Priority Index Development for Implementing (LED) Street Lighting System in UAE Federal Roadways

تطوير مؤشر الأولوية لتنفيذ نظام إنارة الشوارع (LED) للطرق الاتحادية في دولة الإمارات العربية المتحدة

by

AISHAH HASSAN OBAID AL SHEHHI

A dissertation submitted in fulfilment

of the requirements for the degree of

MSc SUSTAINABLE DESIGN OF THE BUILT ENVIRONMENT

at

The British University in Dubai

Dr. Riad Saraiji
March 2018

DECLARATION

I warrant that the content of this research is the direct result of my own work and that any use made in it of published or unpublished copyright material falls within the limits permitted by international copyright conventions.

I understand that a copy of my research will be deposited in the University Library for permanent retention.

I hereby agree that the material mentioned above for which I am author and copyright holder may be copied and distributed by The British University in Dubai for the purposes of research, private study or education and that The British University in Dubai may recover from purchasers the costs incurred in such copying and distribution, where appropriate.

I understand that The British University in Dubai may make a digital copy available in the institutional repository.

I understand that I may apply to the University to retain the right to withhold or to restrict access to my thesis for a period which shall not normally exceed four calendar years from the congregation at which the degree is conferred, the length of the period to be specified in the application, together with the precise reasons for making that application.

____

Signature of the student

COPYRIGHT AND INFORMATION TO USERS

Abstract

Since the World Economic Forum sets in 2004 the first Global Competitiveness Index that list countries according to several indicators, one of which is the infrastructure index, that consists of nine secondary axes, one of which is road quality index, and that the UAE is seeking to raise the standards of global competitiveness and ensure the highest levels of road safety.

This research aligns with the objectives of the UAE in reducing the incidence of irrigated incidents on the network of federal roads associated with the level of lighting at night, Therefore This research examines lighting quality and its impact on car accidents at night by exploring the effects of lighting properties such as boom angle, pole height, number of luminaries, and pole arrangements on the number of night-time accidents. The case study subjects for research and analysis were selected based on a group of factors and examined using quantitative methods to enable the researcher to rank roadway improvements from most to least important.

These improvements include changing the lighting systems on roadways from High-Pressure Sodium (HPS) to Light-Emitting Diodes (LEDs), a conclusion reached by studying lighting measurements and comparing them to British standards applied in infrastructure construction while considering economic and energy consumption factors. The research concludes with the optimum scenario for each proposed parameter and an advanced optimum model created after collecting all optimum scenarios of all phases.

الملخص

حدد منتدى الاقتصاد العالمي لأول مرة عام 2004 مؤشر التنافسية العالمي الذي يستخدم لترتيب الدول عالمياً وفق مؤشرات متعددة أحدها مؤشر البنية التحتية و الذي يتكون من تسعة محاور ثانوية أحدها مؤشر جودة الطرق, و حيث أن دولة الامارات العربية المتحدة تسعى للإرتقاء بمعايير التنافسية العالمية و ضمان أعلى مستويات الأمان على الطرق.

يأتي هذا البحث متماشياً مع أهداف الامارات في التقليل من نسبة الحوادث المروية على شبكة الطرق الاتحادية المرتبطة بمستوى الإنارة ليلاً, و ذلك عن طريق اختبار تأثير عدة عوامل في مستوى كفاءة الإضاءة من مثل : ارتفاع عمود الانارة و زاوية ميل ذراع المصباح و عدد المصابيح و توزيع أعمدة الإنارة على شبكة الطرق الاتحادية .

و قد تم اختيار نطاق الدراسة على شبكة الطرق الاتحادية من خلال استخدام طريقة التصنيف الكمي لمسافة كيلومتر واحد من إجمالي ما يقارب 750 كيلومتر بحسب المعايير التخطيطية كإحصائيات عدد الحوادث المرورية ليلاً , و كثافة الحركة المرورية, وحدود السرعات القصوى و غيرها.

