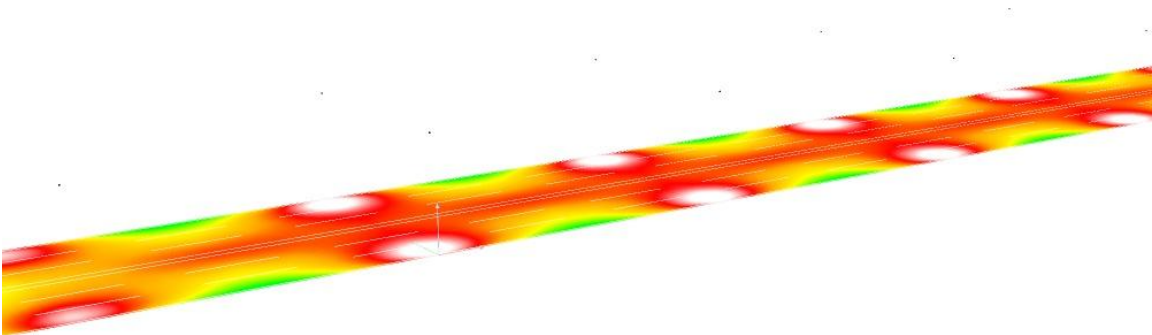
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	12200 lm	Maximum luminous intensities
Luminous flux (Lamps):	12200 lm	at 70°: 896 cd/klm
Luminaire Wattage:	81.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, opposing	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.100 m	No luminous intensities above 90°.
Height:	10.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.000 m	

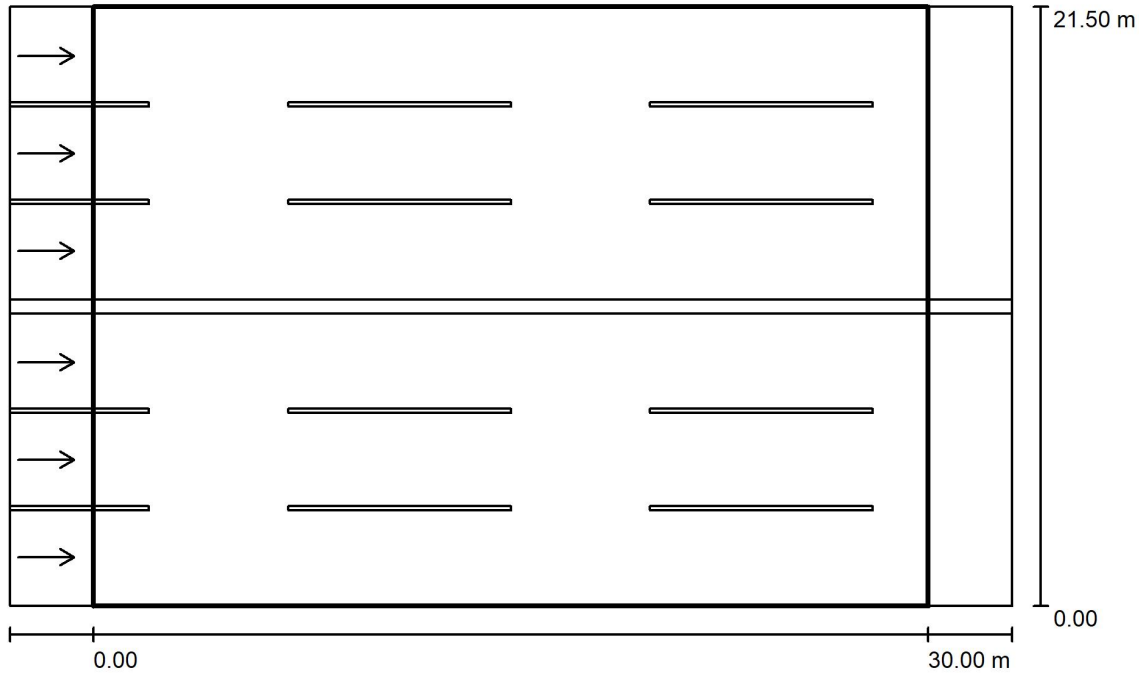


Class A-Within Town Area-6 lanes-ME2-Opposite / False Color Rendering



lx

Class A-Within Town Area-6 lanes-ME2-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME2

(All lighting performance requirements are met.)

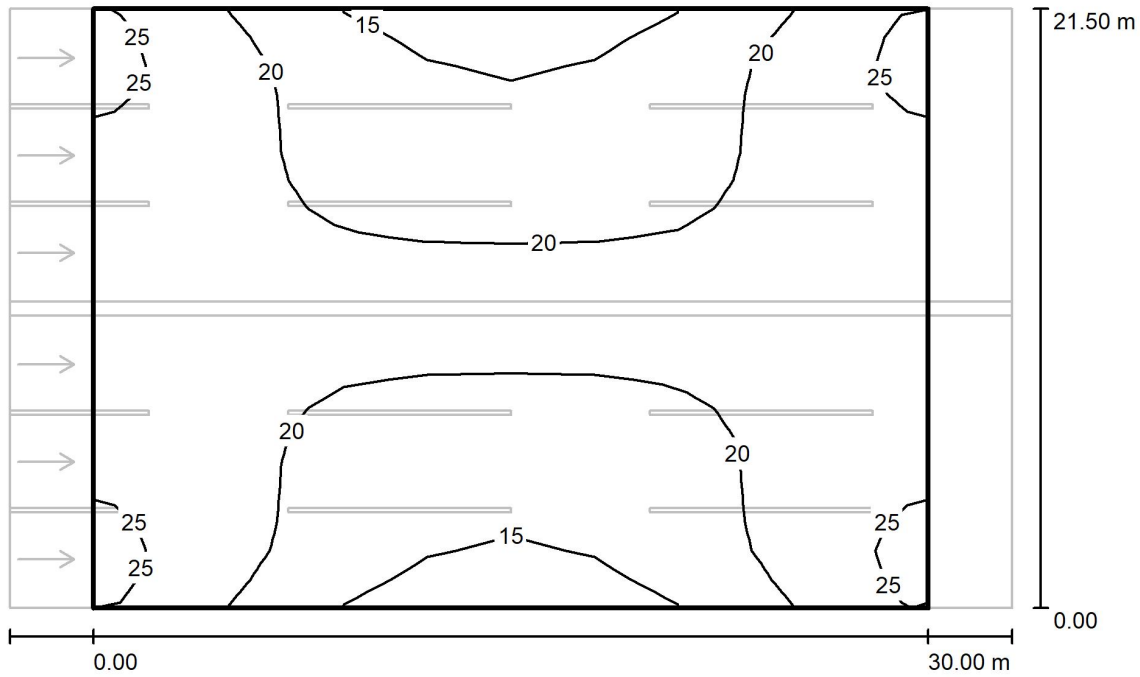
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.51	0.54	0.87	10	0.50
Required values according to class:	≥ 1.50	≥ 0.40	≥ 0.70	≤ 10	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.51	0.54	0.89	9
2	Observer 2	(-60.000, 5.250, 1.500)	1.54	0.58	0.89	10
3	Observer 3	(-60.000, 8.750, 1.500)	1.55	0.64	0.87	9
4	Observer 4	(-60.000, 12.750, 1.500)	1.55	0.64	0.87	9
5	Observer 5	(-60.000, 16.250, 1.500)	1.54	0.58	0.89	10
6	Observer 6	(-60.000, 19.750, 1.500)	1.51	0.54	0.89	9



Class A-Within Town Area-6 lanes-ME2-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

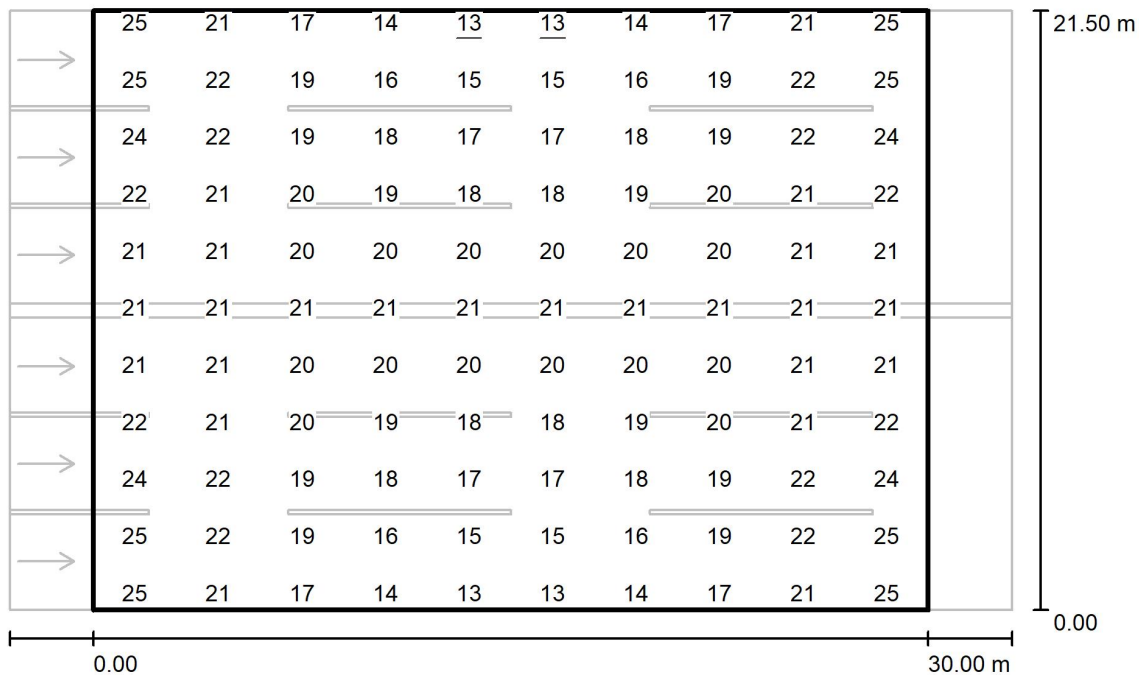


Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
20	13	26	0.635	0.493

Class A-Within Town Area-6 lanes-ME2-Opposite / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
20	13	26	0.635	0.493

APPENDIX D- LIGHTING SIMULATION REPORT FOR CLASS A ROADS NOT WITHIN TOWN AREA

CLASS A-ROADS NOT WITHIN TOWN AREA

Date: 03.10.2020

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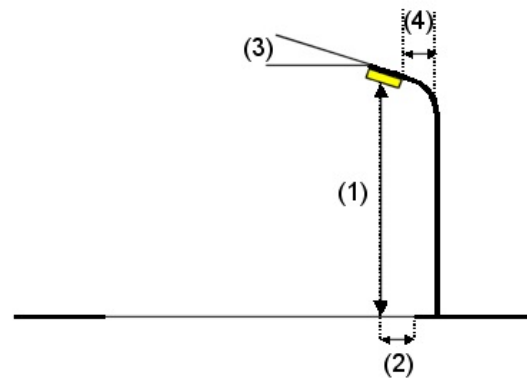
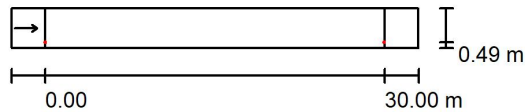
Class A-Other Areas-1 lane-ME3b / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

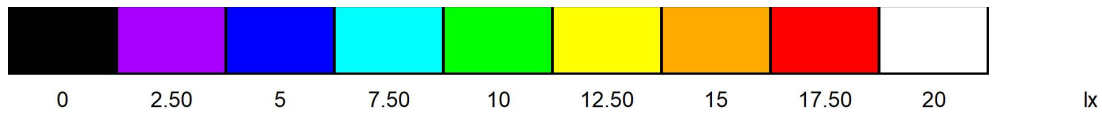
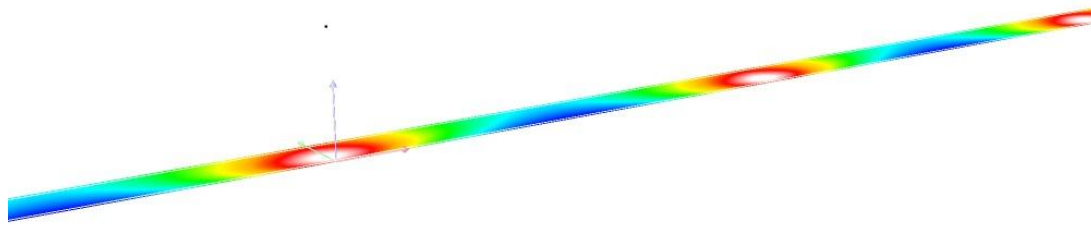
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	5400 lm	Maximum luminous intensities
Luminous flux (Lamps):	5400 lm	at 70°: 855 cd/klm
Luminaire Wattage:	36.0 W	at 80°: 160 cd/klm
Arrangement:	Single row, bottom	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.100 m	No luminous intensities above 95°.
Height:	7.000 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	0.491 m	

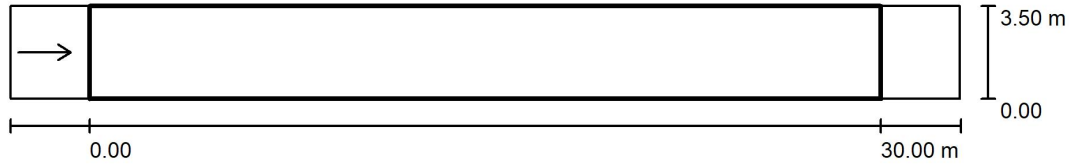


Class A-Other Areas-1 lane-ME3b / False Color Rendering





Class A-Other Areas-1 lane-ME3b / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

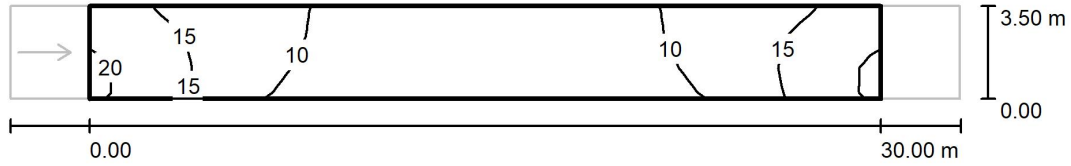
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.65	0.62	14	0.78
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (1 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.65	0.62	14



Class A-Other Areas-1 lane-ME3b / Valuation Field Roadway 1 / Isolines (E)



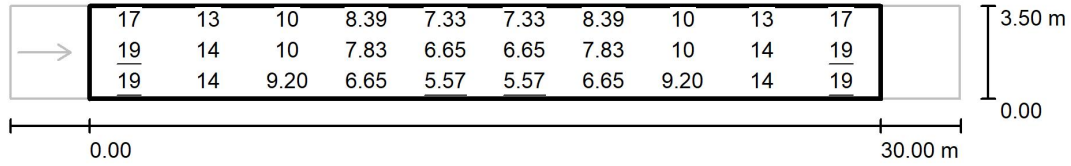
Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
11	5.57	19	0.498	0.294



Class A-Other Areas-1 lane-ME3b / Valuation Field Roadway 1 / Value Chart (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
11	5.57	19	0.498	0.294



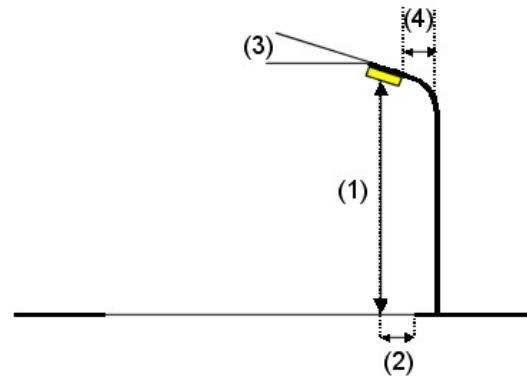
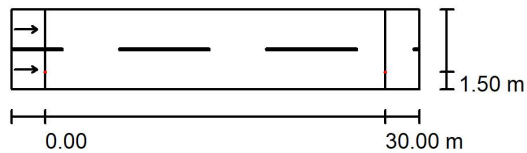
Class A-Other Areas-2 lanes-ME3b / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

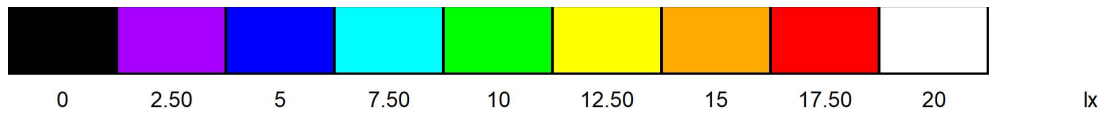
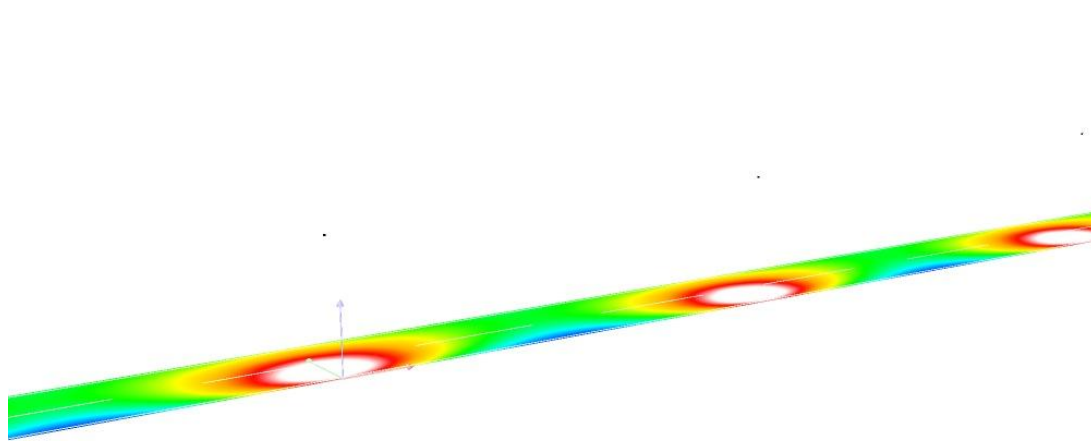
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	6750 lm	Maximum luminous intensities
Luminous flux (Lamps):	6750 lm	at 70°: 896 cd/klm
Luminaire Wattage:	45.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.500 m	No luminous intensities above 90°.
Height:	7.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

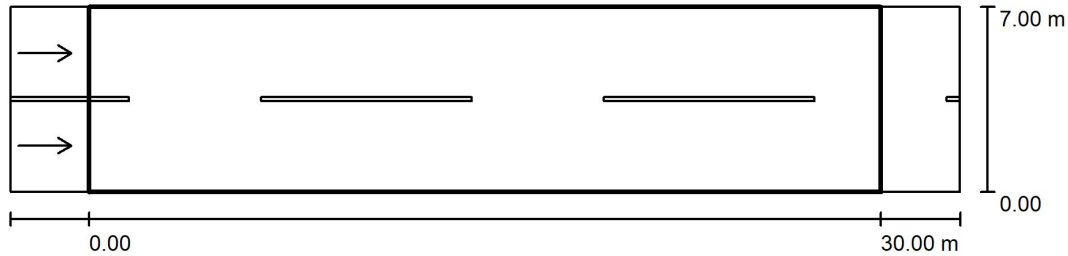


Class A-Other Areas-2 lanes-ME3b / False Color Rendering





Class A-Other Areas-2 lanes-ME3b / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 6 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

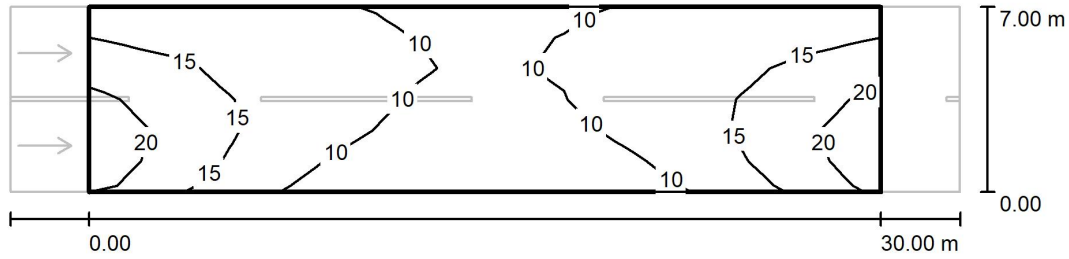
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.49	0.63	14	0.51
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.49	0.68	13
2	Observer 2	(-60.000, 5.250, 1.500)	1.06	0.49	0.63	14



Class A-Other Areas-2 lanes-ME3b / Valuation Field Roadway 1 / Isolines (E)

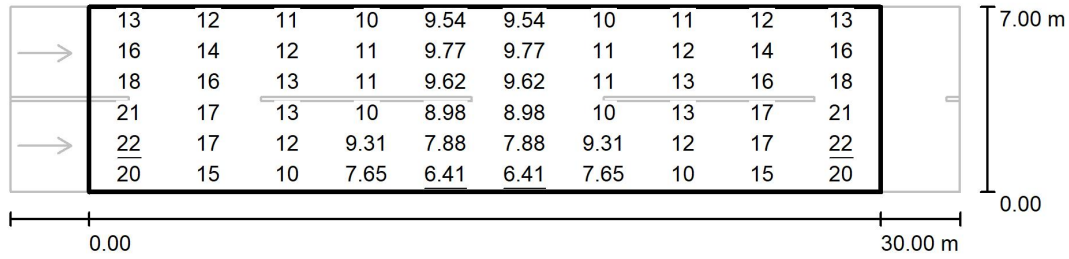


Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	6.41	22	0.504	0.295

Class A-Other Areas-2 lanes-ME3b / Valuation Field Roadway 1 / Value Chart (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]
13

E_{min} [lx]
6.41

E_{max} [lx]
22

u0
0.504

E_{min} / E_{max}
0.295



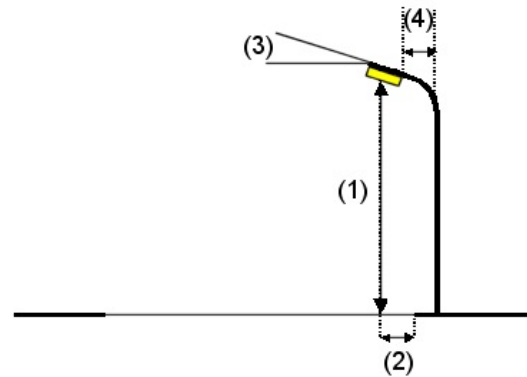
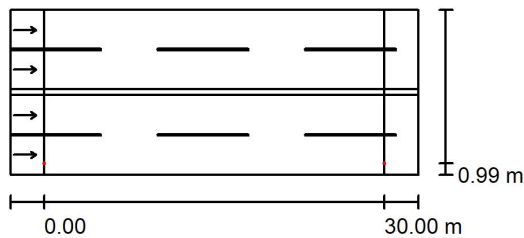
Class A-Other Areas-4 lanes-ME3b-Single side / Planning data

Street Profile

- Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
- Median 1 (Width: 0.500 m, Height: 0.000 m)
- Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

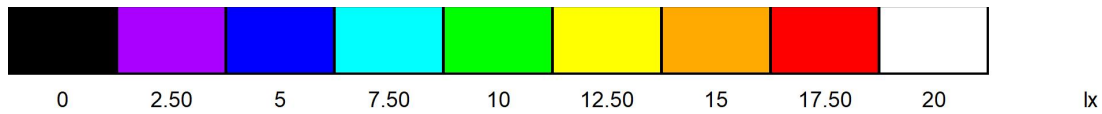
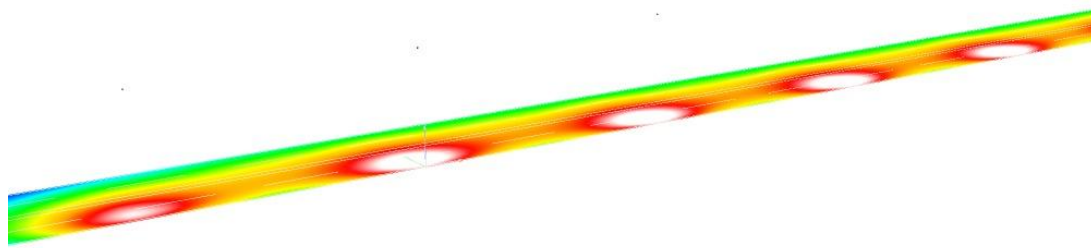
Luminaire Arrangements



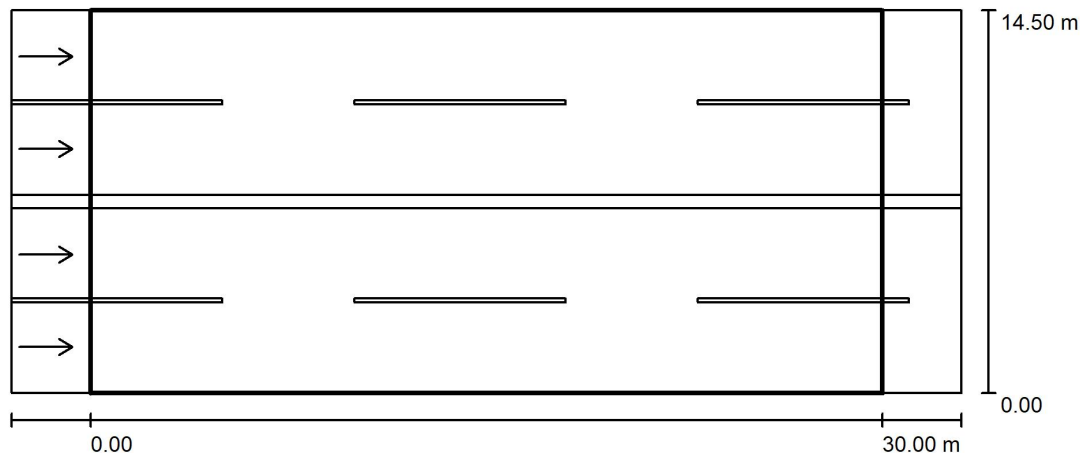
Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	14200 lm	Maximum luminous intensities
Luminous flux (Lamps):	14200 lm	at 70°: 855 cd/klm
Luminaire Wattage:	95.0 W	at 80°: 160 cd/klm
Arrangement:	Single row, bottom	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 95°.
Height:	12.000 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	0.991 m	



Class A-Other Areas-4 lanes-ME3b-Single side / False Color Rendering



Class A-Other Areas-4 lanes-ME3b-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

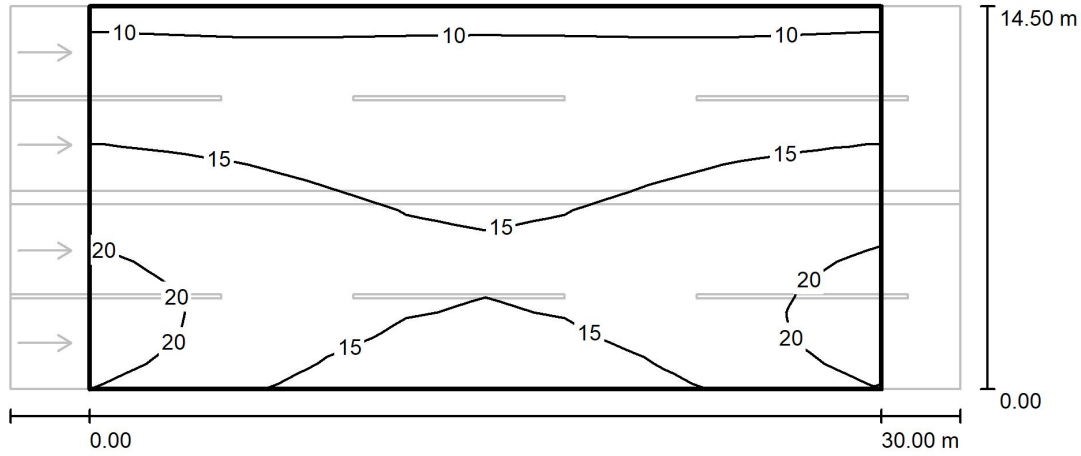
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.41	0.91	10	0.52
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.43	0.94	9
2	Observer 2	(-60.000, 5.250, 1.500)	1.07	0.42	0.94	10
3	Observer 3	(-60.000, 9.250, 1.500)	1.14	0.41	0.91	8
4	Observer 4	(-60.000, 12.750, 1.500)	1.19	0.41	0.91	5