تهدف هذه الدراسة الى تطوير نظام الإنارة ليلا ًعلى الطرق الاتحادية التي بدورها تعتبر مسارات التقاء بين امارات الدولة و مناطقها بشكل مستدام بحيث يتم استبدال الإنارة التي تعتمد على الصوديوم عالي الضغط بنوع آخر يعتمد على الثنائيات الباعثة للضوء بعد مقارنة مستويات الأداء لكلا النوعين حسب النظام البريطاني المعتمد في الدولة للبنية التحتية مع مراعاة الجانب الاقتصادي و الحرص على خفض استهلاك الطاقة.

اختتمت الدراسة بتسليط الضوء على الاختيارالامثل لكل عامل من العوامل المؤثرة في كفاءة نظام الانارة على الطرق الخارجية و ربطها في نموذج واحد لتحقيق اقصى استفادة ممكنة.

Acknowledgments

Great thanks to Allah for inspiring and motivating me, and for giving me the ability and strength to conduct this research.

I would also like to thank my family for their support and their faith in me, which allowed me to pursue graduate study and improve my future.

Hellen Keller once said, ‘Alone we can do so little, together we can do so much’. This thesis is the confluence of the efforts of the various experts who have provided me with the opportunity to learn, identify, and understand the value of research.

I thank and appreciate Minister of Infrastructure Development (MoID) Dr.Abdulla Belhaif Alnuaimi for his encouragement and support in completing my educational career. Without his scholarship, continuing my studies would have been little more than a dream. Similarly, I thank my distinguished colleagues, human resource consultants Mr Abdurhman Khamis and Dr Abdullah Fekry, whose support gave me the strength I needed to undertake the writing of this thesis. In addition, I thank Yousuf Abdullah, director of the project planning department, who has been my role model in leadership, success, having faith in my abilities, and who always believed in me as I continue my learning journey to reach my PhD.

I also thank Eng.Ahmed Redha, the electronics engineer who clarified for me the lighting system on federal roadways using the DIALux program.

Furthermore, I am sincerely grateful to my supervisor, Dr Riad Saraiji, for his continual guidance, and for transferring his skills and knowledge by explaining lighting perspectives to ensure that I would make excellent progress on this research.

Finally, to my dearest friend and soul mate throughout my master’s degree journey, Zainab Ghassan, who was an excellent sounding board while writing this thesis.

Table of Contents

Appendixes

List of Figures

List of Tables

List of Charts

List of Diagrams

List of Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ASNT	American Society for Nondestructive Testing
ANSI	American National Standards Institute
ADT	Average Daily Traffic
AHT	Average Hourly Traffic
BS	British Standards
CO_2	Carbon Dioxide
CLTC	California Lighting Technology Center
CCT	Correlated Color Temperature
CRI	Color Rendering Index
C	Contrast
CIE	International Commission on Illumination
DES	Design and Engineering Services
EEM	Economic Evaluation Manual
FHWA	Federal Highway Administration
FCO	Foreign Commonwealth Office
FRPI	Federal Roadways Priority Index
Fi	Factor Weight
GaAs	Gallium Arsenide
GaSb	Gallium Antimonide
GDP	Gross Domestic Product
GIS	Geographical Information System
GSM	Global System for Mobile communications
GPS	Global Positioning System
HPS	High Pressure Sodium
HID	High intensity discharge
InP	Indium Phosphide
IESNA	Illuminating Engineering Society of North America
LED	Light-Emitting Diode
L_o	Luminance of a matter
L_b	Luminance of background
L_{seq}	Luminance of disability glare
LPS	Low Pressure Sodium
L_{avg}	Average luminance
MoID	Ministry of Infrastructure Development
MoI	Ministry of Interior
MV	Mercury Vapour
NBA	Narrow-Band Amber
NZTA	New Zealand Transport Authority
PG	Parameter Group
PS	Parameter Senario
RVP	Relative Visual Performance
SiGe	Silicon Germanium
SLIM	Street Lighting Inventory Management
TAC	Transportation Association of Canada
TSCZ	Traffic Safety Council of Zimbabwe
Qfi	Quantity factor
UAE	United Arab Emirates
USA	United State of America
U	Adequate Uniformity
U_o	Overall Uniformity
U_l	Longitudinal Uniformity
UNECA	United Nation Economic Commission for Africa
WHO	World Health Organization
ZRP	Zimbabwe Republic Police

Chapter 1: Introduction of the Research

1.1. Introduction

Ministry of Cabinet Affairs and the Future coFordinates as the basic division in United Arab Emirates (UAE) government establish UAE vision 2021, National Agenda, policies and strategies of federal ministries to set their initiatives and targets to achieve the highest results in competitive indicators and sustainable development goals through the alignment with strategic and operational plans. New effective techniques and tools were used in order to obtain the quality, sustainability and satisfaction for all governmental services such as neighbourhood, federal roadways and federal building.

The quality of the roadways is one of the most important achievements of the UAE. It achieved the fifth rank out of 137 world counties according to the global competitive index report of 2017-2018 with score of 6.3 out of 7 marks, as shown in Figure 1.1. (Global Competitiveness Index 2017-2018, 2018).

Rank / 137	Country / Economy	Score 1-7 (best)	Trend	Dist. from best
1	Hong Kong SAR	6.7		
2	Singapore	6.5		
3	Netherlands	6.4		
4	Japan	6.3		
5	United Arab Emirates	6.3		
6	Switzerland	6.3		
7	France	6.1		
8	Korea, Rep.	6.1		
9	United States	6.0		
10	Germany	6.0		

Figure 1.1: Quality of infrastructure indicator results (2017-2018)
(Source: Global Competitiveness Index 2017-2018, 2018).

Aspects of infrastructure quality include the planning, design, and implementation of roadways and roadway fixtures and features, including road lighting. Replacing the existing high-pressure sodium (HPS) lighting system with a modern light-emitting diode (LED) system has been undertaken to enhance the sustainability of the infrastructure industry in general and the construction field in specific. The LED system is considered an efficient alternative, as it reduces the Carbon Dioxide (CO_2) emissions associated with the traditional lighting system and promotes substantial financial savings, thus aligning with the with federal environmental goals and the Ministry of Infrastructure Development's (MoID) strategic plan for 2017–2021.

Lighting systems, particularly LEDs, used in the construction field have undergone several developments and improvements since the 1900s, according to Patent iNSIGHT Pro (2010). In 1907, H. J. Round, a British engineer and inventor, first observed electroluminescence using silicon carbide crystals and cat's whisker sensors.

In 1927, Oleg Vladimirovich further studied this phenomenon, publishing his findings in a Russian scientific journal and coining the phrase 'light-emitting diode'; however, his discovery garnered little interest. Subsequently, in 1955, Rubin Braunstein reported on semiconductors and Gallium Arsenide (GaAs), which produced a simple structure of diodes at 77 K and at room temperature by mixing Indium Phosphide (InP), Gallium Antimonide (GaSb), and Silicon Germanium (SiGe).(Patent Insight Pro, 2010).

On the other hand, in 1962, Nick Holonyak developed red, or visible-spectrum, LEDs while working for an electronics company. LED prototypes and products were extremely expensive, costing almost US$200 per unit. Consequently, Monsanto Company in 1962 began producing LEDs using gallium arsenide phosphide with appropriate displays to control expenses. A decade later, in 1972, M. George Craford, an electrical engineer working for Monsato, further enhanced the illumination of red and red-orange in LED devices by a luminance factor of 10. The first high-efficiency, bright LED was created by Thomas Pearsall in 1976, and this new technique was used in optical fibre communications (Patentinsightpro.com, 2010).

The physical processes early twenty-first century LEDs employ to produce light differ significantly from the processes employed by traditional lighting sources. Instead of relying on features such as ‘electrical filaments, electrodes or gaseous discharge processes’, LEDs produce light through ‘solid-state electroluminescence’, which refers to the production of light when a strong electric current or field passes through a particular material (California Lighting Technology Center (CLTC), 2015, p. 6), To obtain white light, coloured light from multiple single-colour LEDs are combined, or LEDs are coated in phosphor, which allows them to produce white light by absorbing one colour and emitting a combination of other colours that appear white when mixed (CLTC, 2015).