Class A-Other Areas-4 lanes-ME3b-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

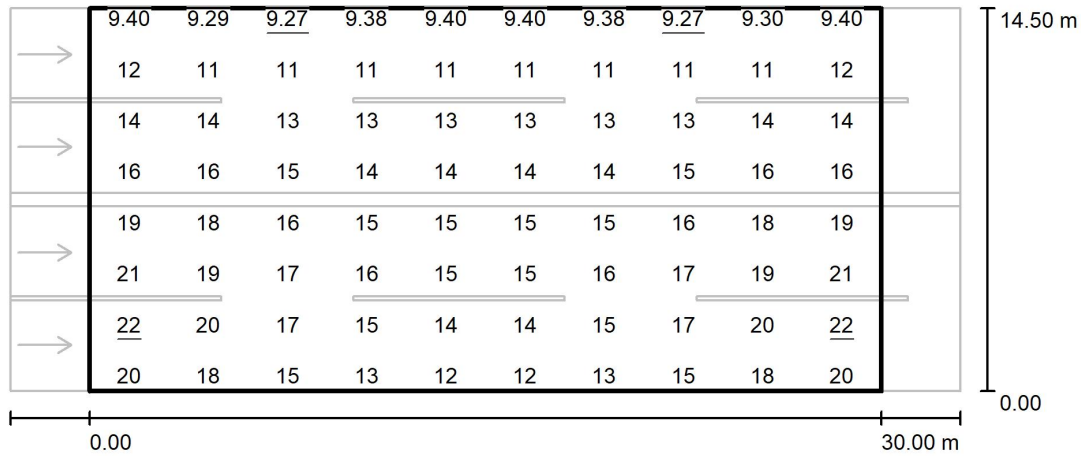


Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
15	9.27	22	0.630	0.431

Class A-Other Areas-4 lanes-ME3b-Single side / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
15	9.27	22	0.630	0.431



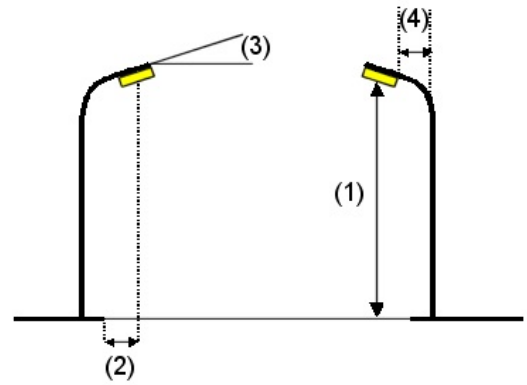
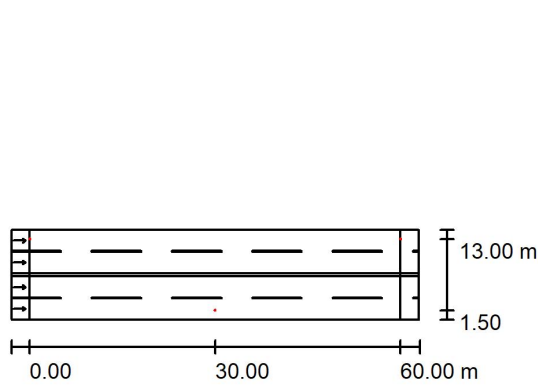
Class A-Other Areas-4 lanes-ME3b-Staggered / Planning data

Street Profile

- Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
- Median 1 (Width: 0.500 m, Height: 0.000 m)
- Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

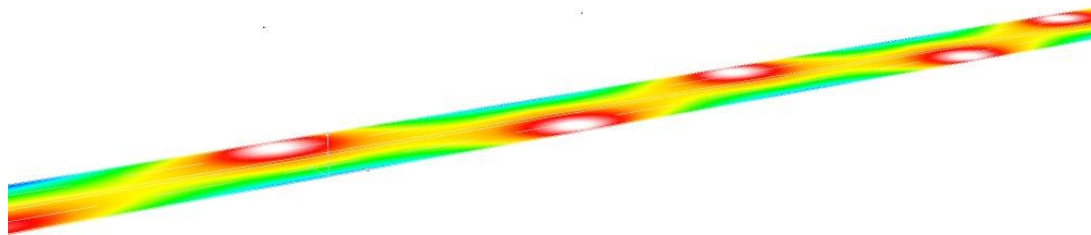
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	12500 lm	Maximum luminous intensities
Luminous flux (Lamps):	12500 lm	at 70°: 896 cd/klm
Luminaire Wattage:	83.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 90°.
Height:	12.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

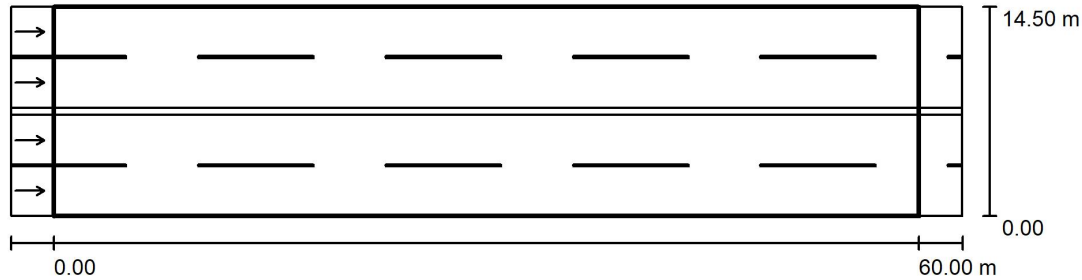


Class A-Other Areas-4 lanes-ME3b-Staggered / False Color Rendering



0 2.50 5 7.50 10 12.50 15 17.50 20 lx

Class A-Other Areas-4 lanes-ME3b-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

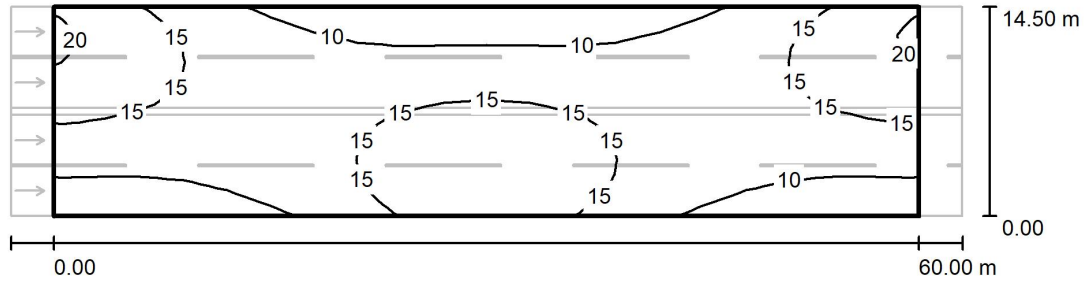
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.01	0.45	0.68	10	0.50
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.01	0.45	0.68	8
2	Observer 2	(-60.000, 5.250, 1.500)	1.02	0.51	0.74	10
3	Observer 3	(-60.000, 9.250, 1.500)	1.02	0.55	0.74	10
4	Observer 4	(-60.000, 12.750, 1.500)	1.02	0.50	0.68	8



Class A-Other Areas-4 lanes-ME3b-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

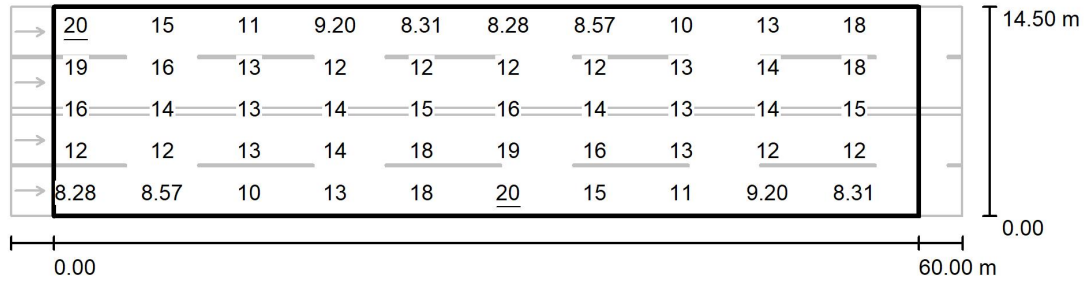


Values in Lux, Scale 1 : 472

Grid: 20 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	7.02	20	0.524	0.350

Class A-Other Areas-4 lanes-ME3b-Staggered / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 472

Not all calculated values could be displayed.

Grid: 20 x 15 Points

E_{av} [lx]
13

E_{min} [lx]
7.02

E_{max} [lx]
20

u0
0.524

E_{min} / E_{max}
0.350

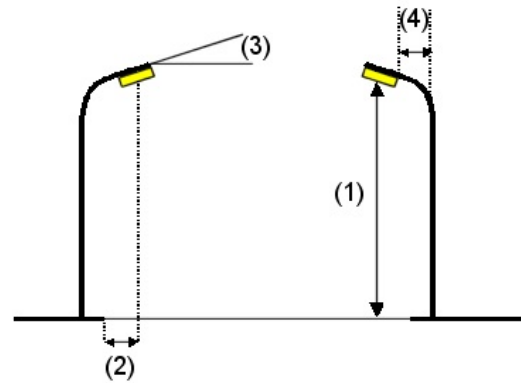
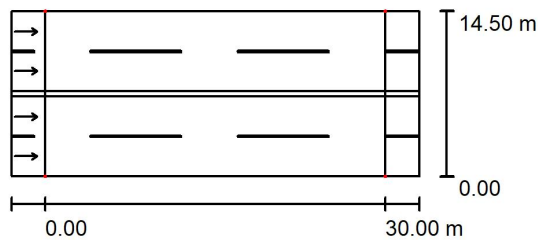
Class A-Other Areas-4 lanes-ME3b-Opposite / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

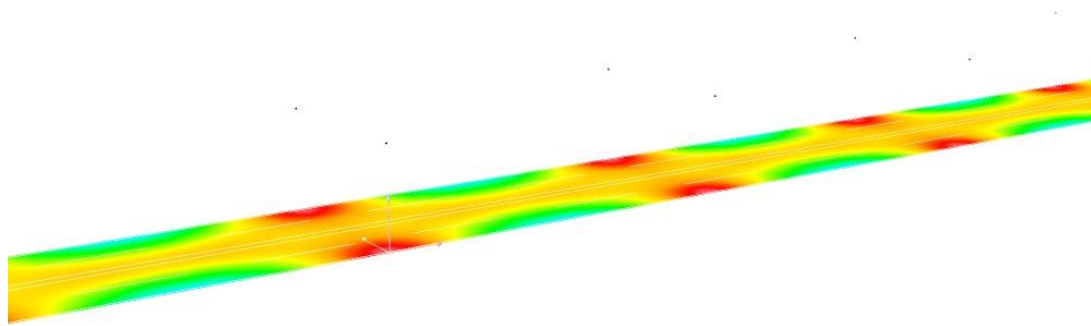
Luminaire Arrangements



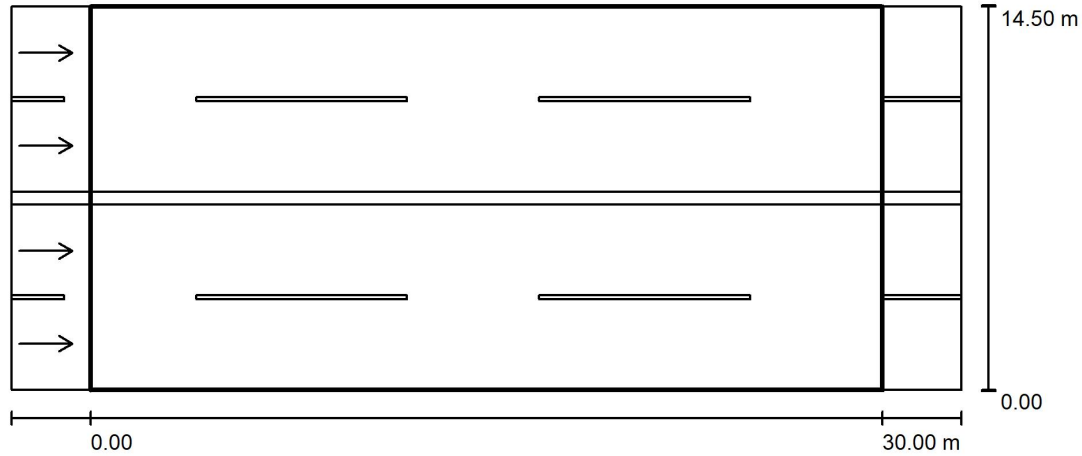
Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	5900 lm	Maximum luminous intensities
Luminous flux (Lamps):	5900 lm	at 70°: 896 cd/klm
Luminaire Wattage:	39.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, opposing	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.100 m	No luminous intensities above 90°.
Height:	8.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.000 m	



Class A-Other Areas-4 lanes-ME3b-Opposite / False Color Rendering



Class A-Other Areas-4 lanes-ME3b-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

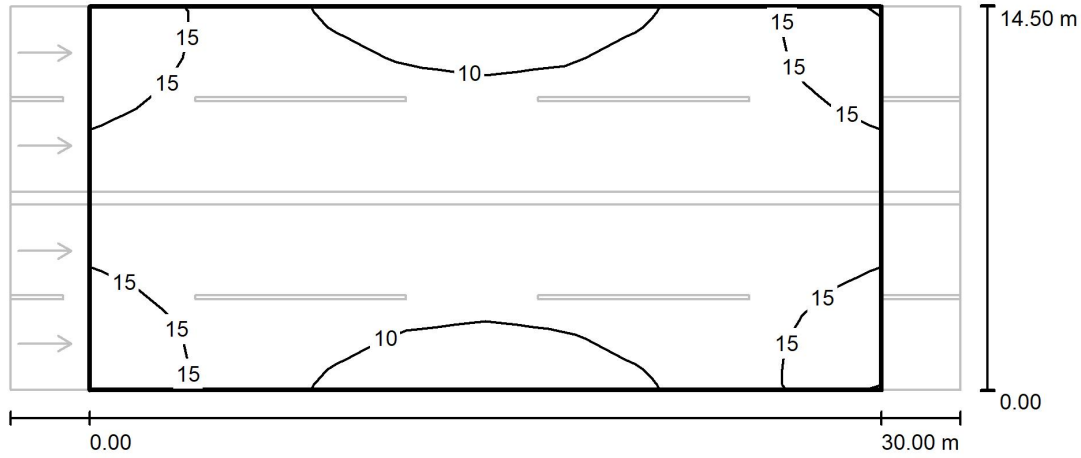
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.60	0.67	12	0.52
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.61	0.69	12
2	Observer 2	(-60.000, 5.250, 1.500)	1.02	0.60	0.67	11
3	Observer 3	(-60.000, 9.250, 1.500)	1.02	0.60	0.67	11
4	Observer 4	(-60.000, 12.750, 1.500)	1.00	0.61	0.69	12



Class A-Other Areas-4 lanes-ME3b-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

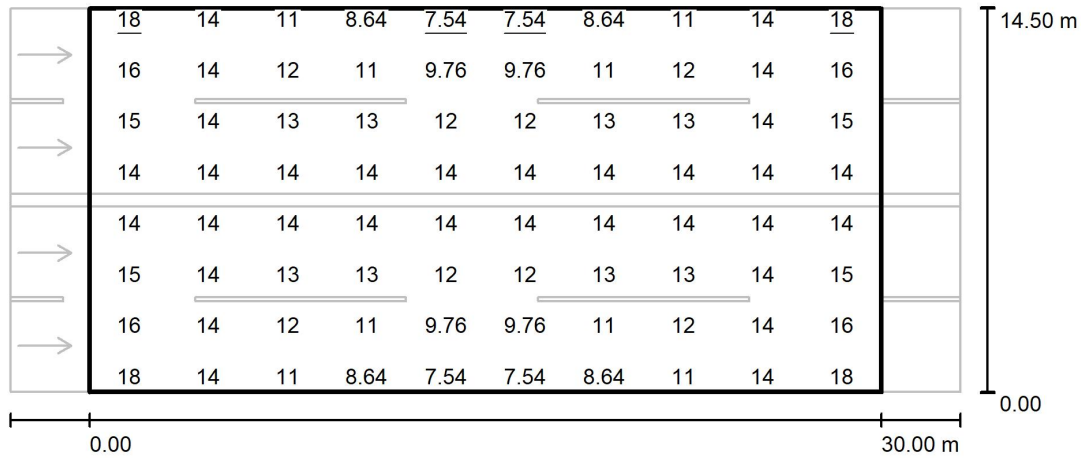


Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	7.54	18	0.581	0.428

Class A-Other Areas-4 lanes-ME3b-Opposite / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Not all calculated values could be displayed.

Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	7.54	18	0.581	0.428

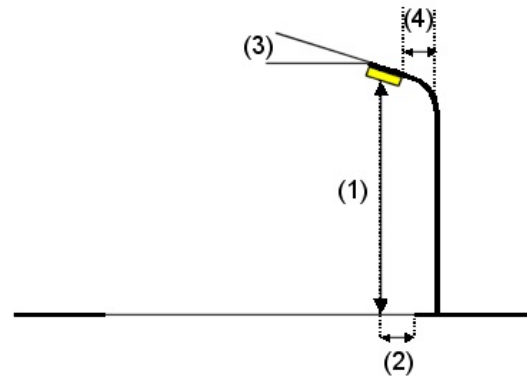
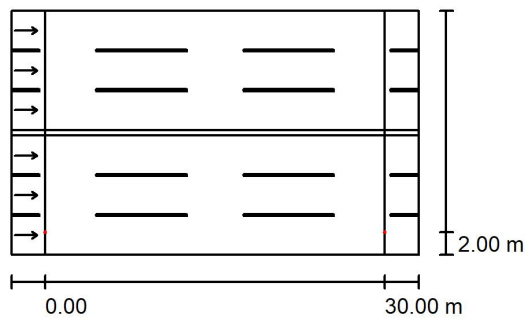
Class A-Other Areas-6 lanes-ME3b-Single side / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

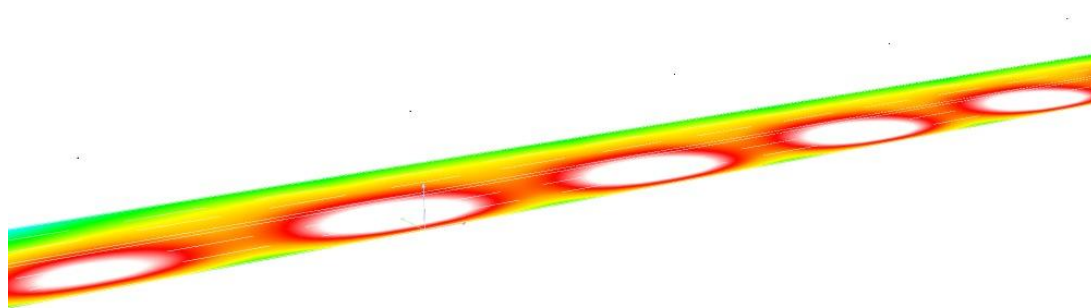
Luminaire Arrangements



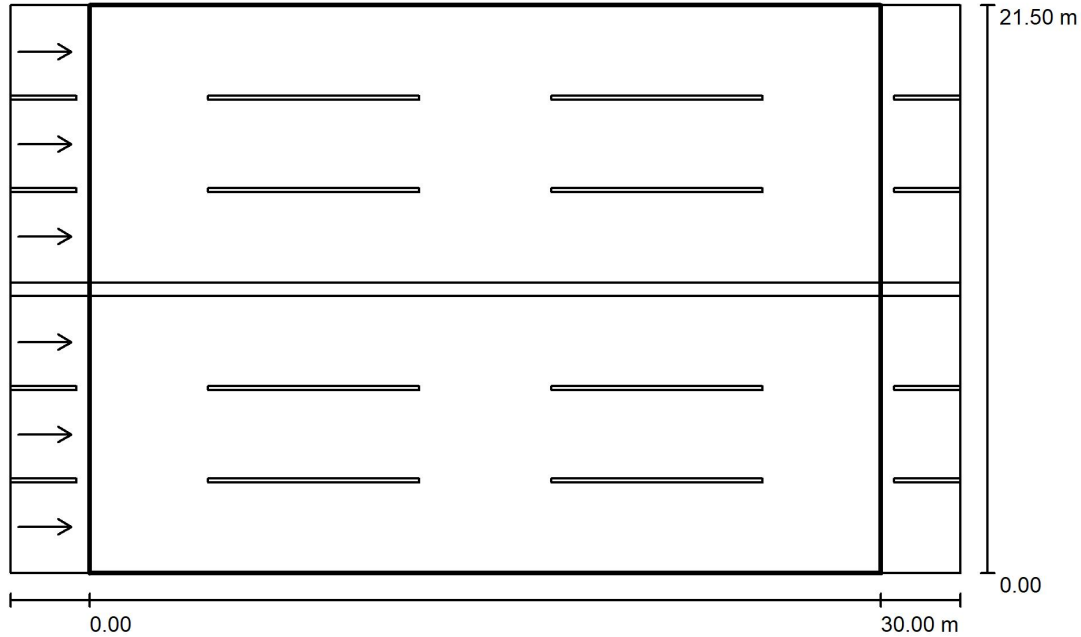
Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-3 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 3 OPTIC, No Shield	
Luminous flux (Luminaire):	20000 lm	Maximum luminous intensities
Luminous flux (Lamps):	20000 lm	at 70°: 711 cd/klm
Luminaire Wattage:	133.0 W	at 80°: 216 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.600 m	No luminous intensities above 90°.
Height:	10.500 m	Arrangement complies with glare index class D.6.
Overhang (2):	2.000 m	
Boom Angle (3):	0.0 °	
Boom Length (4):	2.000 m	



Class A-Other Areas-6 lanes-ME3b-Single side / False Color Rendering



Class A-Other Areas-6 lanes-ME3b-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.41	0.89	15	0.50
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

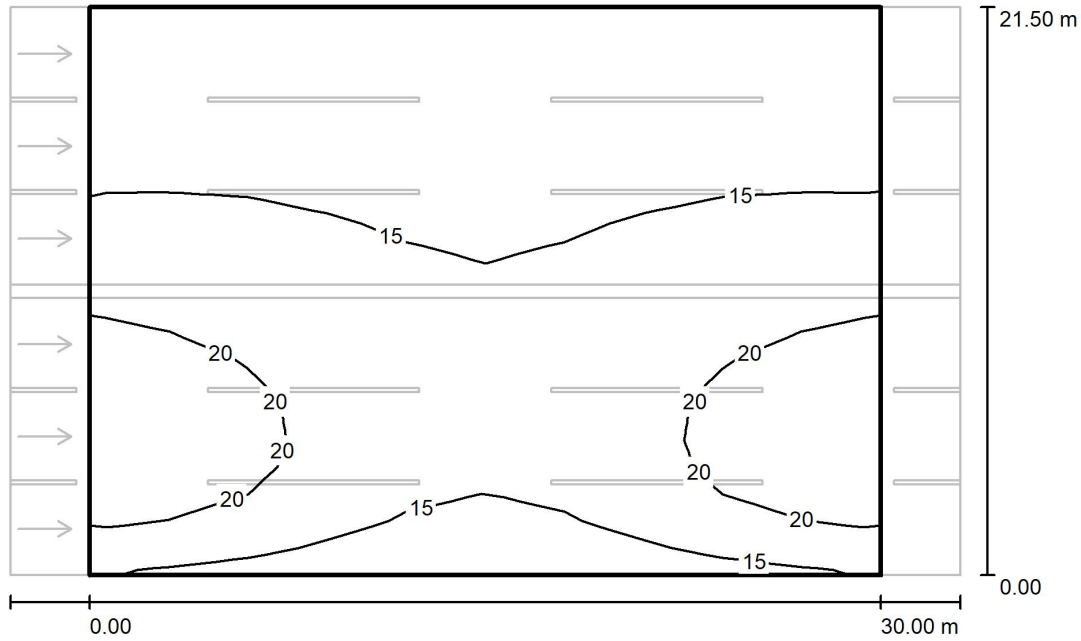
Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.46	0.92	13
2	Observer 2	(-60.000, 5.250, 1.500)	1.05	0.45	0.91	15
3	Observer 3	(-60.000, 8.750, 1.500)	1.10	0.44	0.91	12
4	Observer 4	(-60.000, 12.750, 1.500)	1.14	0.41	0.91	8
5	Observer 5	(-60.000, 16.250, 1.500)	1.18	0.41	0.89	6
6	Observer 6	(-60.000, 19.750, 1.500)	1.21	0.42	0.90	4



Operator
Telephone
Fax
e-Mail

Class A-Other Areas-6 lanes-ME3b-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

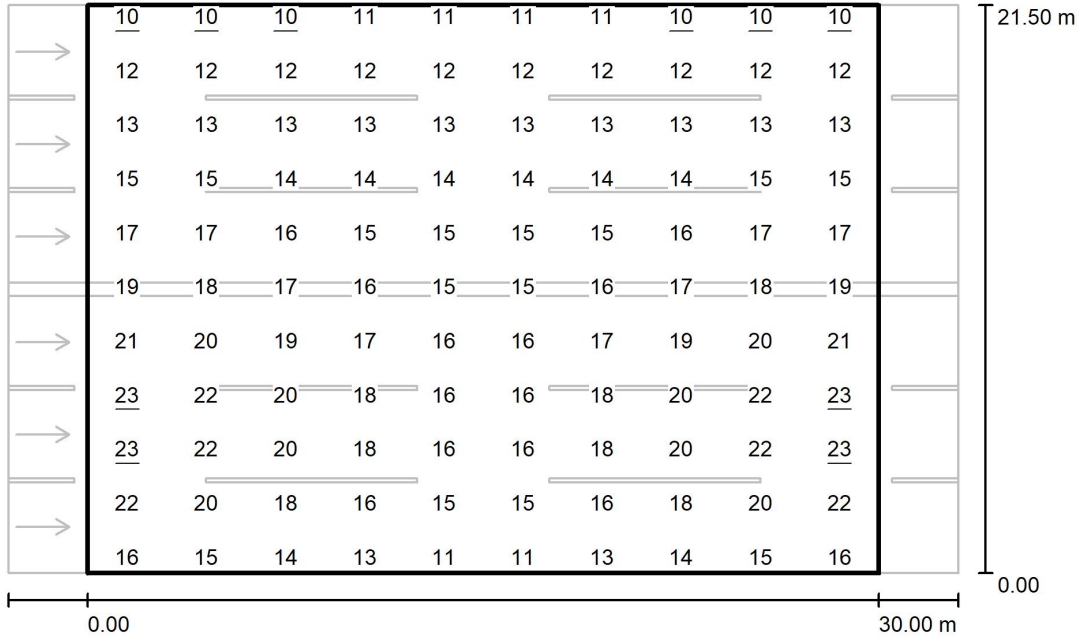


Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
16	10	23	0.632	0.431

Class A-Other Areas-6 lanes-ME3b-Single side / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
16	10	23	0.632	0.431



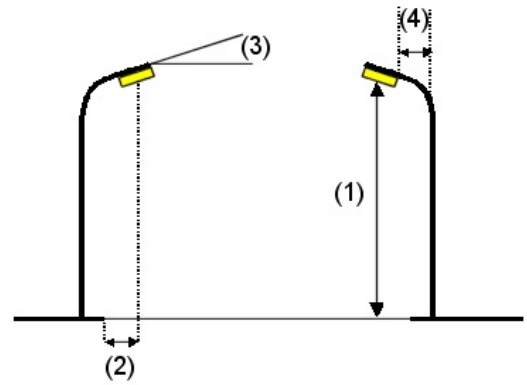
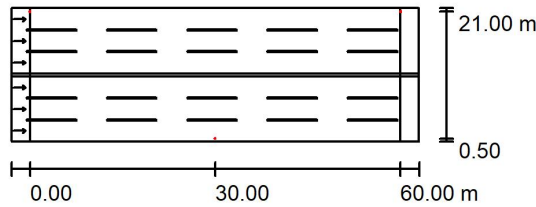
Class A-Other Areas-6 lanes-ME3b-Staggered / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

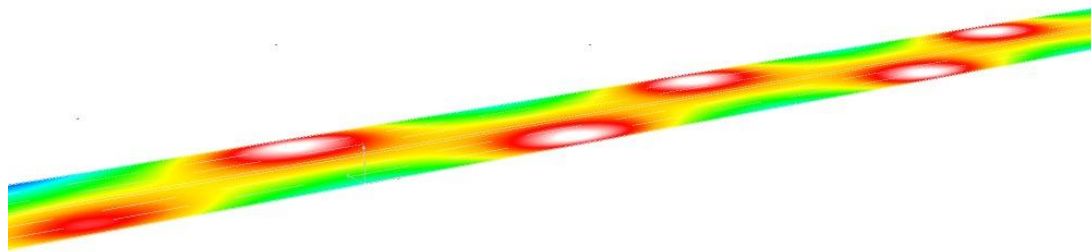
Luminaire Arrangements



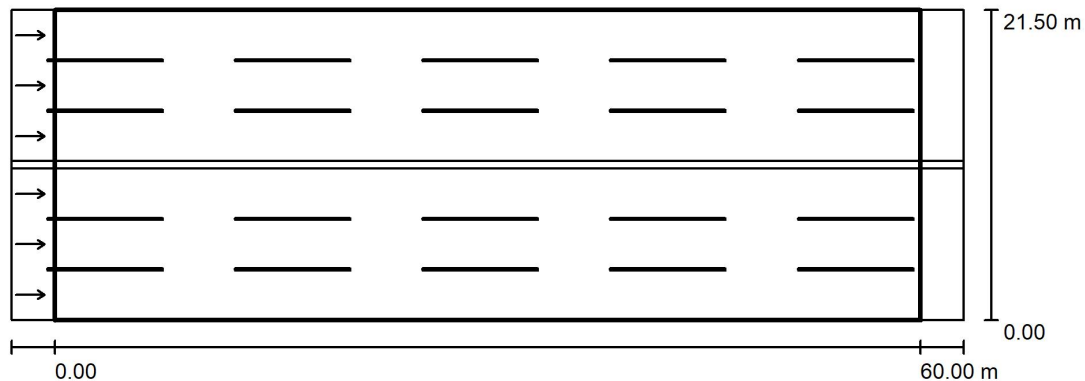
Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-3 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 3 OPTIC, No Shield	
Luminous flux (Luminaire):	19400 lm	Maximum luminous intensities
Luminous flux (Lamps):	19400 lm	at 70°: 711 cd/klm
Luminaire Wattage:	129.0 W	at 80°: 216 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	11.600 m	No luminous intensities above 90°.
Height:	11.500 m	Arrangement complies with glare index class D.6.
Overhang (2):	0.500 m	
Boom Angle (3):	0.0 °	
Boom Length (4):	0.500 m	



Class A-Other Areas-6 lanes-ME3b-Staggered / False Color Rendering



Class A-Other Areas-6 lanes-ME3b-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

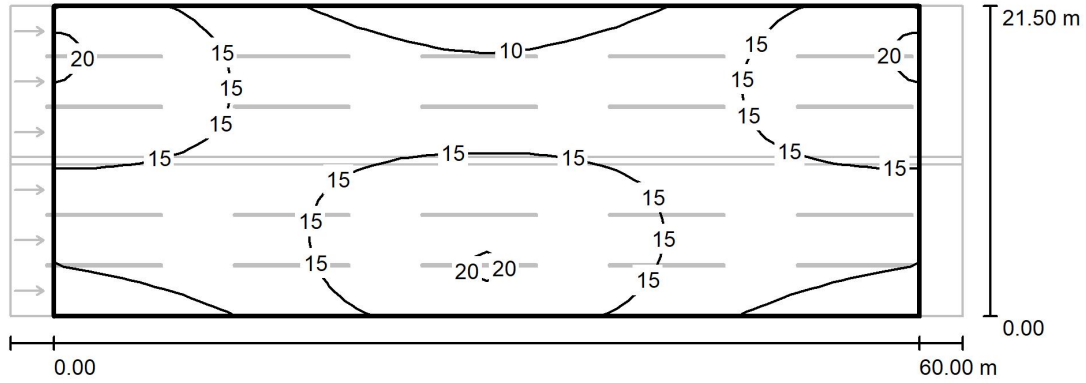
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.51	0.60	11	0.61
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.51	0.60	11
2	Observer 2	(-60.000, 5.250, 1.500)	1.01	0.53	0.75	11
3	Observer 3	(-60.000, 8.750, 1.500)	1.02	0.56	0.86	10
4	Observer 4	(-60.000, 12.750, 1.500)	1.02	0.58	0.86	10
5	Observer 5	(-60.000, 16.250, 1.500)	1.01	0.56	0.75	11
6	Observer 6	(-60.000, 19.750, 1.500)	1.00	0.53	0.60	11



Class A-Other Areas-6 lanes-ME3b-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

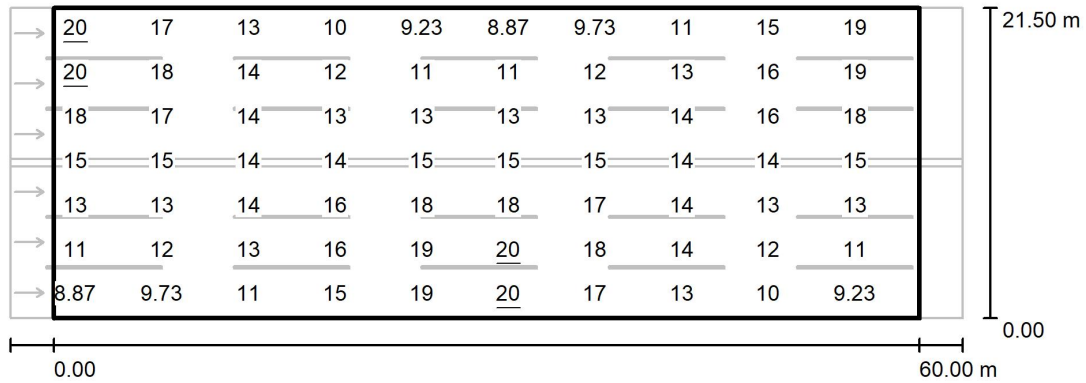


Values in Lux, Scale 1 : 472

Grid: 20 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
14	8.14	20	0.570	0.402

Class A-Other Areas-6 lanes-ME3b-Staggered / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 472

Not all calculated values could be displayed.

Grid: 20 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
14	8.14	20	0.570	0.402



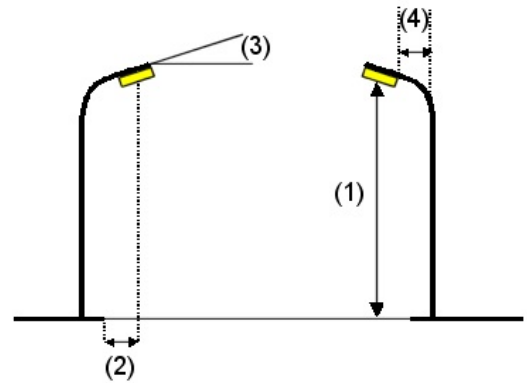
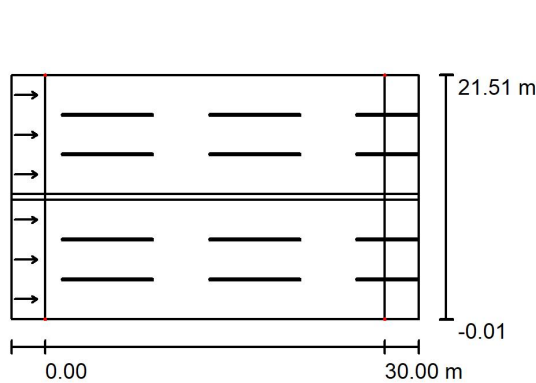
Class A-Other Areas-6 lanes-ME3b-Opposite / Planning data

Street Profile

- Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
- Median 1 (Width: 0.500 m, Height: 0.000 m)
- Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

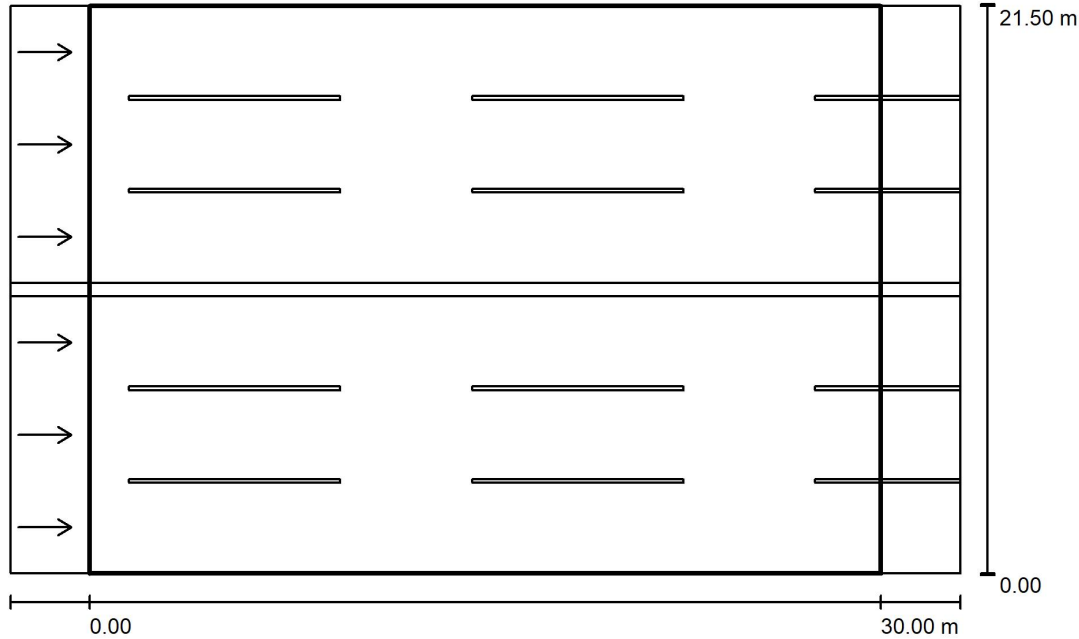
Light loss factor: 0.70

Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	8000 lm	Maximum luminous intensities
Luminous flux (Lamps):	8000 lm	at 70°: 855 cd/klm
Luminaire Wattage:	53.0 W	at 80°: 160 cd/klm
Arrangement:	Double row, opposing	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.600 m	No luminous intensities above 95°.
Height:	8.500 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	-0.009 m	

Class A-Other Areas-6 lanes-ME3b-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3b

(All lighting performance requirements are met.)

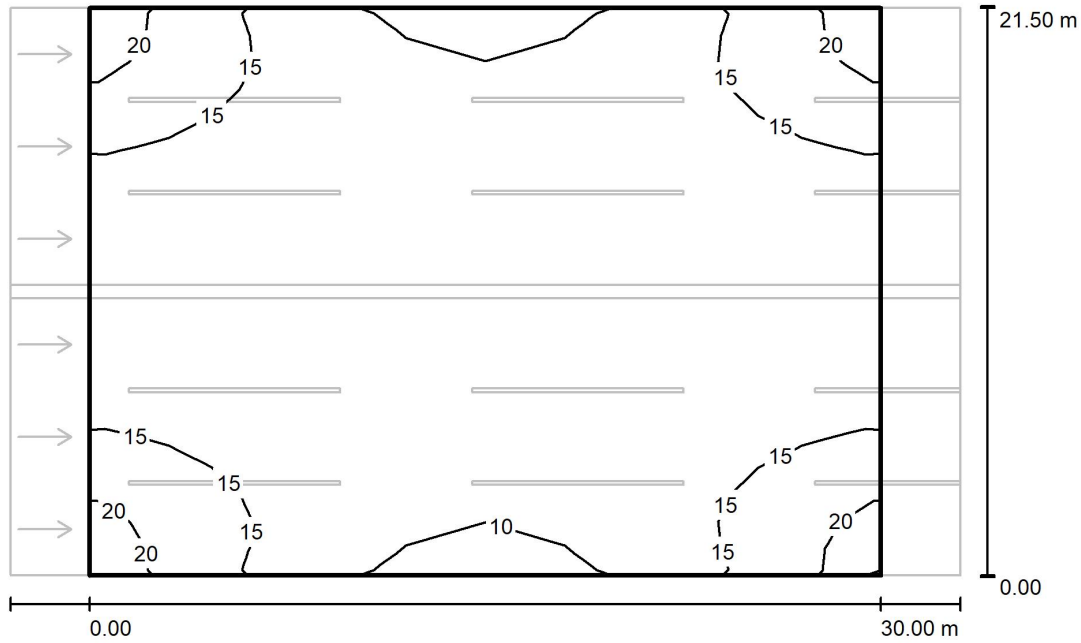
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.57	0.81	13	0.50
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.58	0.81	13
2	Observer 2	(-60.000, 5.250, 1.500)	1.02	0.58	0.85	12
3	Observer 3	(-60.000, 8.750, 1.500)	1.03	0.57	0.81	8
4	Observer 4	(-60.000, 12.750, 1.500)	1.03	0.57	0.81	8
5	Observer 5	(-60.000, 16.250, 1.500)	1.02	0.58	0.85	12
6	Observer 6	(-60.000, 19.750, 1.500)	1.00	0.58	0.81	13



Class A-Other Areas-6 lanes-ME3b-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)

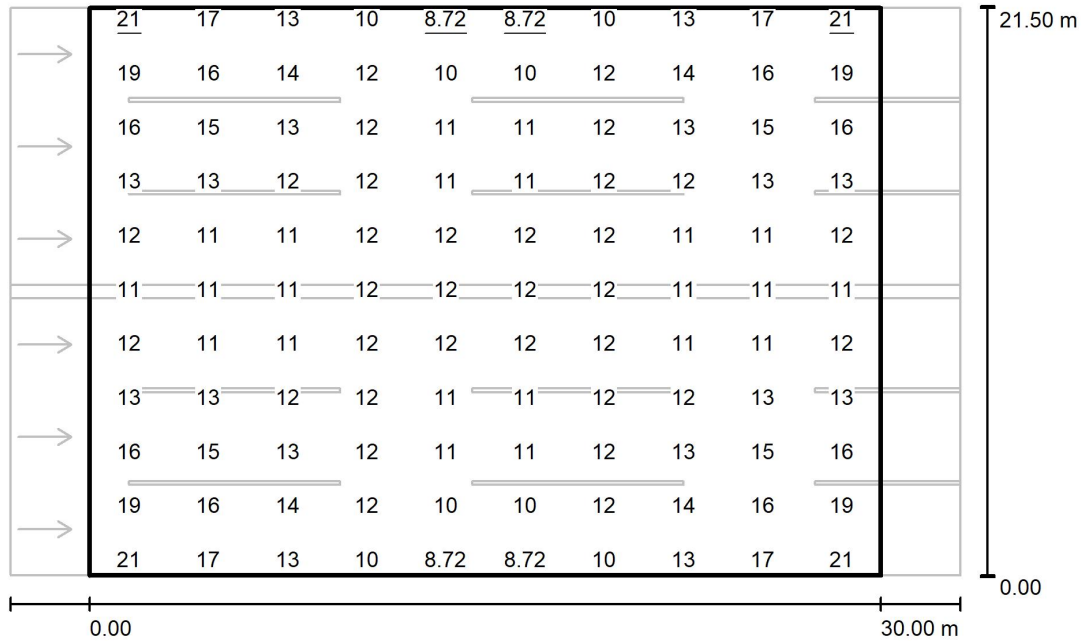


Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	8.72	21	0.679	0.415

Class A-Other Areas-6 lanes-ME3b-Opposite / Valuation Field Roadway 1 & Roadway 2 / Value Chart (E)



Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	8.72	21	0.679	0.415

APPENDIX E- LIGHTING SIMULATION REPORT FOR CLASS B ROADS WITHIN
TOWN AREA

CLASS B-ROADS WITHIN TOWN AREA

Date: 03.10.2020
Operator:

Operator
Telephone
Fax
e-Mail

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Operator
Telephone
Fax
e-Mail

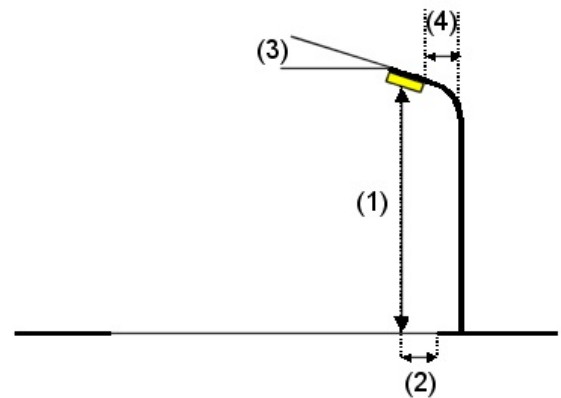
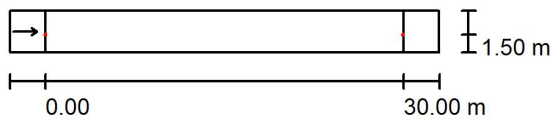
Class B-Within Town Area-ME3c-1 lane / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

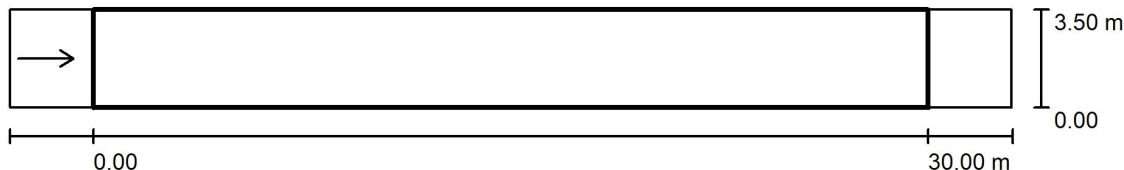
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	4900 lm	Maximum luminous intensities
Luminous flux (Lamps):	4900 lm	at 70°: 896 cd/klm
Luminaire Wattage:	33.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	6.600 m	No luminous intensities above 90°.
Height:	6.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-1 lane / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

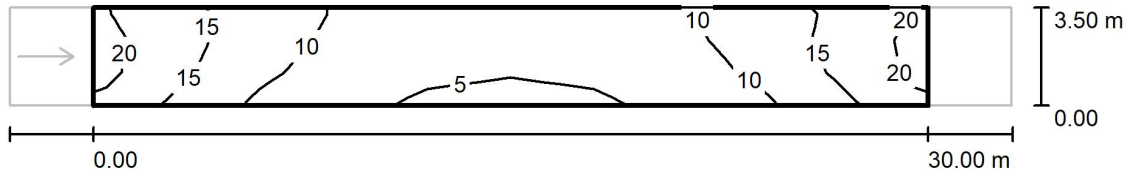
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.66	0.53	14	0.75
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (1 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.66	0.53	14

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-1 lane / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
11	4.53	20	0.418	0.225

Operator
Telephone
Fax
e-Mail

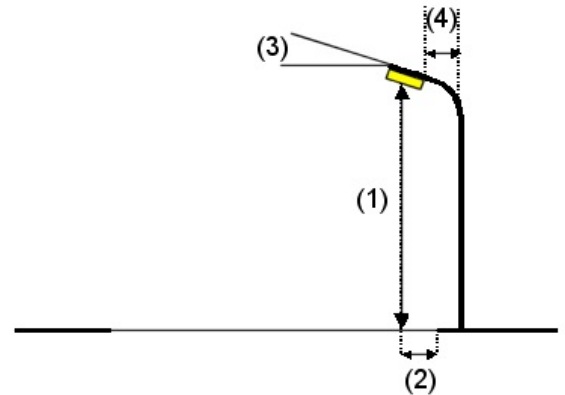
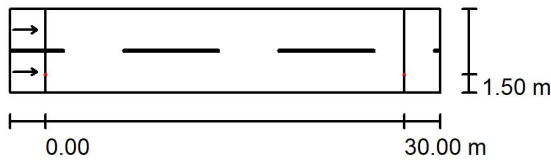
Class B-Within Town Area-ME3c-2 lanes / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

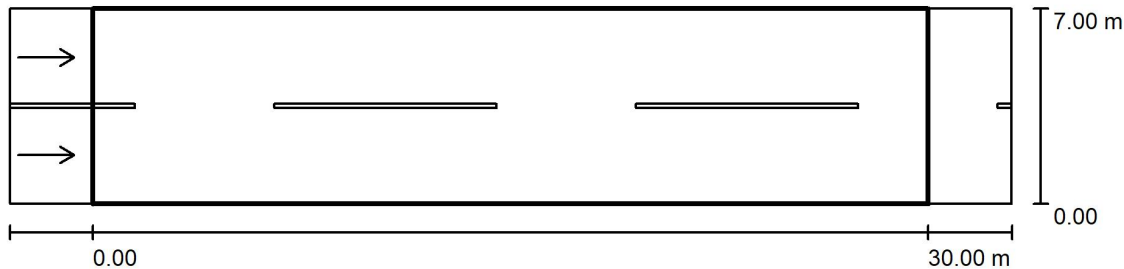
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	6750 lm	Maximum luminous intensities
Luminous flux (Lamps):	6750 lm	at 70°: 896 cd/klm
Luminaire Wattage:	45.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.600 m	No luminous intensities above 90°.
Height:	7.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-2 lanes / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 6 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

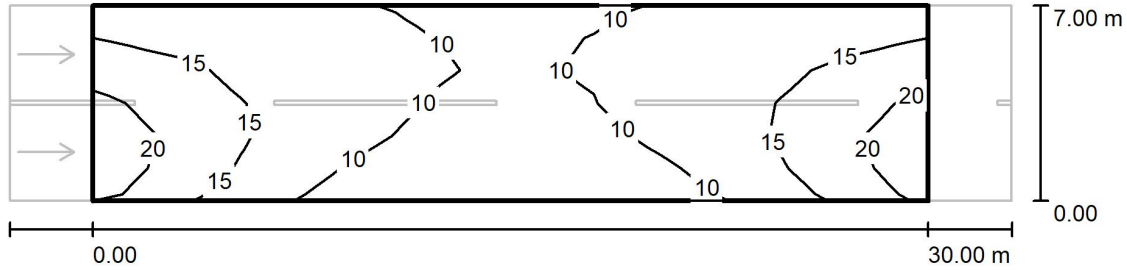
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.49	0.63	14	0.51
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.49	0.68	13
2	Observer 2	(-60.000, 5.250, 1.500)	1.06	0.49	0.63	14

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-2 lanes / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	6.41	22	0.504	0.295

Operator
Telephone
Fax
e-Mail

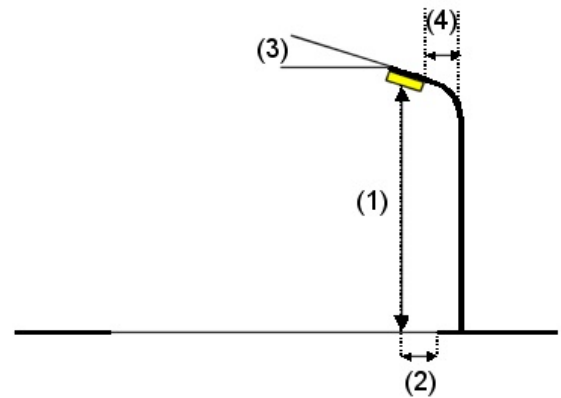
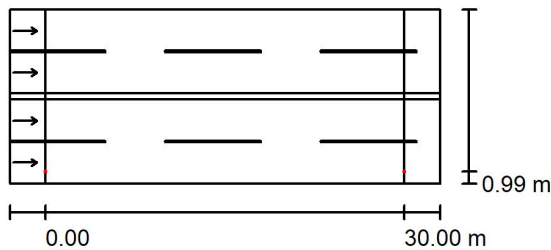
Class B-Within Town Area-ME3c-4 lanes-Single side / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

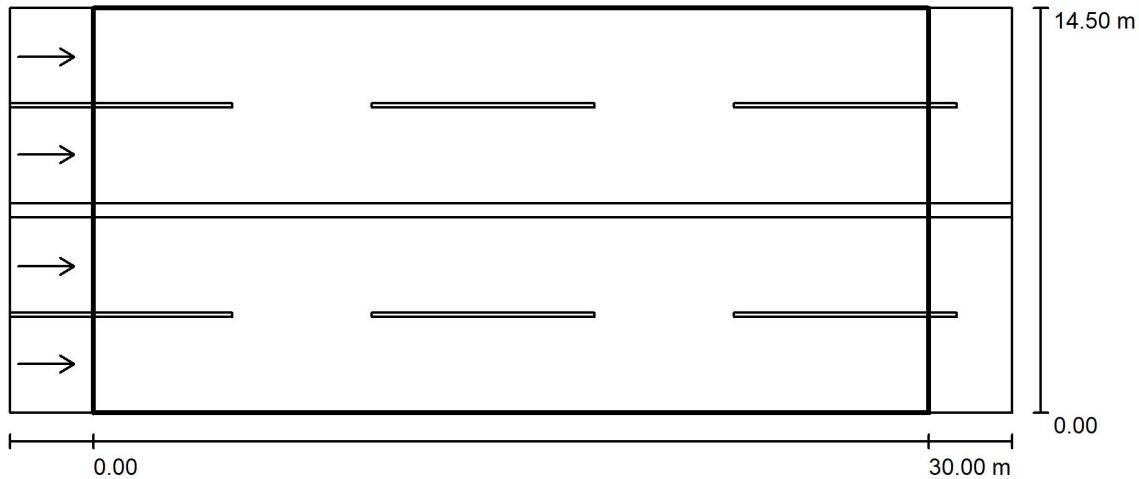
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	14200 lm	Maximum luminous intensities
Luminous flux (Lamps):	14200 lm	at 70°: 855 cd/klm
Luminaire Wattage:	95.0 W	at 80°: 160 cd/klm
Arrangement:	Single row, bottom	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 95°.
Height:	12.000 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	0.991 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-4 lanes-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

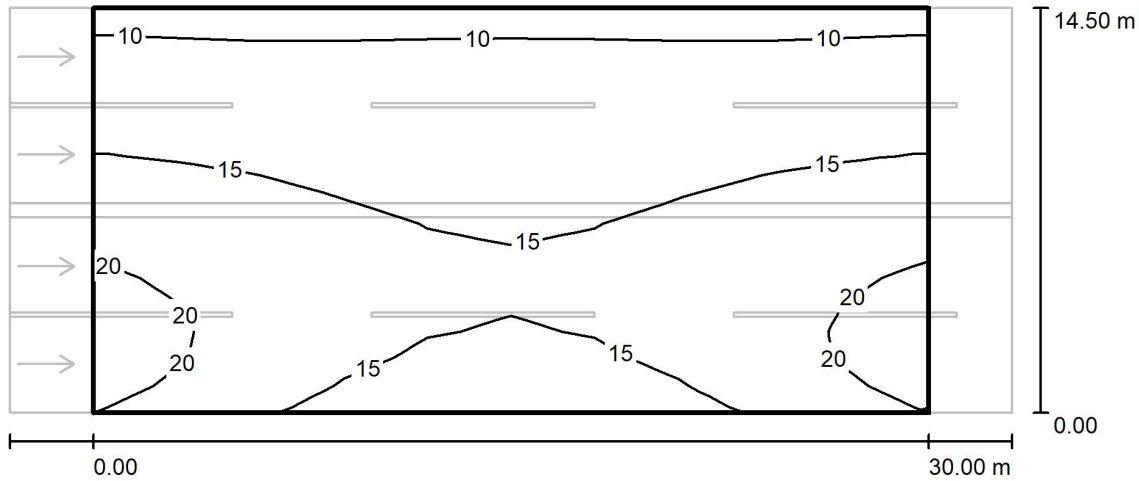
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.41	0.91	10	0.52
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.43	0.94	9
2	Observer 2	(-60.000, 5.250, 1.500)	1.07	0.42	0.94	10
3	Observer 3	(-60.000, 9.250, 1.500)	1.14	0.41	0.91	8
4	Observer 4	(-60.000, 12.750, 1.500)	1.19	0.41	0.91	5

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-4 lanes-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
15	9.27	22	0.630	0.431

Operator
Telephone
Fax
e-Mail

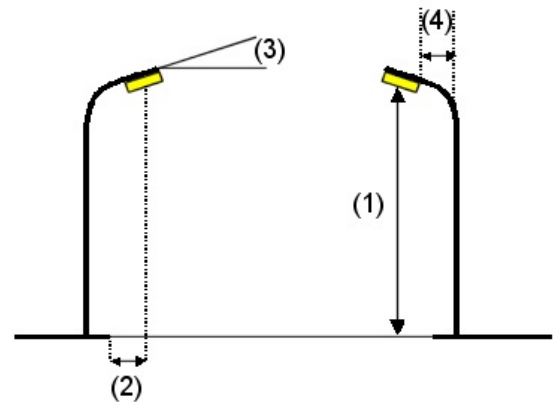
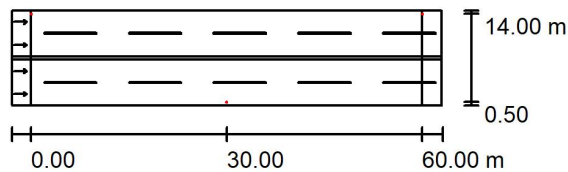
Class B-Within Town Area-ME3c-4 lanes-Staggered / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

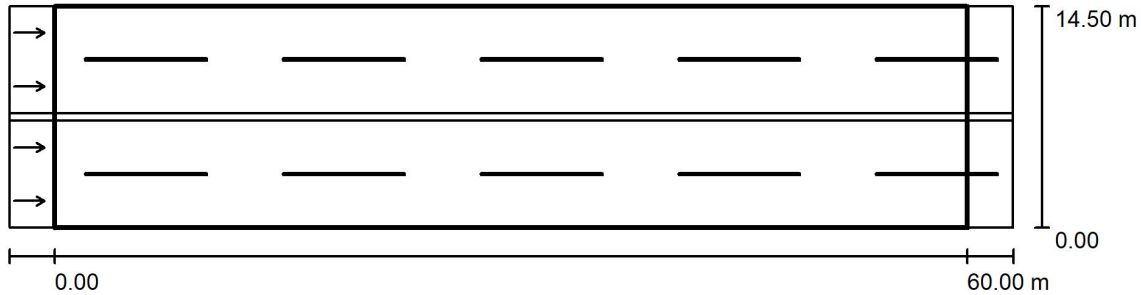
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	12300 lm	Maximum luminous intensities
Luminous flux (Lamps):	12300 lm	at 70°: 896 cd/klm
Luminaire Wattage:	82.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	11.100 m	No luminous intensities above 90°.
Height:	11.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-4 lanes-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

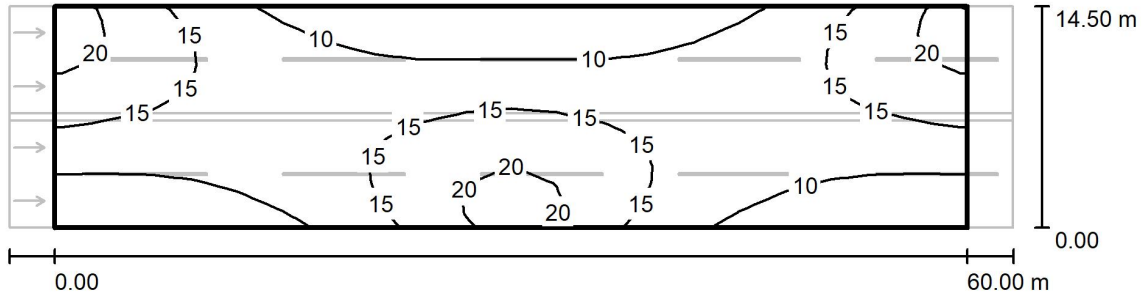
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.44	0.50	11	0.51
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.44	0.50	11
2	Observer 2	(-60.000, 5.250, 1.500)	1.01	0.47	0.74	11
3	Observer 3	(-60.000, 9.250, 1.500)	1.01	0.52	0.74	11
4	Observer 4	(-60.000, 12.750, 1.500)	1.00	0.47	0.50	11

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-4 lanes-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 472

Grid: 20 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	5.80	22	0.440	0.269

Operator
Telephone
Fax
e-Mail

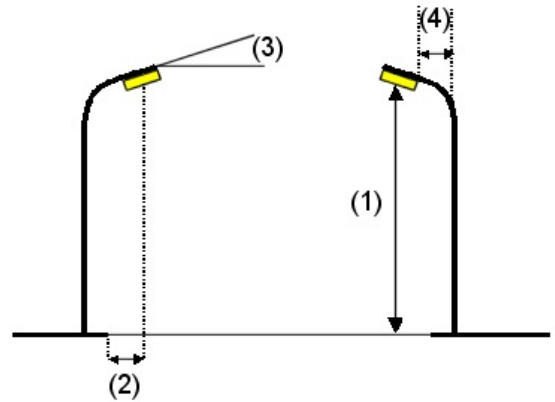
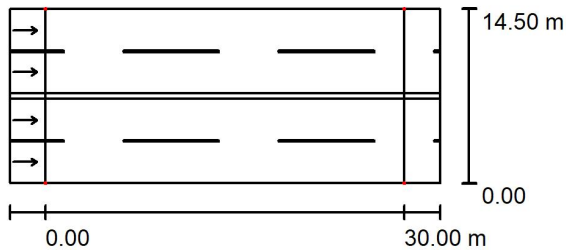
Class B-Within Town Area-ME3c-4 lanes-Opposite / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

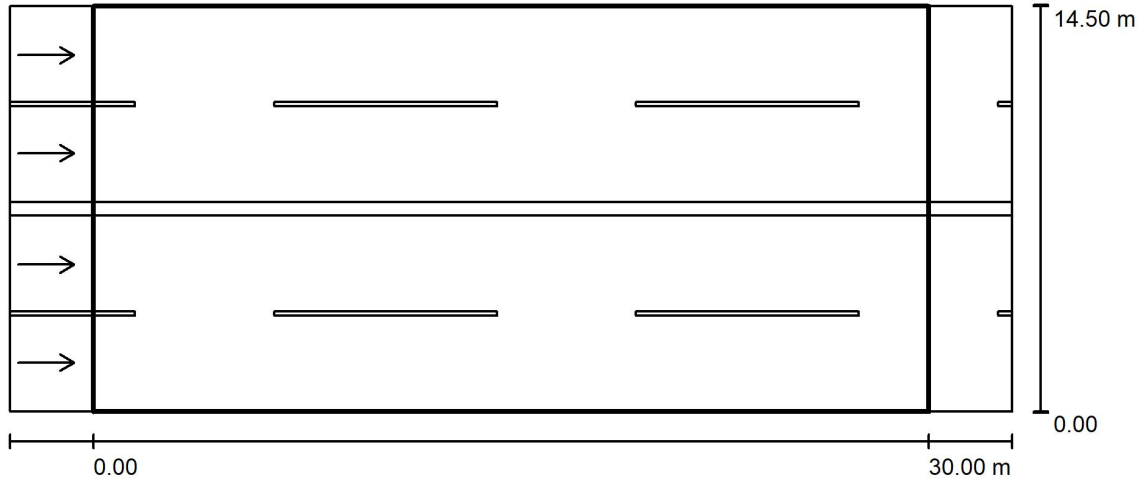
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	5850 lm	Maximum luminous intensities
Luminous flux (Lamps):	5850 lm	at 70°: 896 cd/klm
Luminaire Wattage:	39.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, opposing	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.600 m	No luminous intensities above 90°.
Height:	7.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-4 lanes-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

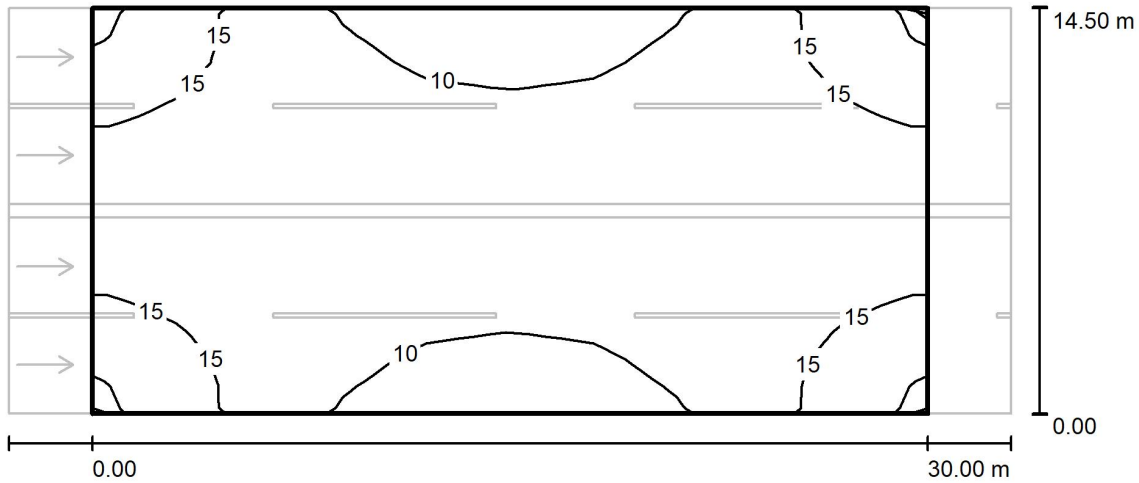
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.52	0.59	14	0.52
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.54	0.63	14
2	Observer 2	(-60.000, 5.250, 1.500)	1.02	0.52	0.59	11
3	Observer 3	(-60.000, 9.250, 1.500)	1.02	0.52	0.59	11
4	Observer 4	(-60.000, 12.750, 1.500)	1.00	0.54	0.63	14

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-4 lanes-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	7.41	19	0.574	0.386

Operator
Telephone
Fax
e-Mail

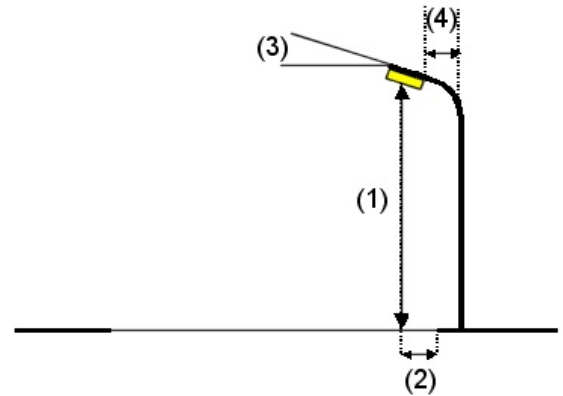
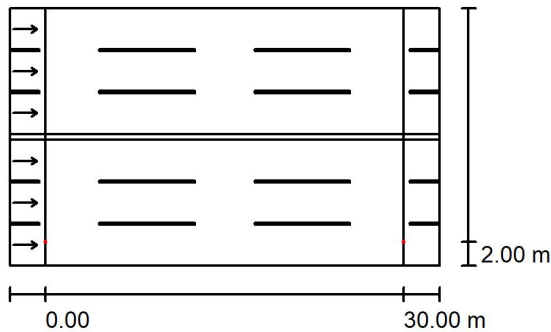
Class B-Within Town Area-ME3c-6 lanes-Single side / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

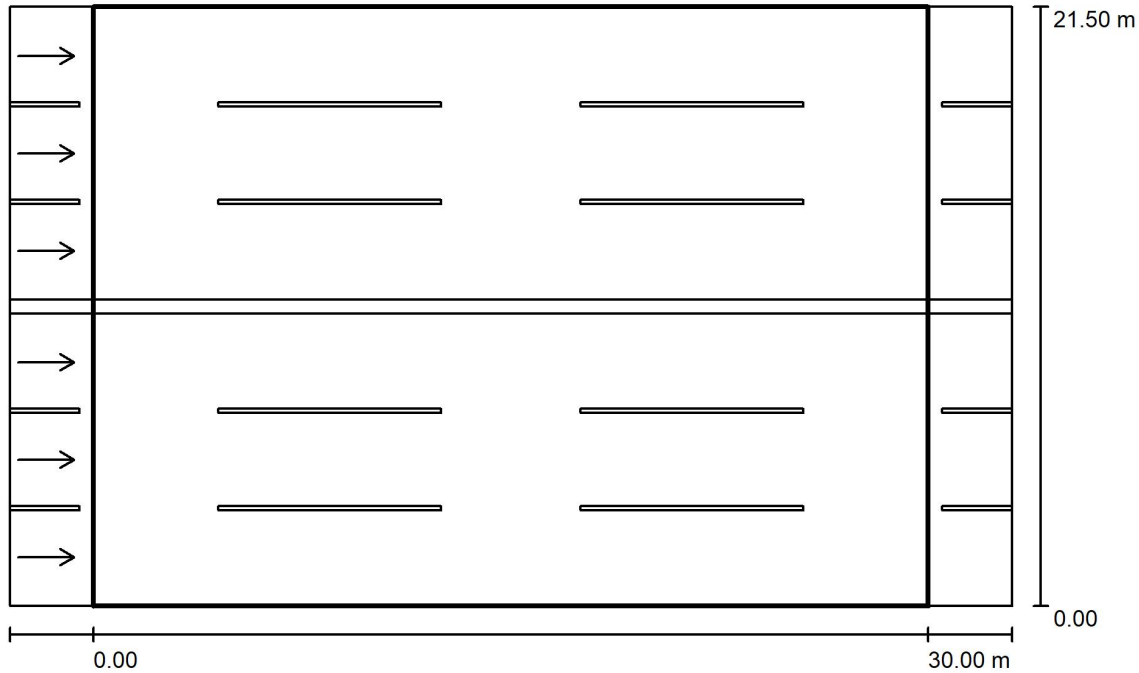
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-3 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 3 OPTIC, No Shield	
Luminous flux (Luminaire):	19900 lm	Maximum luminous intensities
Luminous flux (Lamps):	19900 lm	at 70°: 711 cd/klm
Luminaire Wattage:	133.0 W	at 80°: 216 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.600 m	No luminous intensities above 90°.
Height:	10.500 m	Arrangement complies with glare index class D.6.
Overhang (2):	2.000 m	
Boom Angle (3):	0.0 °	
Boom Length (4):	2.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-6 lanes-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

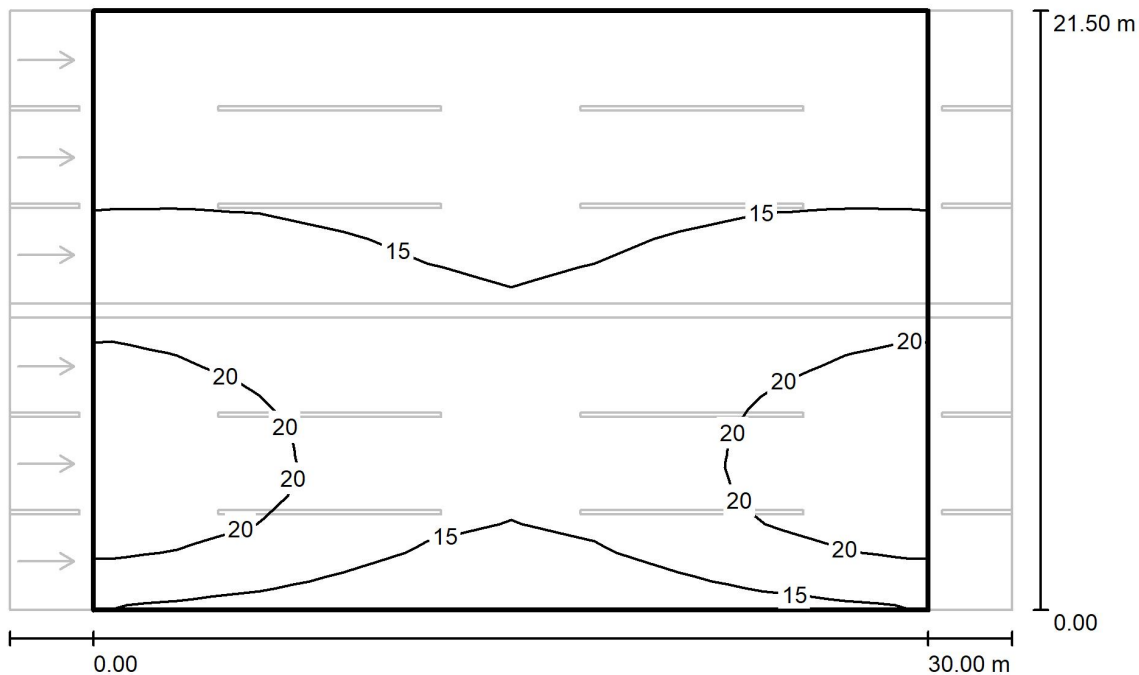
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.41	0.89	15	0.50
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.46	0.92	13
2	Observer 2	(-60.000, 5.250, 1.500)	1.05	0.45	0.91	15
3	Observer 3	(-60.000, 8.750, 1.500)	1.09	0.44	0.91	12
4	Observer 4	(-60.000, 12.750, 1.500)	1.14	0.41	0.91	8
5	Observer 5	(-60.000, 16.250, 1.500)	1.17	0.41	0.89	6
6	Observer 6	(-60.000, 19.750, 1.500)	1.20	0.42	0.90	4

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-6 lanes-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
16	10	23	0.632	0.431

Operator
Telephone
Fax
e-Mail

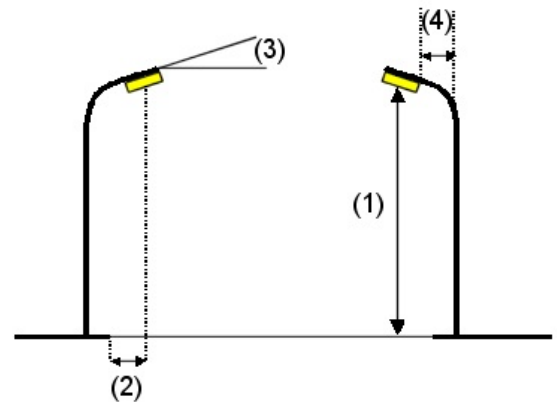
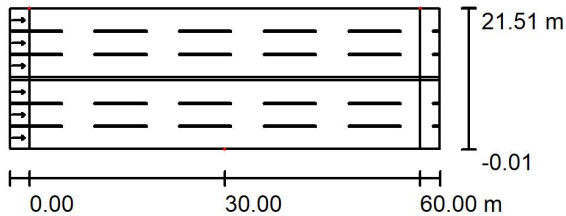
Class B-Within Town Area-ME3c-6 lanes-Staggered / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

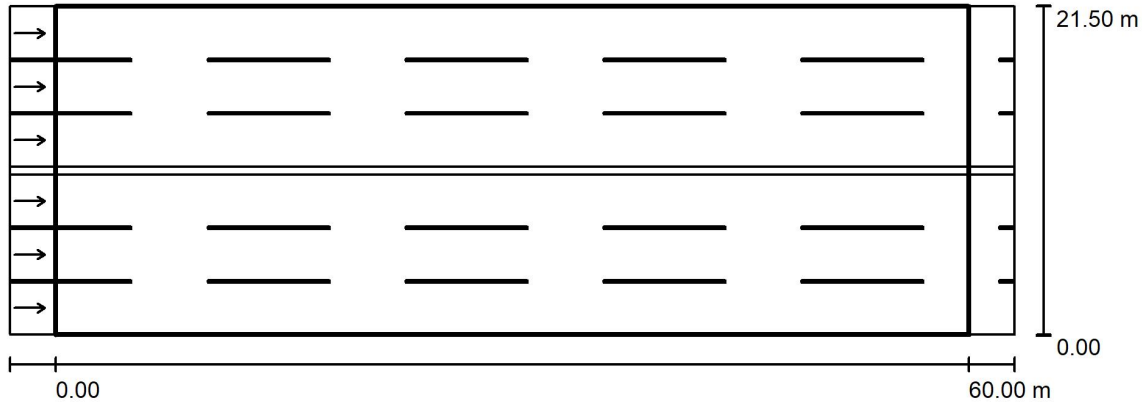
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	17150 lm	Maximum luminous intensities
Luminous flux (Lamps):	17150 lm	at 70°: 855 cd/klm
Luminaire Wattage:	114.0 W	at 80°: 160 cd/klm
Arrangement:	Double row, with offset	at 90°: 10 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 95°.
Height:	12.000 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	-0.009 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-6 lanes-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

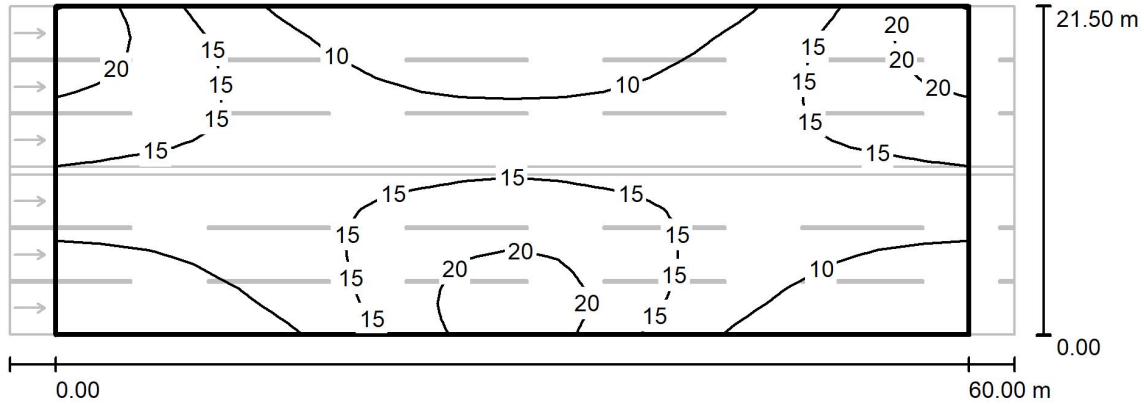
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.42	0.53	13	0.56
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.42	0.53	12
2	Observer 2	(-60.000, 5.250, 1.500)	1.02	0.44	0.68	13
3	Observer 3	(-60.000, 8.750, 1.500)	1.02	0.47	0.88	10
4	Observer 4	(-60.000, 12.750, 1.500)	1.02	0.51	0.88	10
5	Observer 5	(-60.000, 16.250, 1.500)	1.02	0.49	0.68	13
6	Observer 6	(-60.000, 19.750, 1.500)	1.00	0.47	0.53	12

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-6 lanes-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 472

Grid: 20 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	5.47	23	0.408	0.235

Operator
Telephone
Fax
e-Mail

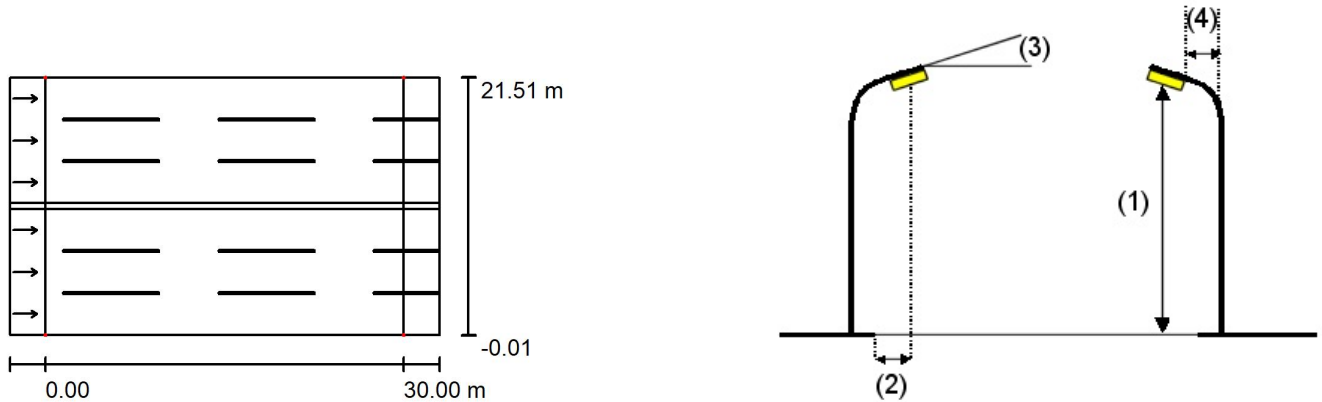
Class B-Within Town Area-ME3c-6 lanes-Opposite / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

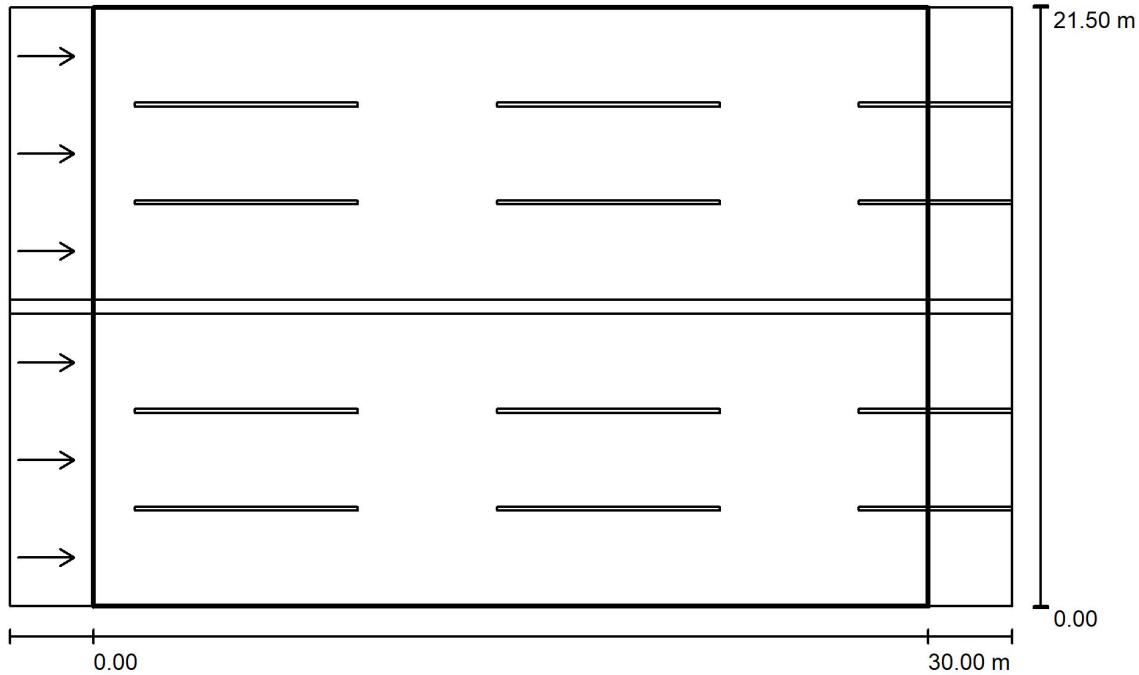
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	8000 lm	Maximum luminous intensities
Luminous flux (Lamps):	8000 lm	at 70°: 855 cd/klm
Luminaire Wattage:	53.0 W	at 80°: 160 cd/klm
Arrangement:	Double row, opposing	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.600 m	No luminous intensities above 95°.
Height:	8.500 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	-0.009 m	

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-6 lanes-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME3c

(All lighting performance requirements are met.)

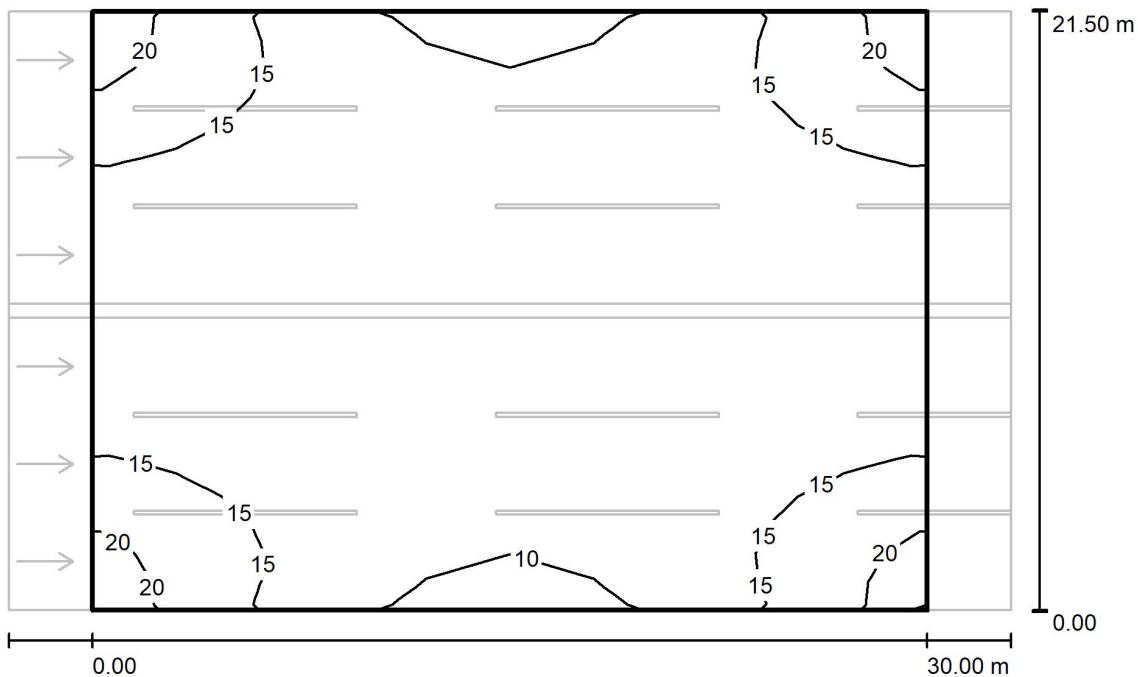
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	1.00	0.57	0.81	13	0.50
Required values according to class:	≥ 1.00	≥ 0.40	≥ 0.50	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	1.00	0.58	0.81	13
2	Observer 2	(-60.000, 5.250, 1.500)	1.02	0.58	0.85	12
3	Observer 3	(-60.000, 8.750, 1.500)	1.03	0.57	0.81	8
4	Observer 4	(-60.000, 12.750, 1.500)	1.03	0.57	0.81	8
5	Observer 5	(-60.000, 16.250, 1.500)	1.02	0.58	0.85	12
6	Observer 6	(-60.000, 19.750, 1.500)	1.00	0.58	0.81	13

Operator
Telephone
Fax
e-Mail

Class B-Within Town Area-ME3c-6 lanes-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
13	8.72	21	0.679	0.415

APPENDIX F- LIGHTING SIMULATION REPORT FOR CLASS B ROADS NOT WITHIN TOWN AREA

CLASS B-ROADS NOT WITHIN TOWN AREA

Date: 03.10.2020
Operator:

Operator
Telephone
Fax
e-Mail

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Operator
Telephone
Fax
e-Mail

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Operator
Telephone
Fax
e-Mail

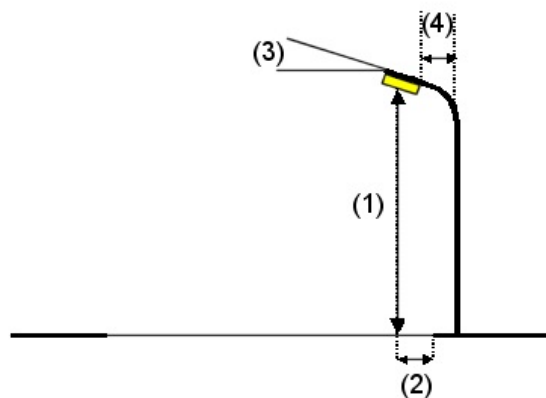
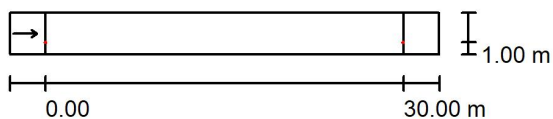
Class B-Other Areas-1 lane-ME5 / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

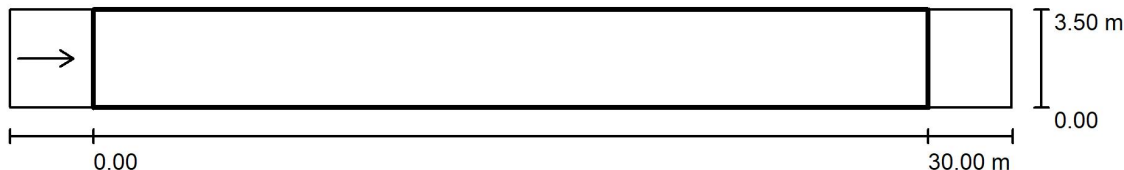
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	2300 lm	Maximum luminous intensities
Luminous flux (Lamps):	2300 lm	at 70°: 896 cd/klm
Luminaire Wattage:	15.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	6.100 m	No luminous intensities above 90°.
Height:	6.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-1 lane-ME5 / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.51	0.51	0.42	15	0.74
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

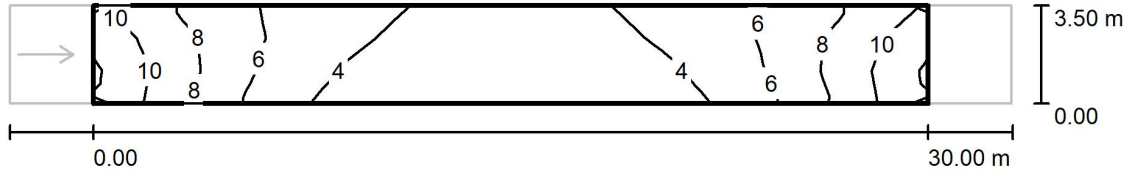
Assigned observer (1 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.51	0.51	0.42	15



Operator
Telephone
Fax
e-Mail

Class B-Other Areas-1 lane-ME5 / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]
5.68

E_{min} [lx]
2.35

E_{max} [lx]
11

u_0
0.415

E_{min} / E_{max}
0.220

Operator
Telephone
Fax
e-Mail

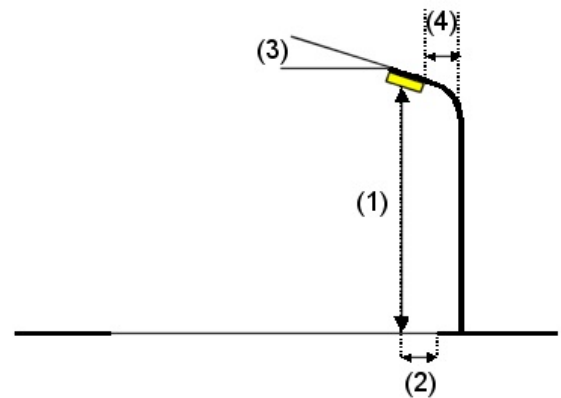
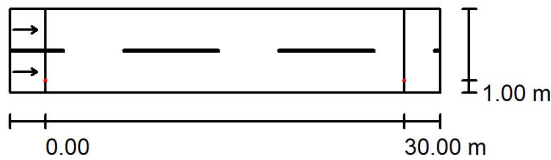
Class B-Other Areas-2 lanes-ME5 / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

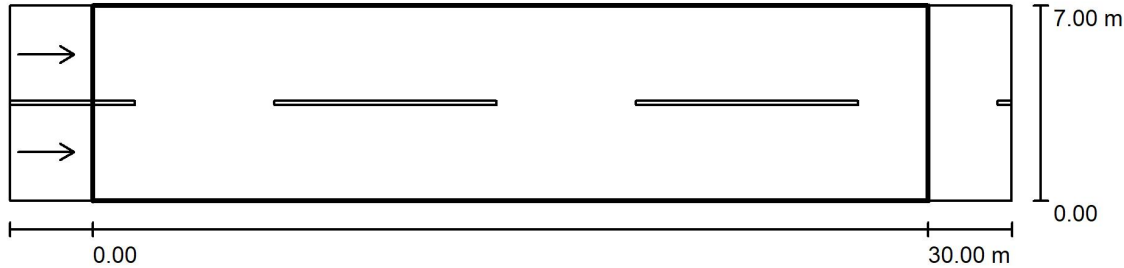
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	3450 lm	Maximum luminous intensities
Luminous flux (Lamps):	3450 lm	at 70°: 896 cd/klm
Luminaire Wattage:	23.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.600 m	No luminous intensities above 90°.
Height:	7.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-2 lanes-ME5 / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 6 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

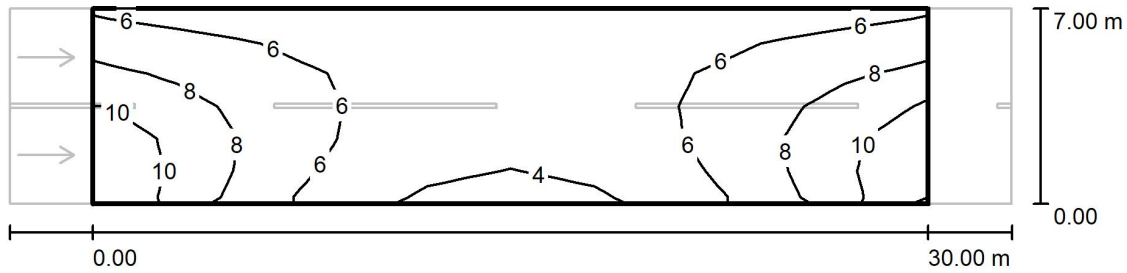
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.44	0.62	13	0.53
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.46	0.62	13
2	Observer 2	(-60.000, 5.250, 1.500)	0.54	0.44	0.64	11

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-2 lanes-ME5 / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
6.46	3.62	11	0.560	0.330

Operator
Telephone
Fax
e-Mail

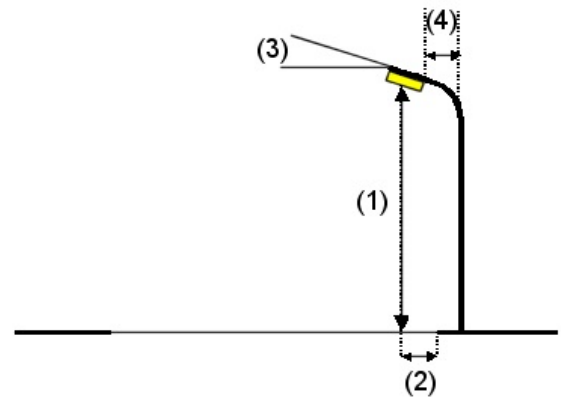
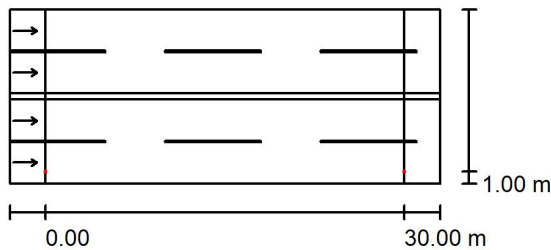
Class B-Other Areas-4 lanes-ME5-Single side / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

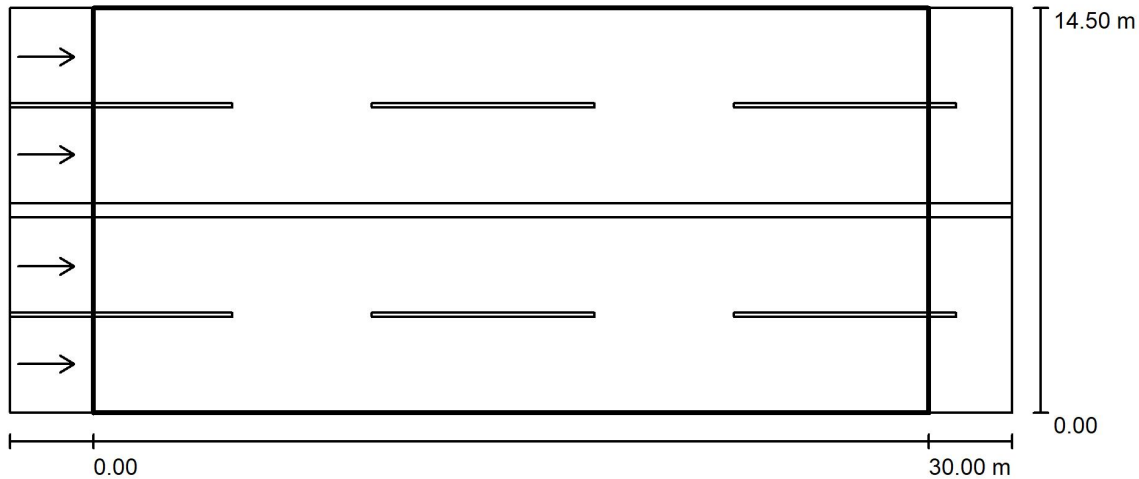
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	6850 lm	Maximum luminous intensities
Luminous flux (Lamps):	6850 lm	at 70°: 896 cd/klm
Luminaire Wattage:	46.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 90°.
Height:	12.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME5-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

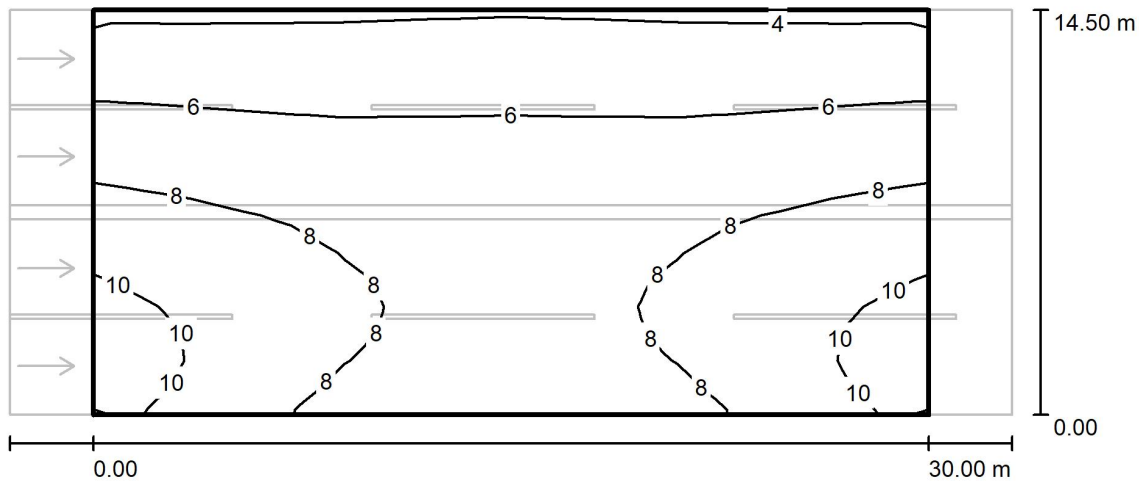
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.35	0.90	9	0.53
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.37	0.95	8
2	Observer 2	(-60.000, 5.250, 1.500)	0.53	0.36	0.94	9
3	Observer 3	(-60.000, 9.250, 1.500)	0.57	0.35	0.92	7
4	Observer 4	(-60.000, 12.750, 1.500)	0.59	0.35	0.90	4

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME5-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
7.21	3.99	11	0.553	0.377

Operator
Telephone
Fax
e-Mail

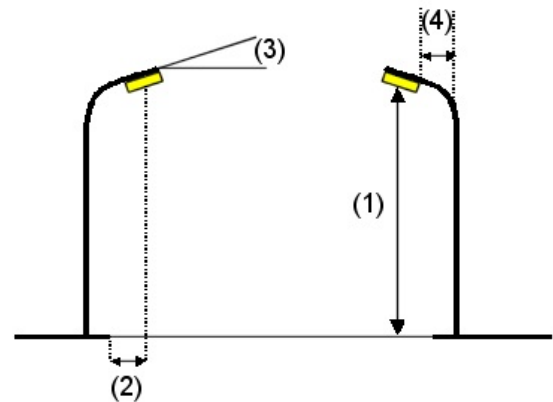
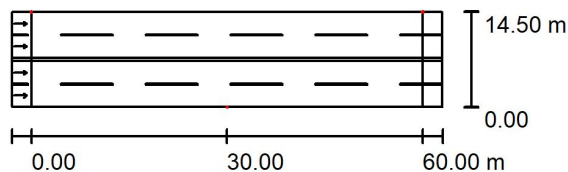
Class B-Other Areas-4 lanes-ME5-Staggered / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

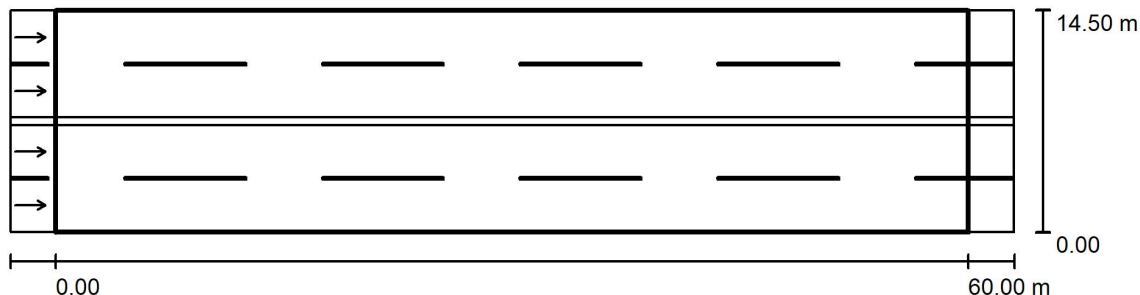
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	6250 lm	Maximum luminous intensities
Luminous flux (Lamps):	6250 lm	at 70°: 896 cd/klm
Luminaire Wattage:	42.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.600 m	No luminous intensities above 90°.
Height:	10.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME5-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

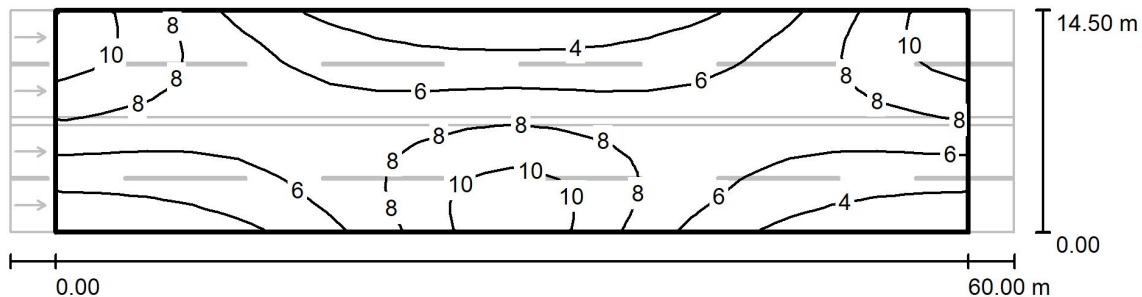
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.42	0.44	11	0.54
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.42	0.44	11
2	Observer 2	(-60.000, 5.250, 1.500)	0.50	0.45	0.71	11
3	Observer 3	(-60.000, 9.250, 1.500)	0.51	0.49	0.71	11
4	Observer 4	(-60.000, 12.750, 1.500)	0.50	0.45	0.44	11

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME5-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 472

Grid: 20 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
6.59	2.63	11	0.399	0.232

Operator
Telephone
Fax
e-Mail

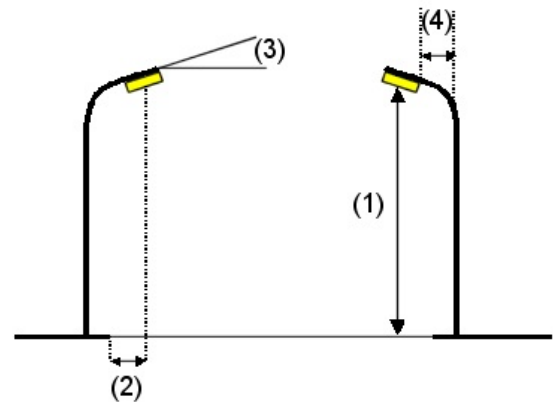
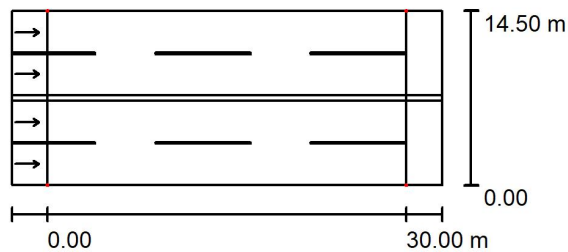
Class B-Other Areas-4 lanes-ME5-Opposite / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	2900 lm	Maximum luminous intensities
Luminous flux (Lamps):	2900 lm	at 70°: 896 cd/klm
Luminaire Wattage:	19.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, opposing	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.100 m	No luminous intensities above 90°.
Height:	7.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME5-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

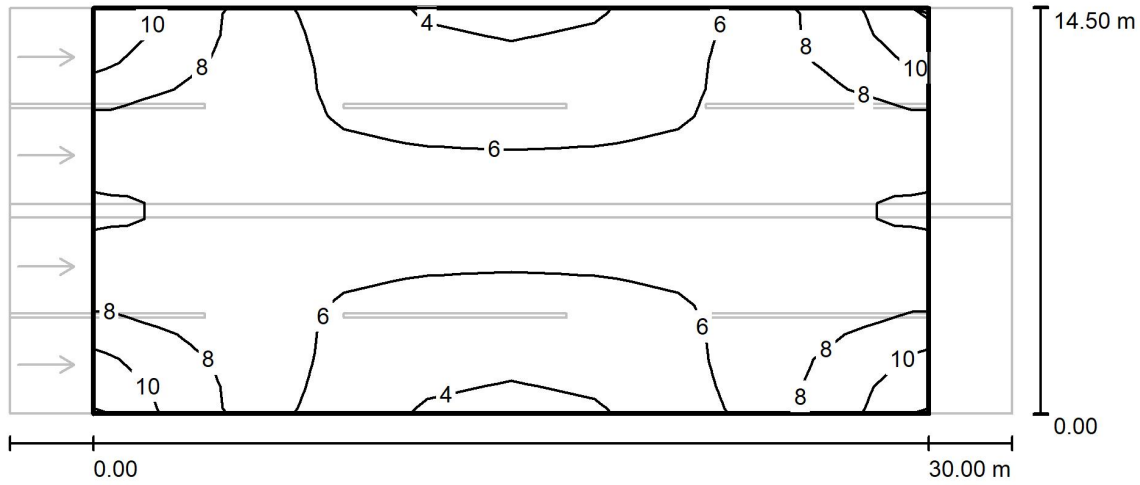
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.43	0.52	14	0.51
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.45	0.56	14
2	Observer 2	(-60.000, 5.250, 1.500)	0.51	0.43	0.52	10
3	Observer 3	(-60.000, 9.250, 1.500)	0.51	0.43	0.52	10
4	Observer 4	(-60.000, 12.750, 1.500)	0.50	0.45	0.56	14

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME5-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]
6.41

E_{min} [lx]
3.67

E_{max} [lx]
11

$u0$
0.572

E_{min} / E_{max}
0.345

Operator
Telephone
Fax
e-Mail

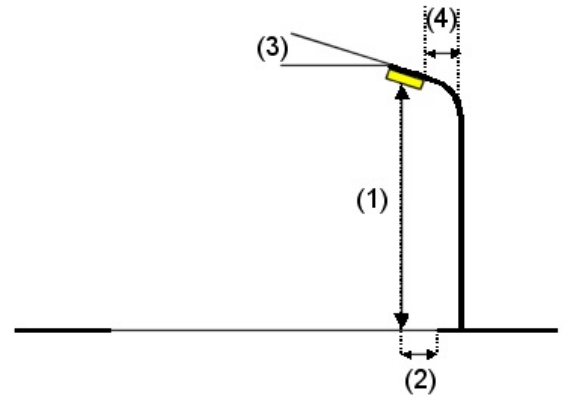
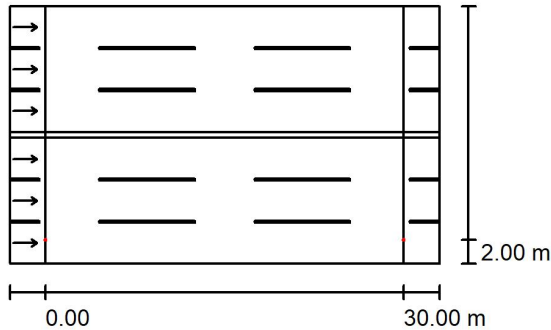
Class B-Other Areas-6 lanes-ME5-Single side / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

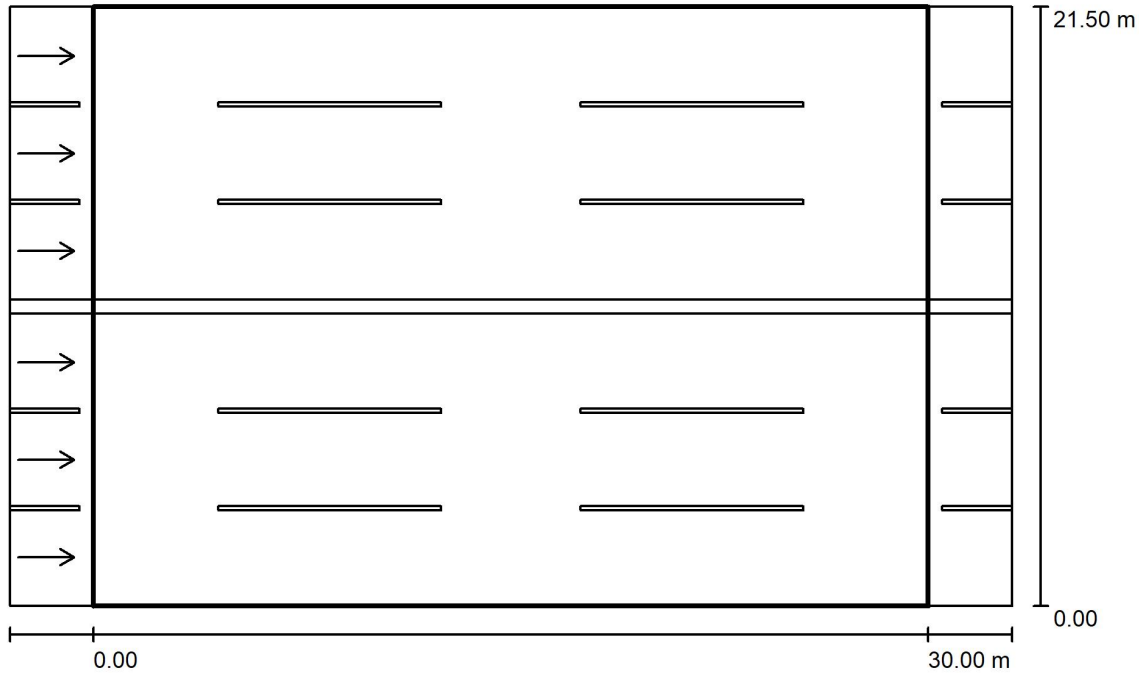
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-3 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 3 OPTIC, No Shield	
Luminous flux (Luminaire):	9950 lm	Maximum luminous intensities
Luminous flux (Lamps):	9950 lm	at 70°: 711 cd/klm
Luminaire Wattage:	66.0 W	at 80°: 216 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.600 m	No luminous intensities above 90°.
Height:	10.500 m	Arrangement complies with glare index class D.6.
Overhang (2):	2.000 m	
Boom Angle (3):	0.0°	
Boom Length (4):	2.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME5-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

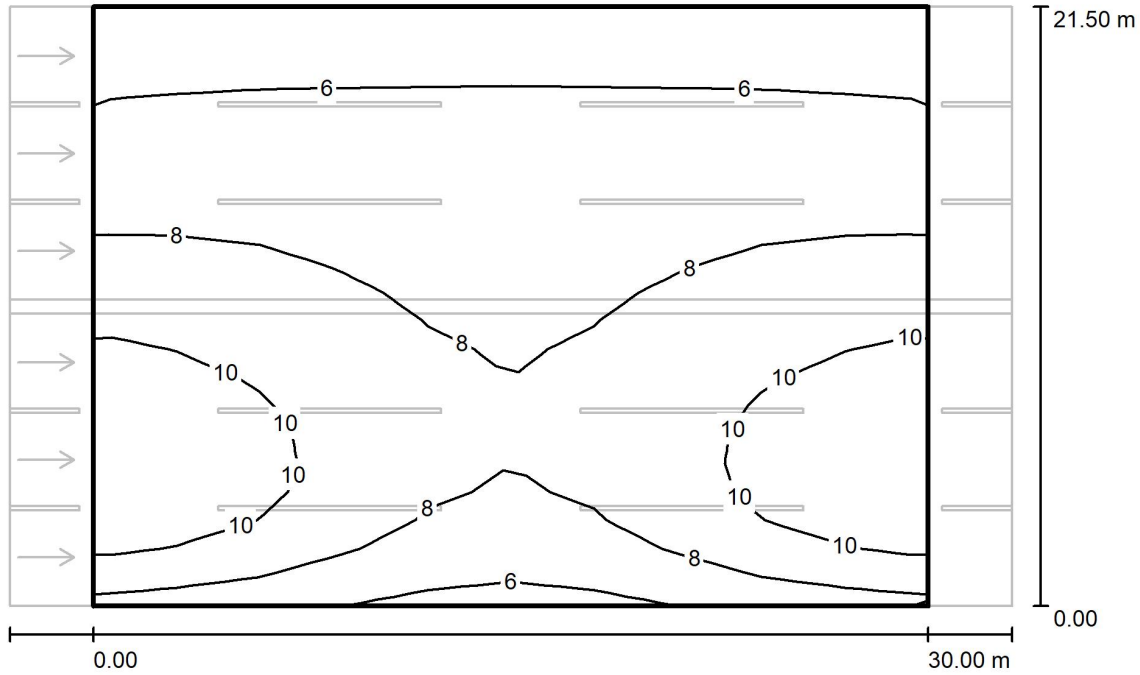
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.41	0.89	13	0.50
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.46	0.92	11
2	Observer 2	(-60.000, 5.250, 1.500)	0.52	0.45	0.91	13
3	Observer 3	(-60.000, 8.750, 1.500)	0.55	0.44	0.91	11
4	Observer 4	(-60.000, 12.750, 1.500)	0.57	0.41	0.91	7
5	Observer 5	(-60.000, 16.250, 1.500)	0.59	0.41	0.89	5
6	Observer 6	(-60.000, 19.750, 1.500)	0.60	0.42	0.90	3

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME5-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
7.92	5.01	12	0.632	0.431

Operator
Telephone
Fax
e-Mail

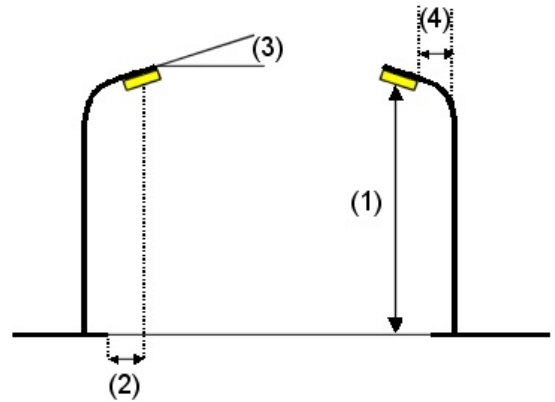
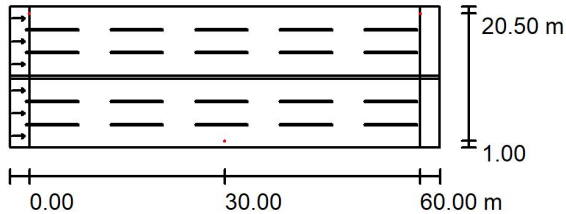
Class B-Other Areas-6 lanes-ME5-Staggered / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

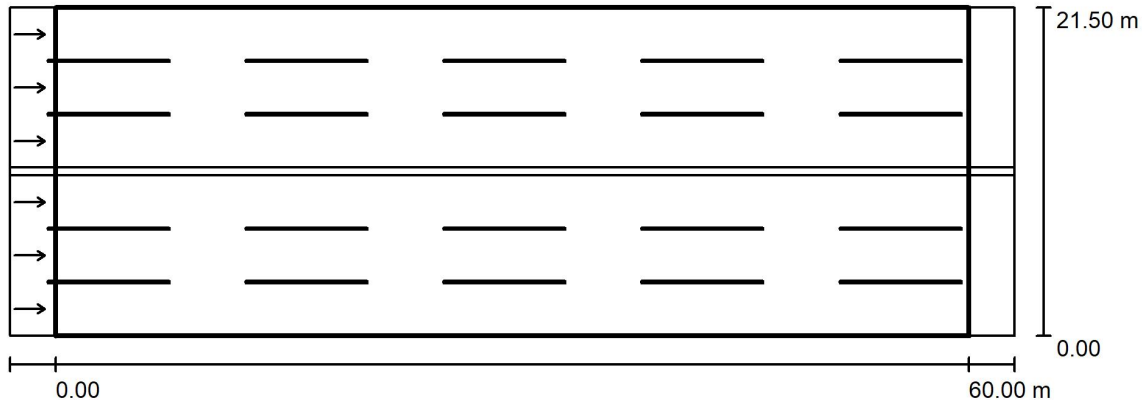
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	8300 lm	Maximum luminous intensities
Luminous flux (Lamps):	8300 lm	at 70°: 896 cd/klm
Luminaire Wattage:	55.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	11.600 m	No luminous intensities above 90°.
Height:	11.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME5-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

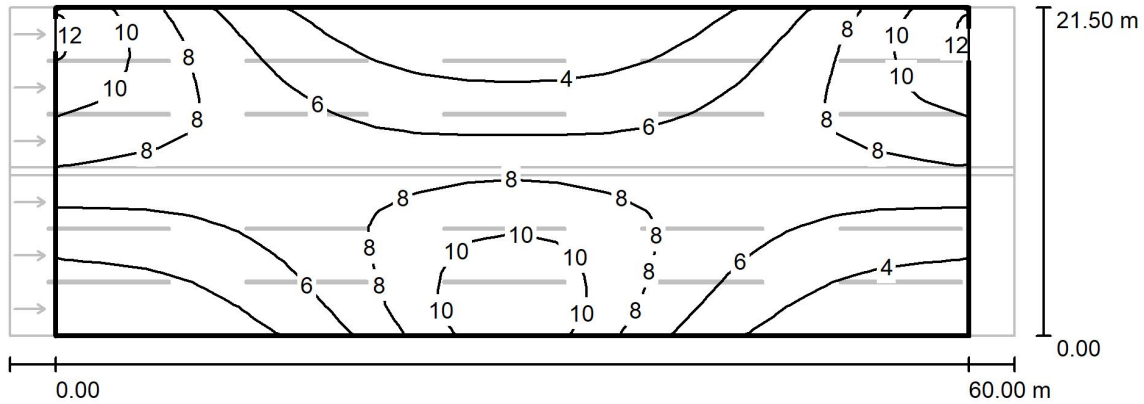
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.35	0.42	12	0.54
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.35	0.42	11
2	Observer 2	(-60.000, 5.250, 1.500)	0.51	0.37	0.55	12
3	Observer 3	(-60.000, 8.750, 1.500)	0.51	0.39	0.83	10
4	Observer 4	(-60.000, 12.750, 1.500)	0.51	0.42	0.83	10
5	Observer 5	(-60.000, 16.250, 1.500)	0.51	0.40	0.55	12
6	Observer 6	(-60.000, 19.750, 1.500)	0.51	0.39	0.42	11

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME5-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 472

Grid: 20 x 21 Points

E_{av} [lx]
6.63

E_{min} [lx]
2.41

E_{max} [lx]
12

$u0$
0.364

E_{min} / E_{max}
0.205

Operator
Telephone
Fax
e-Mail

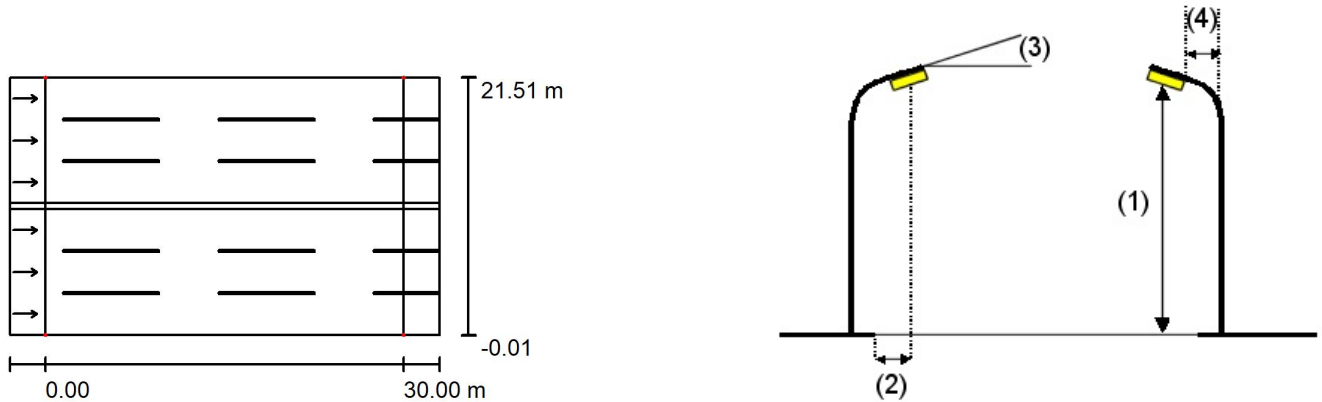
Class B-Other Areas-6 lanes-ME5-Opposite / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

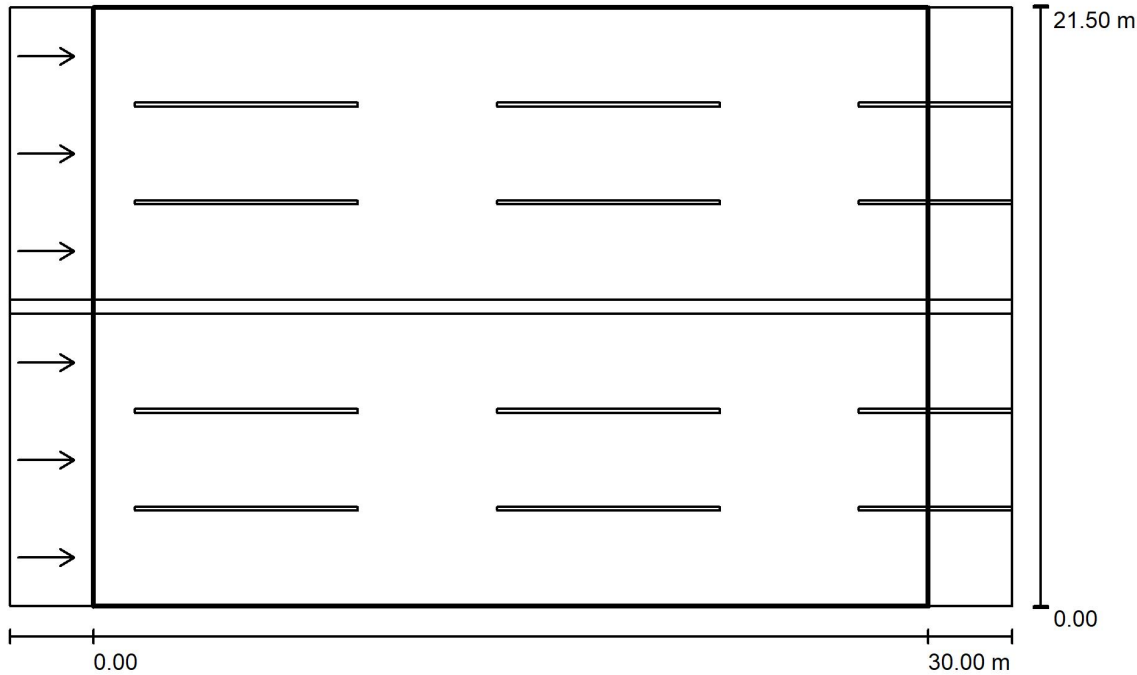
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	4000 lm	Maximum luminous intensities
Luminous flux (Lamps):	4000 lm	at 70°: 855 cd/klm
Luminaire Wattage:	27.0 W	at 80°: 160 cd/klm
Arrangement:	Double row, opposing	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.600 m	No luminous intensities above 95°.
Height:	8.500 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	-0.009 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME5-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME5

(All lighting performance requirements are met.)

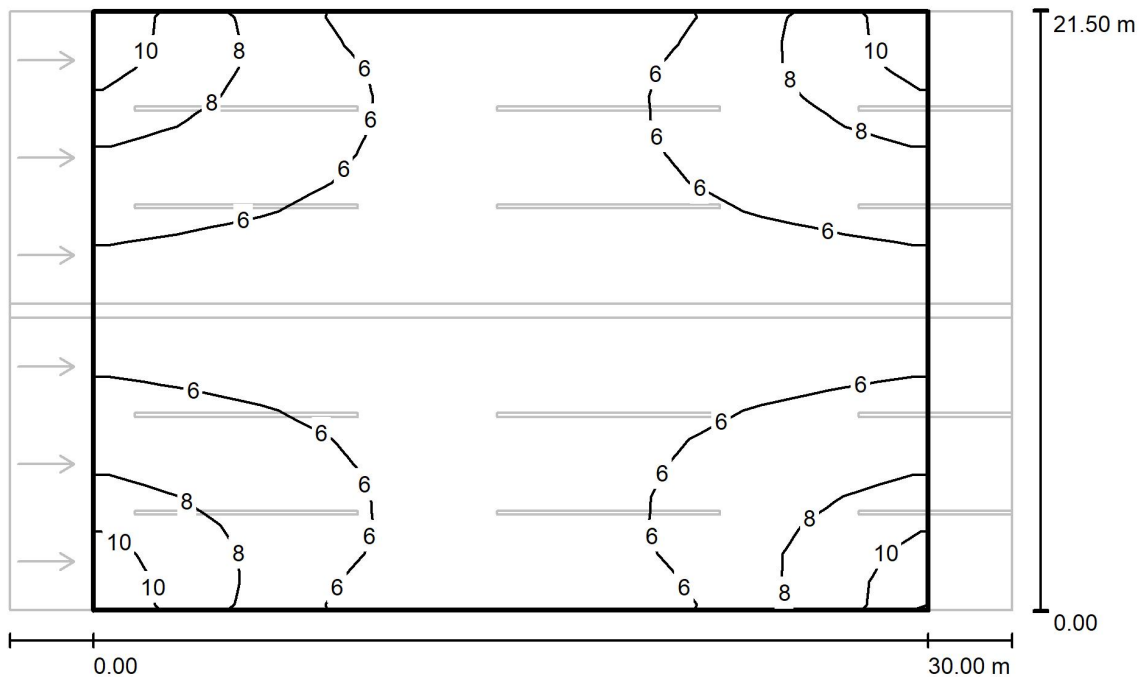
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.50	0.57	0.81	11	0.50
Required values according to class:	≥ 0.50	≥ 0.35	≥ 0.40	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.50	0.58	0.81	11
2	Observer 2	(-60.000, 5.250, 1.500)	0.51	0.58	0.85	10
3	Observer 3	(-60.000, 8.750, 1.500)	0.51	0.57	0.81	7
4	Observer 4	(-60.000, 12.750, 1.500)	0.51	0.57	0.81	7
5	Observer 5	(-60.000, 16.250, 1.500)	0.51	0.58	0.85	10
6	Observer 6	(-60.000, 19.750, 1.500)	0.50	0.58	0.81	11

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME5-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
6.42	4.36	10	0.679	0.415

Operator
Telephone
Fax
e-Mail

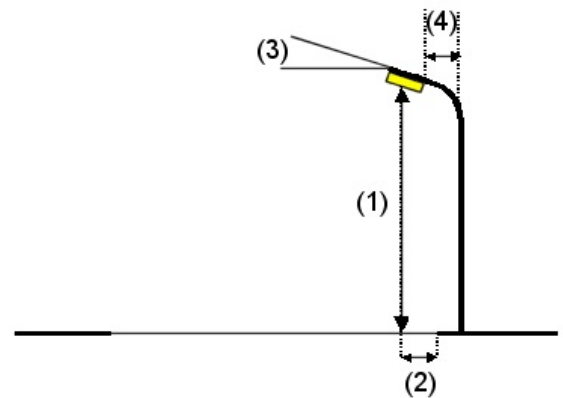
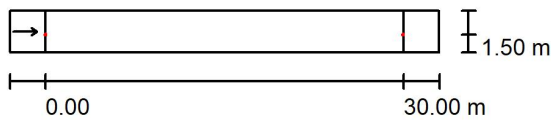
Class B-Other Areas-1 lane-ME4a / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

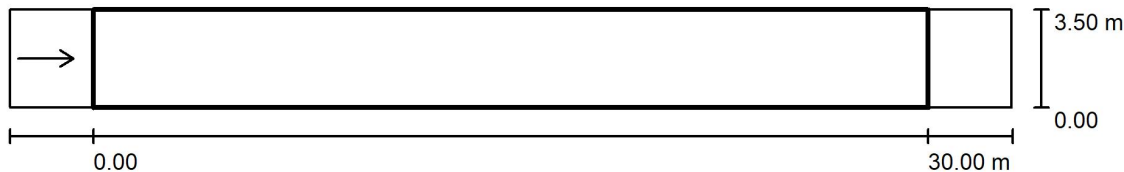
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	3900 lm	Maximum luminous intensities
Luminous flux (Lamps):	3900 lm	at 70°: 896 cd/klm
Luminaire Wattage:	26.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.100 m	No luminous intensities above 90°.
Height:	7.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-1 lane-ME4a / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

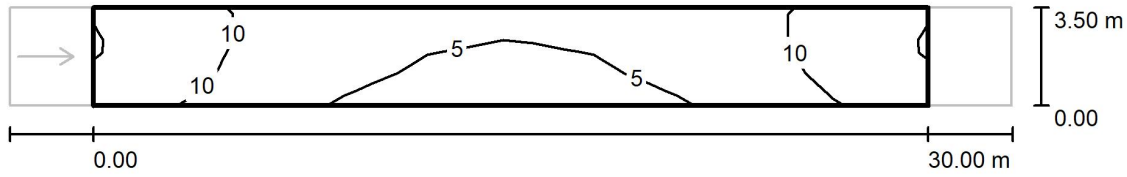
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.73	0.60	12	0.77
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (1 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.73	0.60	12

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-1 lane-ME4a / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]
8.06

E_{min} [lx]
3.68

E_{max} [lx]
14

u0
0.456

E_{min} / E_{max}
0.260

Operator
Telephone
Fax
e-Mail

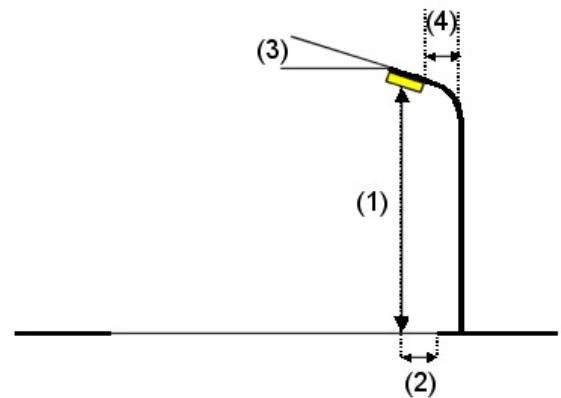
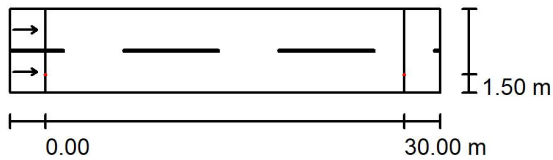
Class B-Other Areas-2 lanes-ME4a / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

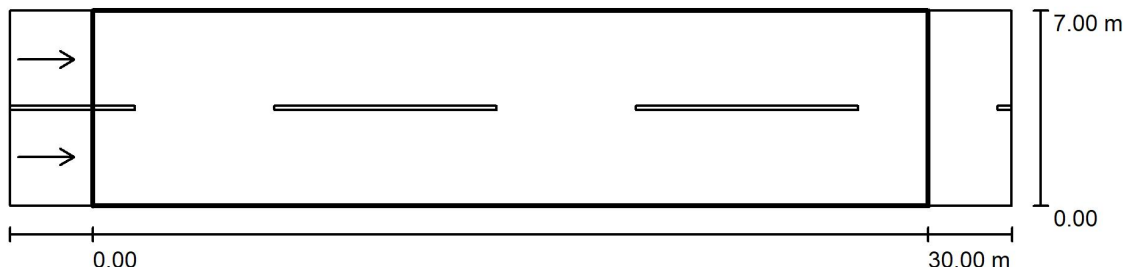
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	5100 lm	Maximum luminous intensities
Luminous flux (Lamps):	5100 lm	at 70°: 896 cd/klm
Luminaire Wattage:	34.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	7.600 m	No luminous intensities above 90°.
Height:	7.500 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-2 lanes-ME4a / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 6 Points

Accompanying Street Elements: Roadway 1.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

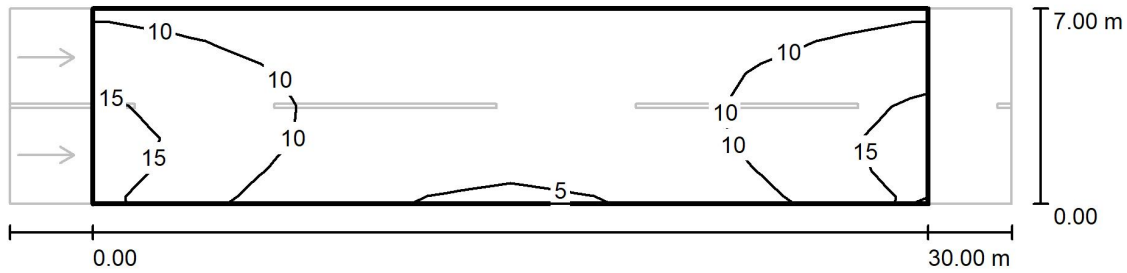
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.49	0.63	13	0.51
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.49	0.68	13
2	Observer 2	(-60.000, 5.250, 1.500)	0.80	0.49	0.63	13

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-2 lanes-ME4a / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
9.61	4.84	16	0.504	0.295

Operator
Telephone
Fax
e-Mail

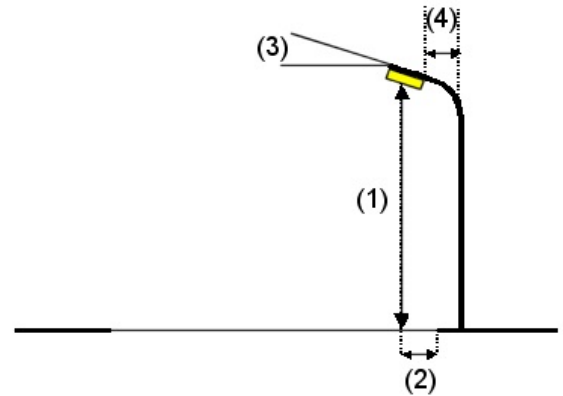
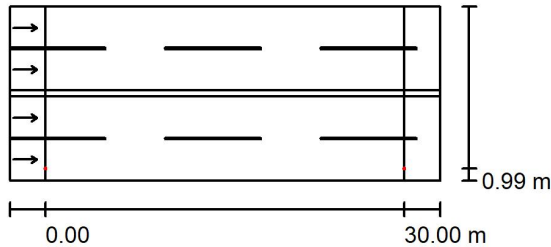
Class B-Other Areas-4 lanes-ME4a-Single side / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

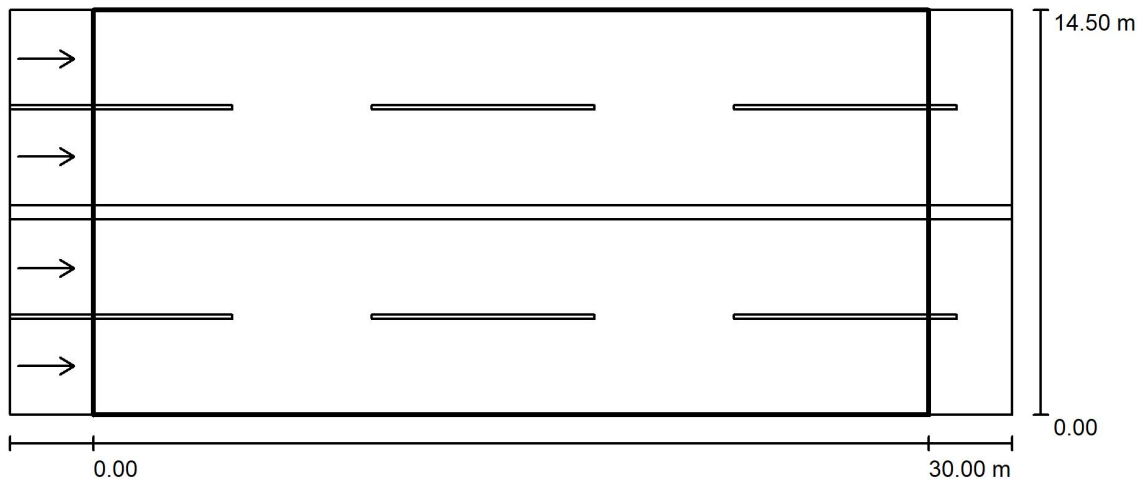
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	10650 lm	Maximum luminous intensities
Luminous flux (Lamps):	10650 lm	at 70°: 855 cd/klm
Luminaire Wattage:	71.0 W	at 80°: 160 cd/klm
Arrangement:	Single row, bottom	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 95°.
Height:	12.000 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	1.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	0.991 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME4a-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

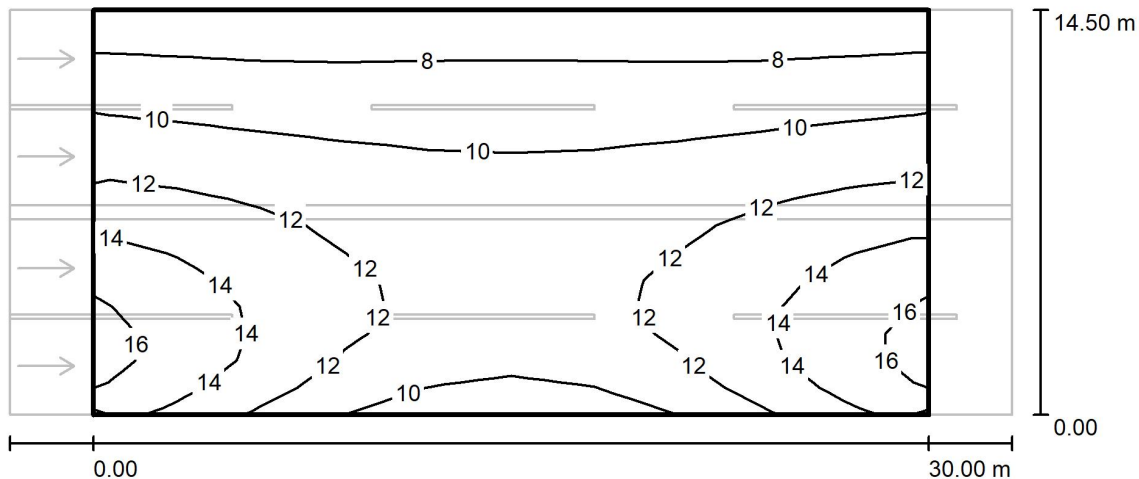
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.41	0.91	10	0.52
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.43	0.94	9
2	Observer 2	(-60.000, 5.250, 1.500)	0.80	0.42	0.94	10
3	Observer 3	(-60.000, 9.250, 1.500)	0.86	0.41	0.91	8
4	Observer 4	(-60.000, 12.750, 1.500)	0.89	0.41	0.91	5

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME4a-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
11	6.95	16	0.630	0.431

Operator
Telephone
Fax
e-Mail

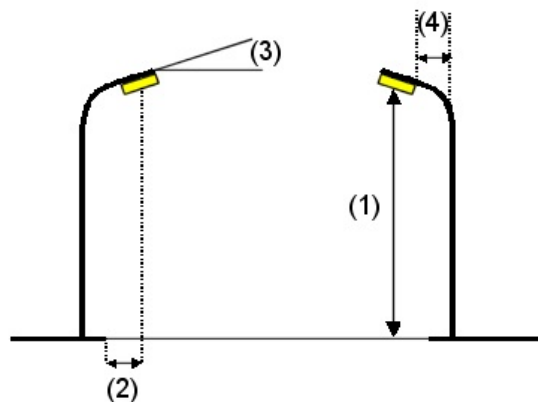
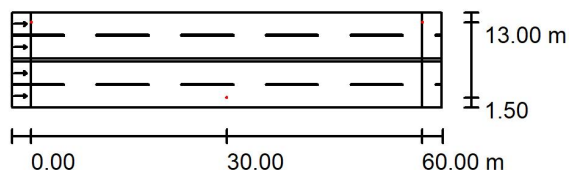
Class B-Other Areas-4 lanes-ME4a-Staggered / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

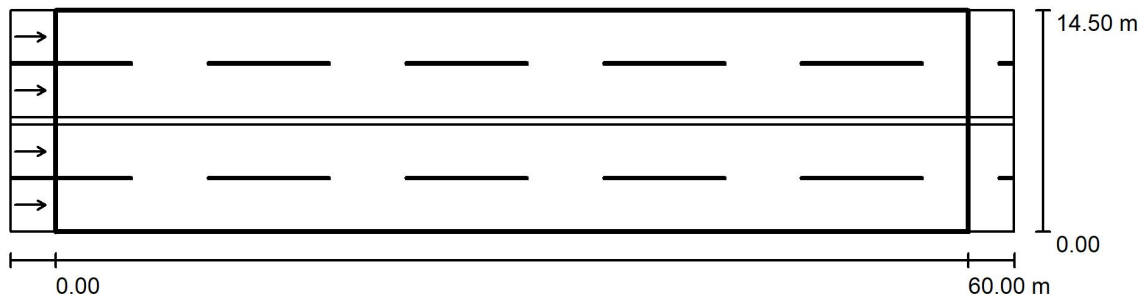
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	9250 lm	Maximum luminous intensities
Luminous flux (Lamps):	9250 lm	at 70°: 896 cd/klm
Luminaire Wattage:	62.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	12.100 m	No luminous intensities above 90°.
Height:	12.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME4a-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

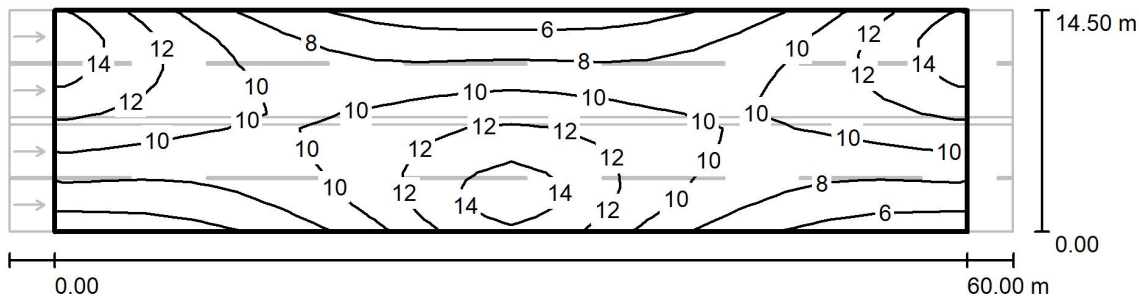
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.45	0.68	9	0.50
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.45	0.68	8
2	Observer 2	(-60.000, 5.250, 1.500)	0.76	0.51	0.74	9
3	Observer 3	(-60.000, 9.250, 1.500)	0.76	0.55	0.74	9
4	Observer 4	(-60.000, 12.750, 1.500)	0.75	0.50	0.68	8

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME4a-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 472

Grid: 20 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
9.91	5.19	15	0.524	0.350

Operator
Telephone
Fax
e-Mail

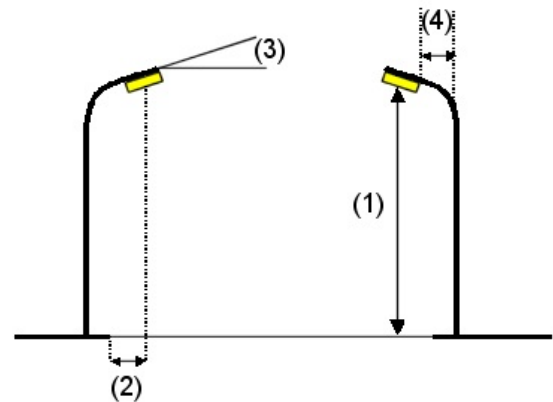
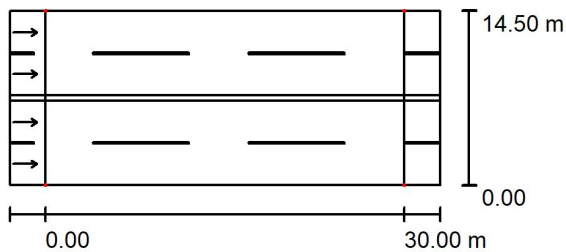
Class B-Other Areas-4 lanes-ME4a-Opposite / Planning data

Street Profile

Roadway 2 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	4450 lm	Maximum luminous intensities
Luminous flux (Lamps):	4450 lm	at 70°: 896 cd/klm
Luminaire Wattage:	30.0 W	at 80°: 70 cd/klm
Arrangement:	Double row, opposing	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.100 m	No luminous intensities above 90°.
Height:	8.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME4a-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 15 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

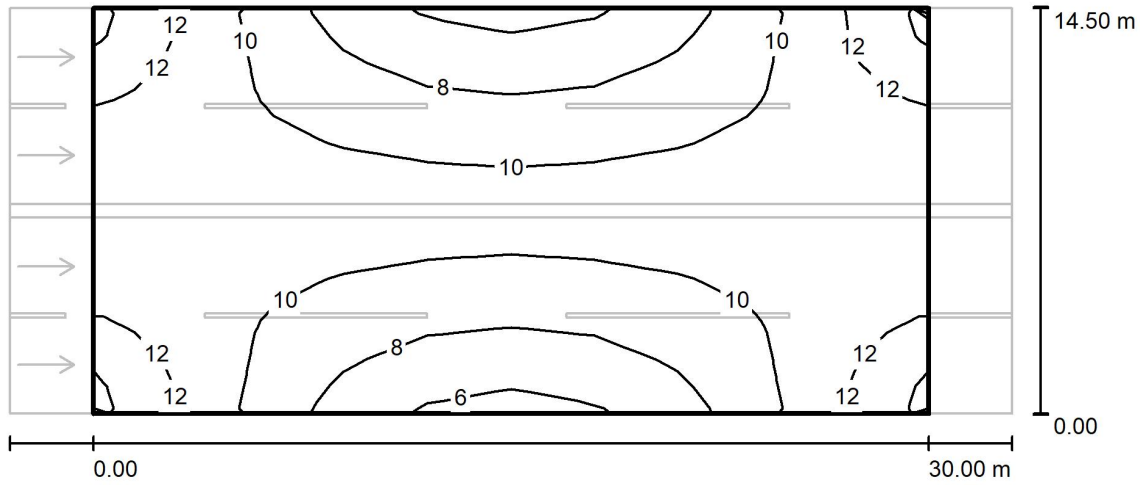
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.76	0.60	0.67	11	0.52
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (4 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.76	0.61	0.69	11
2	Observer 2	(-60.000, 5.250, 1.500)	0.77	0.60	0.67	11
3	Observer 3	(-60.000, 9.250, 1.500)	0.77	0.60	0.67	11
4	Observer 4	(-60.000, 12.750, 1.500)	0.76	0.61	0.69	11

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-4 lanes-ME4a-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	$u0$	E_{min} / E_{max}
9.78	5.69	13	0.581	0.428

Operator
Telephone
Fax
e-Mail

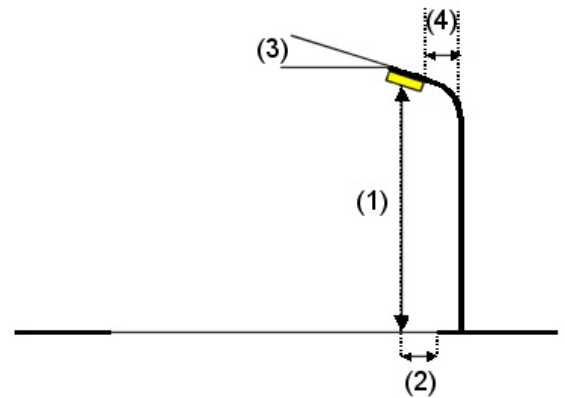
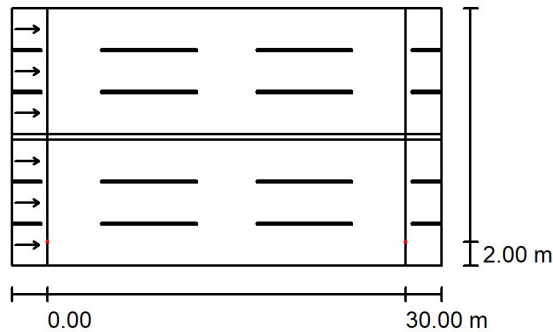
Class B-Other Areas-6 lanes-ME4a-Single side / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

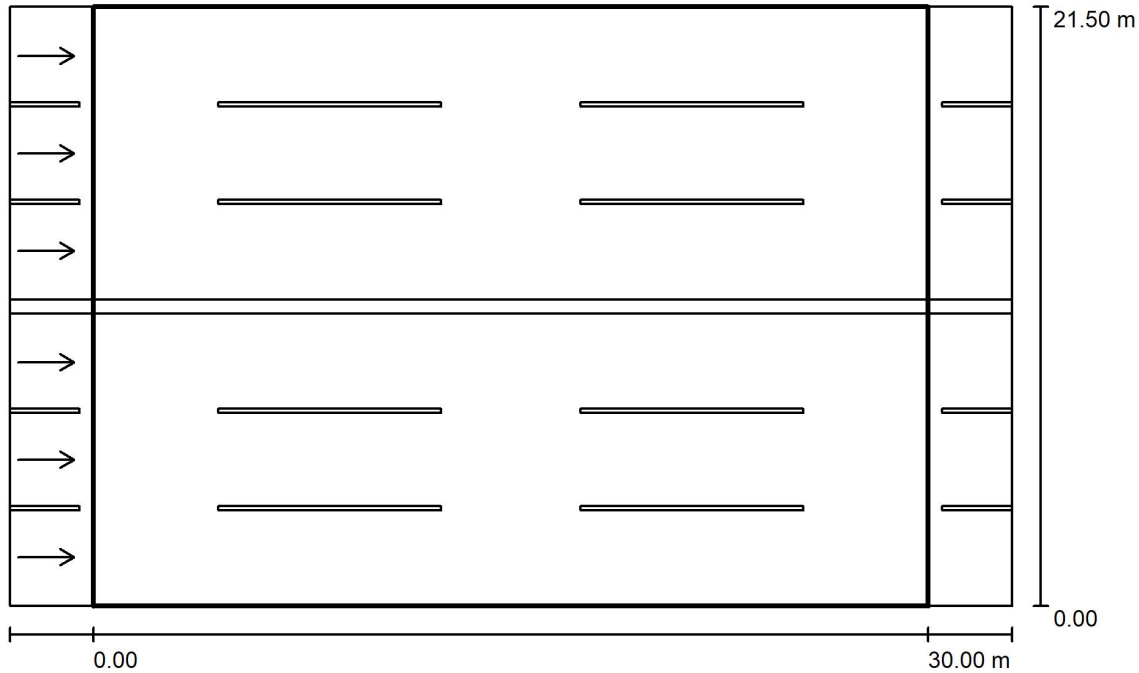
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-3 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 3 OPTIC, No Shield	
Luminous flux (Luminaire):	14900 lm	Maximum luminous intensities
Luminous flux (Lamps):	14900 lm	at 70°: 711 cd/klm
Luminaire Wattage:	99.0 W	at 80°: 216 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	10.600 m	No luminous intensities above 90°.
Height:	10.500 m	Arrangement complies with glare index class D.6.
Overhang (2):	2.000 m	
Boom Angle (3):	0.0 °	
Boom Length (4):	2.000 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME4a-Single side / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

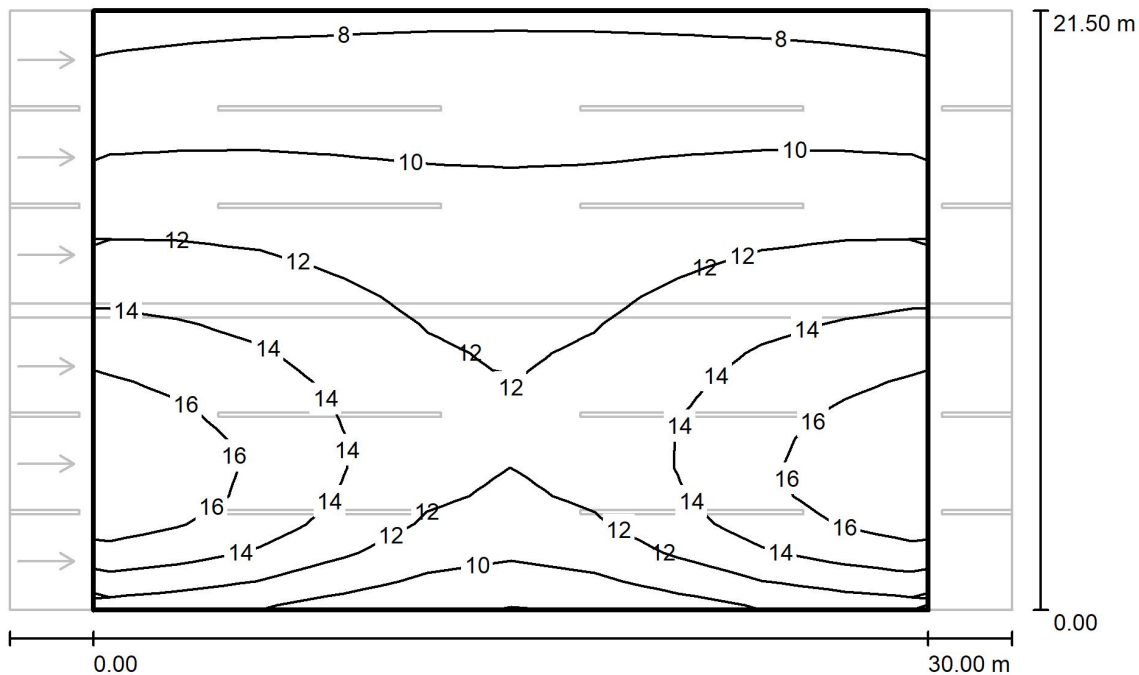
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.41	0.89	14	0.50
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.46	0.92	12
2	Observer 2	(-60.000, 5.250, 1.500)	0.78	0.45	0.91	14
3	Observer 3	(-60.000, 8.750, 1.500)	0.82	0.44	0.91	12
4	Observer 4	(-60.000, 12.750, 1.500)	0.85	0.41	0.91	8
5	Observer 5	(-60.000, 16.250, 1.500)	0.88	0.41	0.89	5
6	Observer 6	(-60.000, 19.750, 1.500)	0.90	0.42	0.90	3

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME4a-Single side / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
12	7.50	17	0.632	0.431

Operator
Telephone
Fax
e-Mail

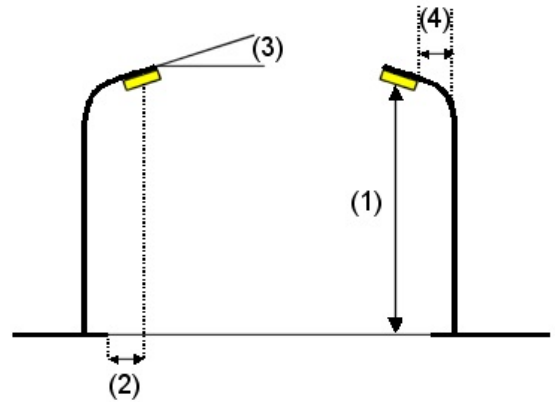
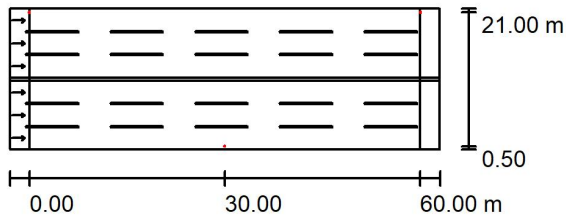
Class B-Other Areas-6 lanes-ME4a-Staggered / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

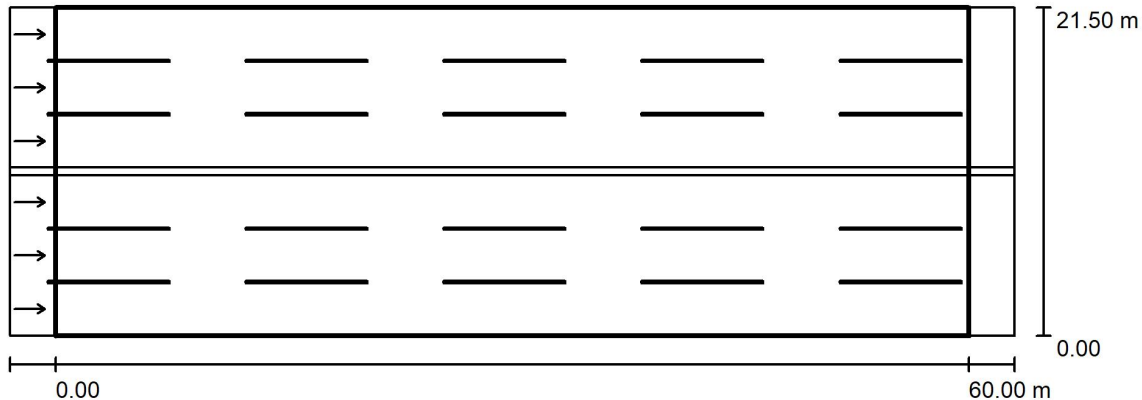
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-3 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 3 OPTIC, No Shield	
Luminous flux (Luminaire):	14550 lm	Maximum luminous intensities
Luminous flux (Lamps):	14550 lm	at 70°: 711 cd/klm
Luminaire Wattage:	97.0 W	at 80°: 216 cd/klm
Arrangement:	Double row, with offset	at 90°: 0.00 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	11.600 m	No luminous intensities above 90°.
Height:	11.500 m	Arrangement complies with glare index class D.6.
Overhang (2):	0.500 m	
Boom Angle (3):	0.0 °	
Boom Length (4):	0.500 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME4a-Staggered / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

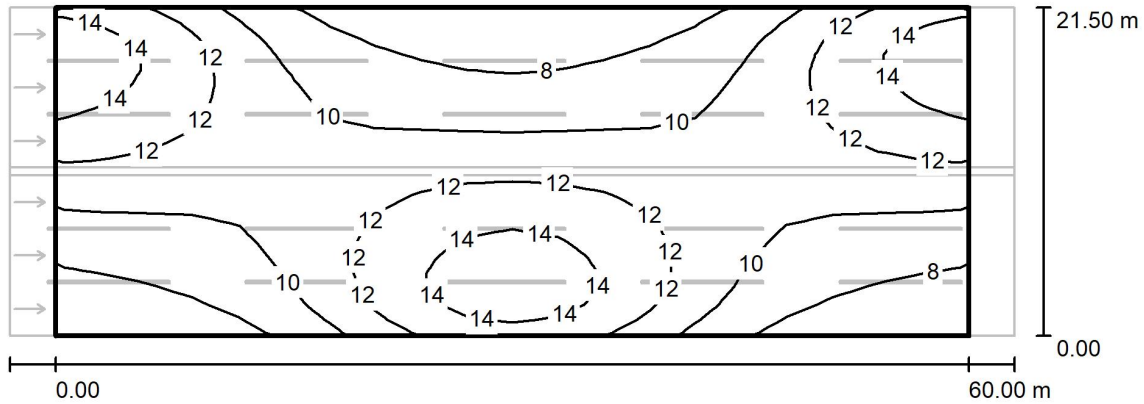
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.51	0.60	10	0.61
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.51	0.60	10
2	Observer 2	(-60.000, 5.250, 1.500)	0.76	0.53	0.75	10
3	Observer 3	(-60.000, 8.750, 1.500)	0.76	0.56	0.86	9
4	Observer 4	(-60.000, 12.750, 1.500)	0.76	0.58	0.86	9
5	Observer 5	(-60.000, 16.250, 1.500)	0.76	0.56	0.75	10
6	Observer 6	(-60.000, 19.750, 1.500)	0.75	0.53	0.60	10

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME4a-Staggered / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 472

Grid: 20 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
11	6.10	15	0.570	0.402

Operator
Telephone
Fax
e-Mail

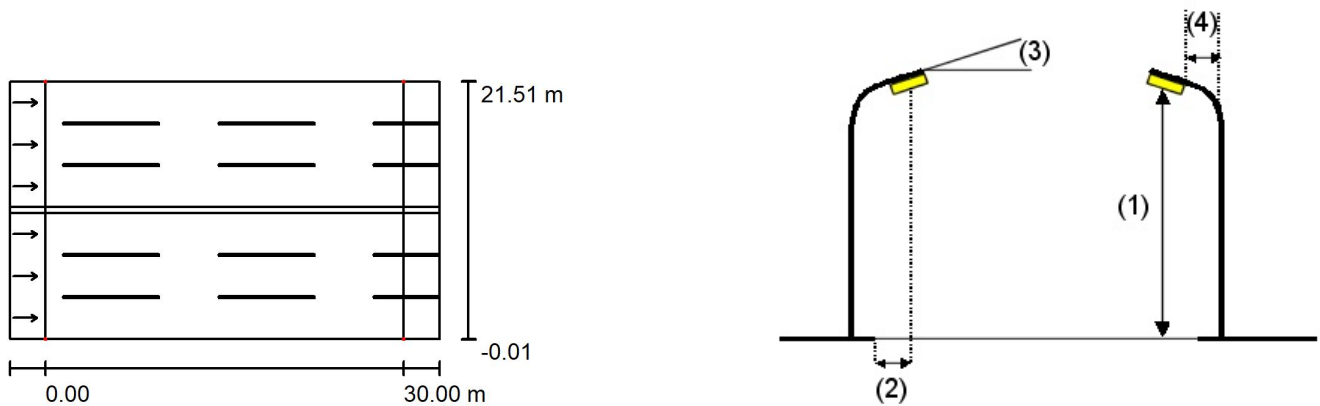
Class B-Other Areas-6 lanes-ME4a-Opposite / Planning data

Street Profile

Roadway 2 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)
 Median 1 (Width: 0.500 m, Height: 0.000 m)
 Roadway 1 (Width: 10.500 m, Number of lanes: 3, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

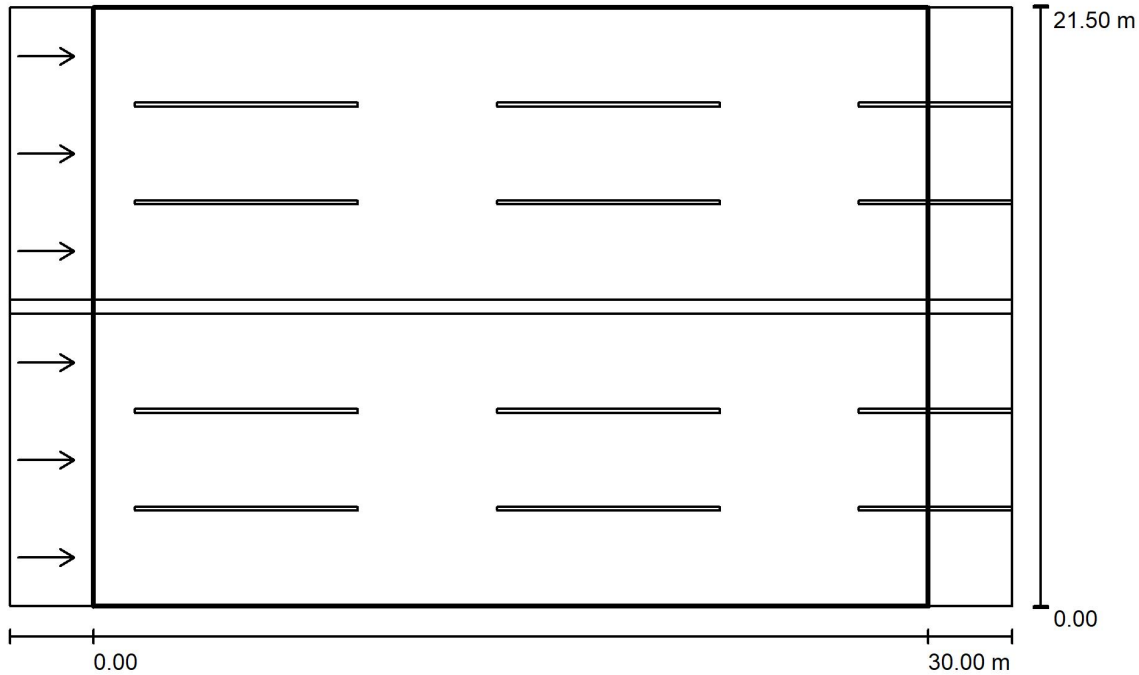
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	6000 lm	Maximum luminous intensities
Luminous flux (Lamps):	6000 lm	at 70°: 855 cd/klm
Luminaire Wattage:	40.0 W	at 80°: 160 cd/klm
Arrangement:	Double row, opposing	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	8.600 m	No luminous intensities above 95°.
Height:	8.500 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	-0.009 m	

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME4a-Opposite / Valuation Field Roadway 1 & Roadway 2 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 21 Points

Accompanying Street Elements: Roadway 1, Median 1, Roadway 2.

tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a

(All lighting performance requirements are met.)

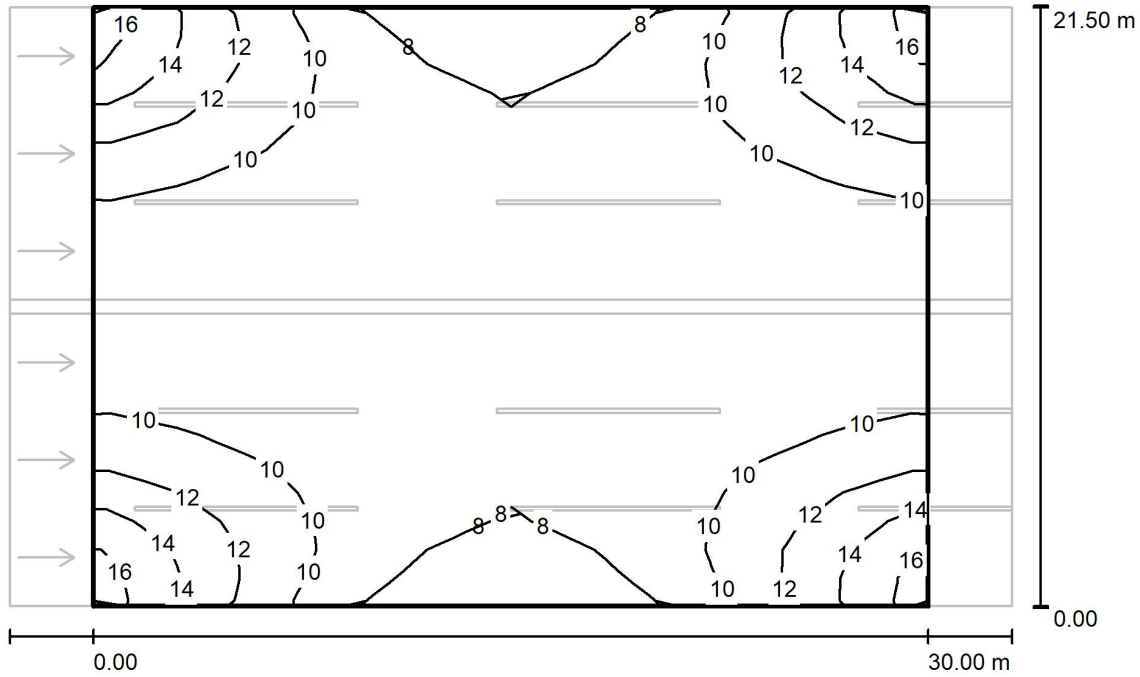
	L_{av} [cd/m ²]	U0	UI	TI [%]	SR
Calculated values:	0.75	0.57	0.81	12	0.50
Required values according to class:	≥ 0.75	≥ 0.40	≥ 0.60	≤ 15	≥ 0.50
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned observer (6 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m ²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.750, 1.500)	0.75	0.58	0.81	12
2	Observer 2	(-60.000, 5.250, 1.500)	0.76	0.58	0.85	11
3	Observer 3	(-60.000, 8.750, 1.500)	0.77	0.57	0.81	7
4	Observer 4	(-60.000, 12.750, 1.500)	0.77	0.57	0.81	7
5	Observer 5	(-60.000, 16.250, 1.500)	0.76	0.58	0.85	11
6	Observer 6	(-60.000, 19.750, 1.500)	0.75	0.58	0.81	12

Operator
Telephone
Fax
e-Mail

Class B-Other Areas-6 lanes-ME4a-Opposite / Valuation Field Roadway 1 & Roadway 2 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 21 Points

E_{av} [lx]
9.64

E_{min} [lx]
6.54

E_{max} [lx]
16

$u0$
0.679

E_{min} / E_{max}
0.415

APPENDIX G- LIGHTING SIMULATION REPORT FOR MINOR/ SECONDARY ROADS
WITHIN TOWN AREA

SECONDARY/ MINOR ROADS- WITHIN TOWN AREA

Date: 03.10.2020



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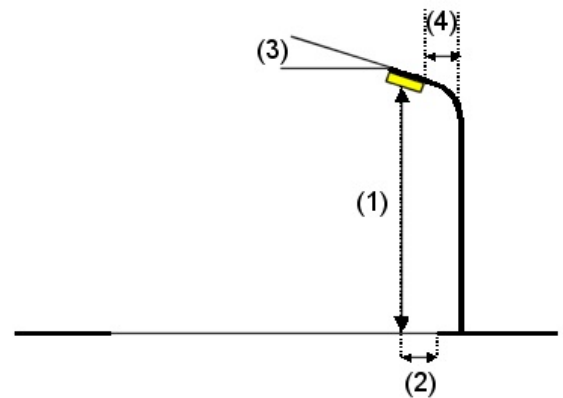
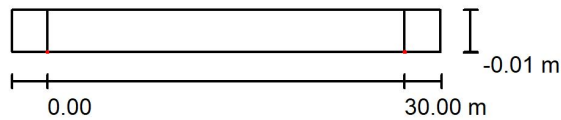
Secondary/Minor Roads-S5-1 Lane / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

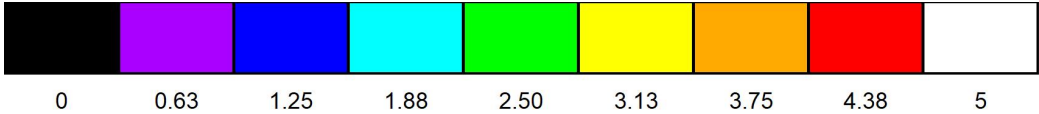
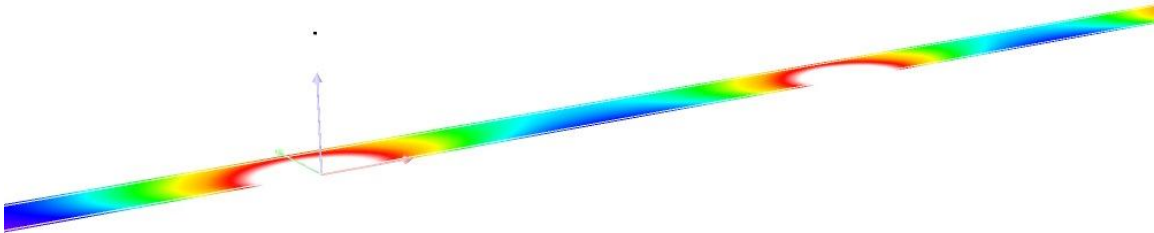
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	1250 lm	Maximum luminous intensities
Luminous flux (Lamps):	1250 lm	at 70°: 855 cd/klm
Luminaire Wattage:	183.0 W	at 80°: 160 cd/klm
Arrangement:	Single row, bottom	at 90°: 10 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	6.100 m	No luminous intensities above 95°.
Height:	6.000 m	Arrangement complies with luminous intensity class G1.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	5.0 °	
Boom Length (4):	-0.009 m	

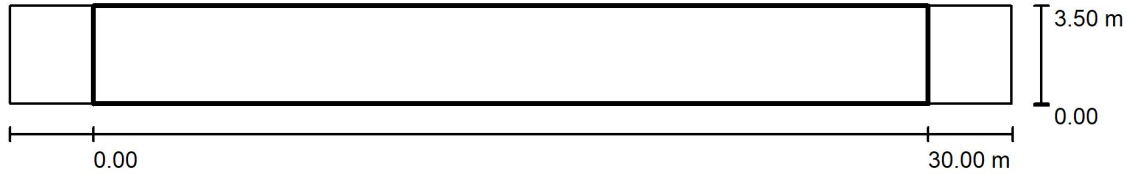


Secondary/Minor Roads-S5-1 Lane / False Color Rendering



lx

Secondary/Minor Roads-S5-1 Lane / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

Accompanying Street Elements: Roadway 1.

Selected Lighting Class: S5

(All lighting performance requirements are met.)

Calculated values:	E_{av} [lx]	E_{min} [lx]
Required values according to class:	3.00	1.41
Fulfilled/Not fulfilled:	≥ 3.00	≥ 0.60
	✓	✓

Secondary/Minor Roads-S5-1 Lane / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
3.00	1.41	5.86	0.472	0.241

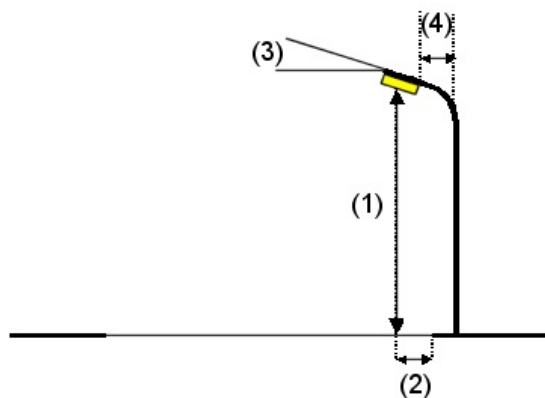
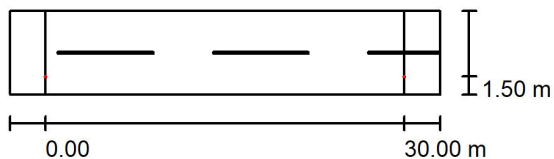
Secondary/Minor Roads-S5-2 Lanes / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

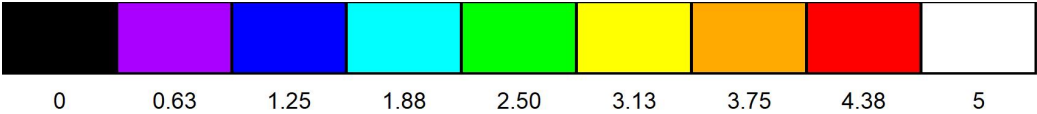
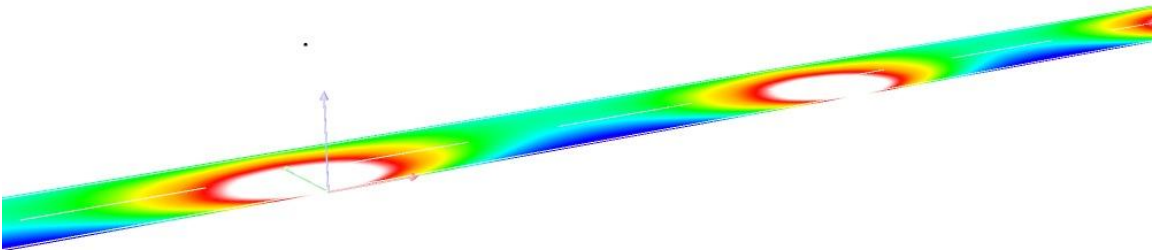
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	1350 lm	Maximum luminous intensities
Luminous flux (Lamps):	1350 lm	at 70°: 896 cd/klm
Luminaire Wattage:	135.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	6.100 m	No luminous intensities above 90°.
Height:	6.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

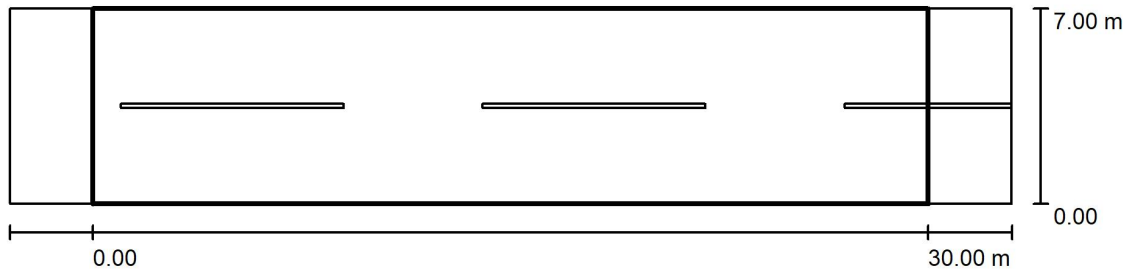


Secondary/Minor Roads-S5-2 Lanes / False Color Rendering



lx

Secondary/Minor Roads-S5-2 Lanes / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 5 Points

Accompanying Street Elements: Roadway 1.

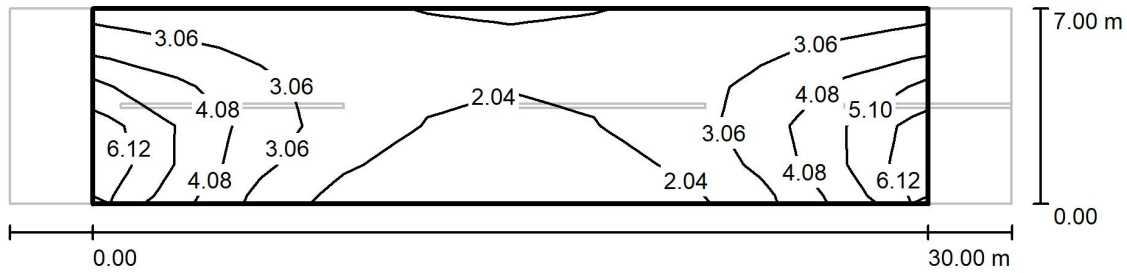
Selected Lighting Class: S5

(All lighting performance requirements are met.)

Calculated values:	E_{av} [lx]	E_{min} [lx]
Required values according to class:	3.03	
Fulfilled/Not fulfilled:	≥ 3.00	≥ 0.60
	✓	✓

Operator
Telephone
Fax
e-Mail

Secondary/Minor Roads-S5-2 Lanes / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
3.03	1.25	6.34	0.413	0.197

APPENDIX H- LIGHTING SIMULATION REPORT FOR MINOR/ SECONDARY ROADS
NOT WITHIN TOWN AREA

SECONDARY/ MINOR ROADS- NOT WITHIN TOWN AREA

Date: 03.10.2020

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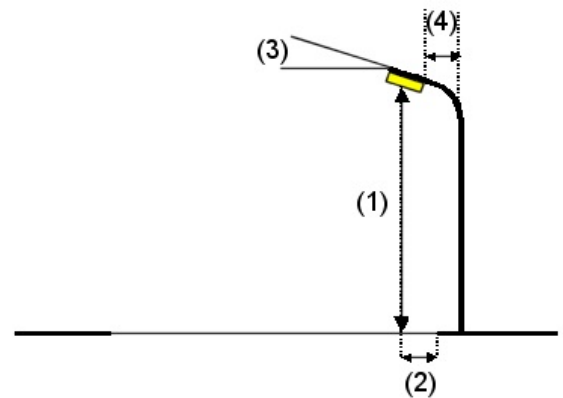
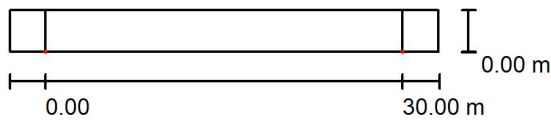
Secondary/Minor Roas-S6-1 Lane / Planning data

Street Profile

Roadway 1 (Width: 3.500 m, Number of lanes: 1, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

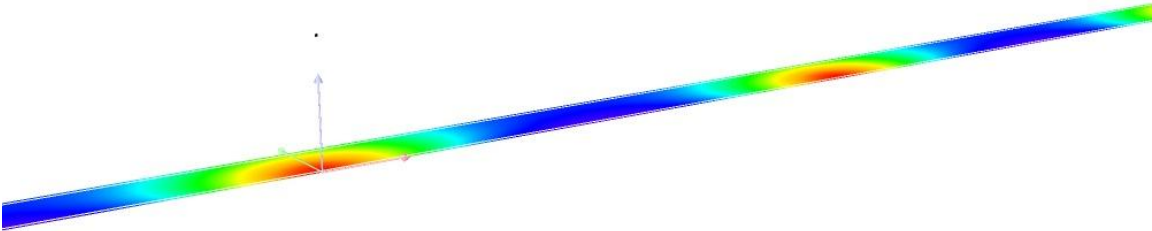
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	850 lm	Maximum luminous intensities
Luminous flux (Lamps):	850 lm	at 70°: 896 cd/klm
Luminaire Wattage:	9.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	6.100 m	No luminous intensities above 90°.
Height:	6.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	0.000 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	0.000 m	



Secondary/Minor Roads-S6-1 Lane / False Color Rendering

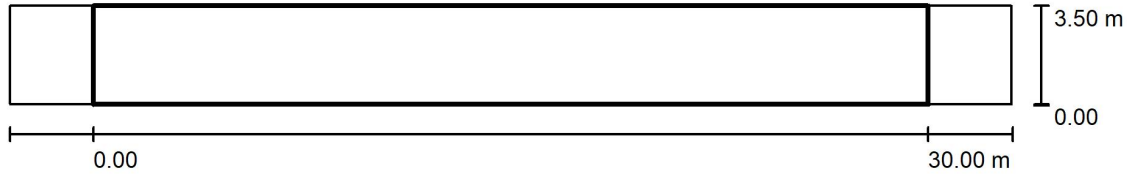


0 0.63 1.25 1.88 2.50 3.13 3.75 4.38 5

lx

Operator
Telephone
Fax
e-Mail

Secondary/Minor Roads-S6-1 Lane / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 3 Points

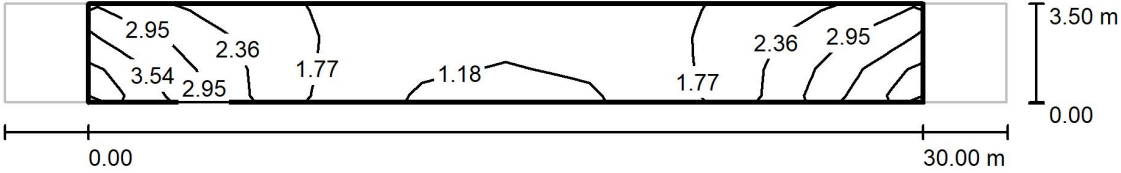
Accompanying Street Elements: Roadway 1.

Selected Lighting Class: S6

(All lighting performance requirements are met.)

Calculated values:	E_{av} [lx]	E_{min} [lx]
Required values according to class:	2.10	1.06
Fulfilled/Not fulfilled:	≥ 2.00	≥ 0.60
	✓	✓

Secondary/Minor Roads-S6-1 Lane / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
2.10	1.06	3.99	0.506	0.266

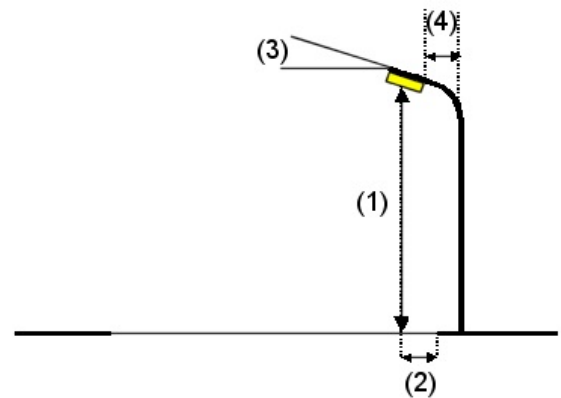
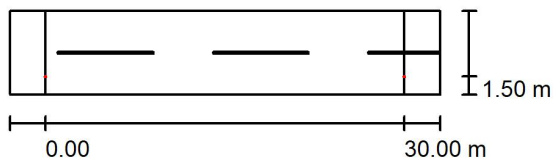
Secondary/Minor Roads-S6-2 Lanes / Planning data

Street Profile

Roadway 1 (Width: 7.000 m, Number of lanes: 2, tarmac: R3, q0: 0.070)

Light loss factor: 0.70

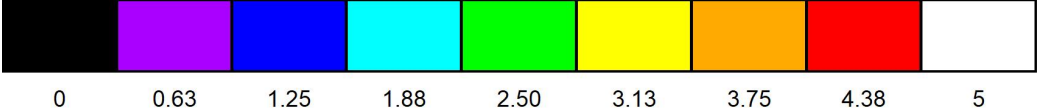
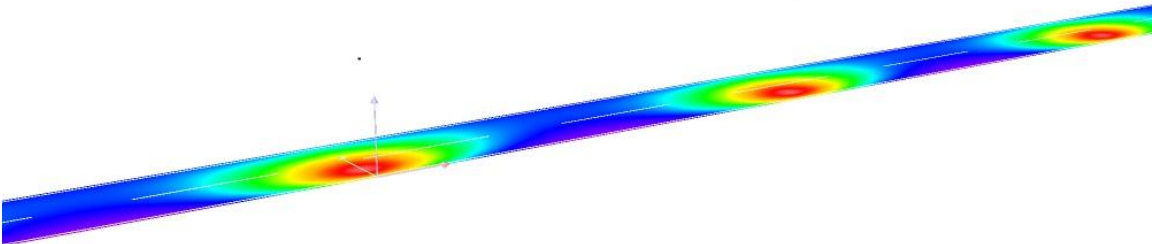
Luminaire Arrangements



Luminaire:	Gardco by Signify ECF-S-48L-1.2A-CW-G2-2 EcoForm Area LED ECF - Small, 48 LED's, 5000K CCT, TYPE 2 OPTIC, No Shield	
Luminous flux (Luminaire):	900 lm	Maximum luminous intensities
Luminous flux (Lamps):	900 lm	at 70°: 896 cd/klm
Luminaire Wattage:	9.0 W	at 80°: 70 cd/klm
Arrangement:	Single row, bottom	at 90°: 0.00 cd/klm
Pole Distance:	30.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.
Mounting Height (1):	6.100 m	No luminous intensities above 90°.
Height:	6.000 m	Arrangement complies with luminous intensity class G3.
Overhang (2):	1.500 m	Arrangement complies with glare index class D.6.
Boom Angle (3):	0.0 °	
Boom Length (4):	1.500 m	

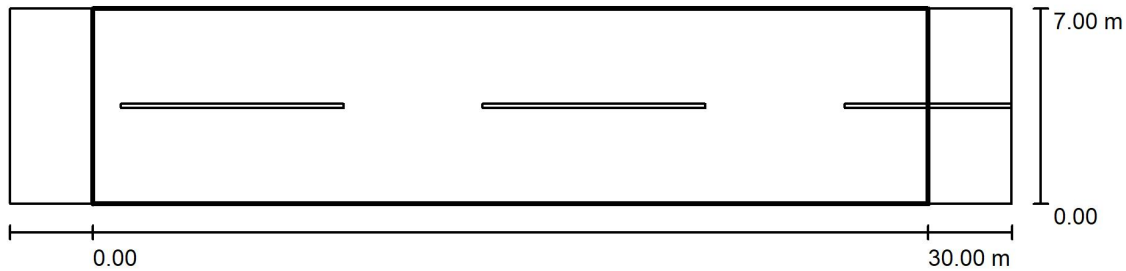


Secondary/Minor Roads-S6-2 Lanes / False Color Rendering



lx

Secondary/Minor Roads-S6-2 Lanes / Valuation Field Roadway 1 / Results overview



Light loss factor: 0.70

Scale 1:258

Grid: 10 x 5 Points

Accompanying Street Elements: Roadway 1.

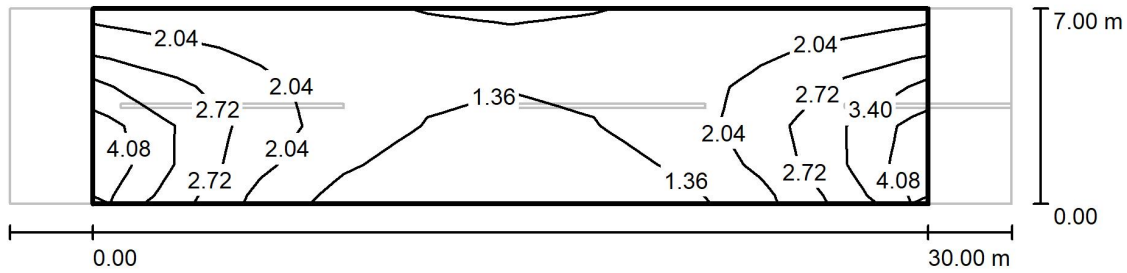
Selected Lighting Class: S6

(All lighting performance requirements are met.)

Calculated values:
 Required values according to class:
 Fulfilled/Not fulfilled:

E_{av} [lx]	E_{min} [lx]
2.02	0.83
≥ 2.00	≥ 0.60
✓	✓

Secondary/Minor Roads-S6-2 Lanes / Valuation Field Roadway 1 / Isolines (E)



Values in Lux, Scale 1 : 258

Grid: 10 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
2.02	0.83	4.22	0.413	0.197