Furthermore,LEDs are a multi-directional light-spotting device that has the ability to spread light through the LED chip that is being diffused through a secondary element such as the lenses. Its efficacy has been improved to 170 lighting measurements per watt (lm/w) to ensure the extended life span of the product with a range of (25,000 – 100,000) hours. Furthermore, Correlated Color Temperature (CCT) a description of the color appearance of the light emitted. Relating to the color of light from at a specific temperature, measured in degrees Kelvin. This parameter is influence the efficacy with positive relationship with Color Rendering Index (CRI).(CLTC, 2015). (CRI) which is an index that scale from 0 – 100 % signifying the accuracy of given light source at rendering color with comparison to reference light source the better color rendering the higher values of CRI. The higher CCT leads to higher efficacy. The lower the efficacy of LEDs of (20) lm/w at (1900) degrees Kelvin (CCT) is accompanied with low color rendering index (CRI). (Cltc.ucdavis.edu, 2015).

Hence, in order to accomplish the suitable light output in the LED device with respect to the aforementioned parameters; CRI, CCT and efficacy, the LED device shall be examined in site conditions and device production specifications shall be established. Since the 1990s the LEDs have been used to light up the roadways in Europe especially through traffic lights, which resulted in high power efficiency.

Federal and local authorities in several municipalities in the world such as China, Europe, North America and UAE has tested, implemented and maintained the LED lightings in their roadways and highways. The technology offer lifetime of 10-15 years, and sustains energy savings to approximately (50%). However, today's LEDs are capable of obtaining the regulations and policies of luminance levels. LEDs can enhance visibility performance, reduce the glare and offers a solution to the wasted energy. Besides, it has improved the functionality of lightings in general where it has generated sustainable lighting levels to the public.(Lumileds.com, 2016).

Nowadays, lighting in roadways applications is integrated with metal halide lamps and High-Pressure Sodium lamps (HPS), which are considered as High Intensity Discharge (HID). Also, there are some downsides in performance level such as low colour rendering abilities and low rate of maintenance. That being said, it is important to mention that LEDs, being the fourth light generation, is considered as a valuable solution to roadway lighting since 1960s. The economical markets share the viability to modernize the demand for replacing conventional light fixtures to LEDs to be gradually replaced between 25-30% in several types of lighting devices and applications. The new lighting LED generation is an optimized option for roadways due to its variety of advantages such as dimming abilities, guiding light distribution and saving energy as well as environment resources. (Avrenli, Benekohal and Medina, 2012).

Since this study is covering roadways in UAE, it was found that the Ministry of Infrastructure Development (MOID) have started to implement LEDs in roadways since 2011. Examples of LEDs projects in roadways include: Al Hamidiyah Interchange in Ajman emirate in 2012, Al Taween roadway in Ras Al Khaimah in 2013, Dibba – Massafi roadways in Fujairah in 2014, Yabssa roadway in Fujairah in 2015 and Umm Al Quween interchange in 2016-2017. MoID decided to install LEDs within the exiting roadways which can be implemented through several phases where the first phase include replacing conventional light fixtures of 550km with more than 20,000 luminaries. The project was divided into phases of feasibility study, technical performance indicators and field measurements.

1.2. Traffic Accidents Worldwide and in the United Arab Emirates

According to the World Health Organization report (WHO) in the road safety report of 2015, more than 1.2 million deaths each year among the youth drivers average of 29 years. This traffic accidents cost the governments around 3% of Gross Domestic Product (GDP) spent over roadway maintenance and emergency services.

Most of world traffic accidents were in both low and middles incomes countries with 90% of traffic deaths. These countries presented 82% world population. On the other hand, 65% of traffic accidents was in the high income countries such as the Americas Region, as shown in Figure 1.2.

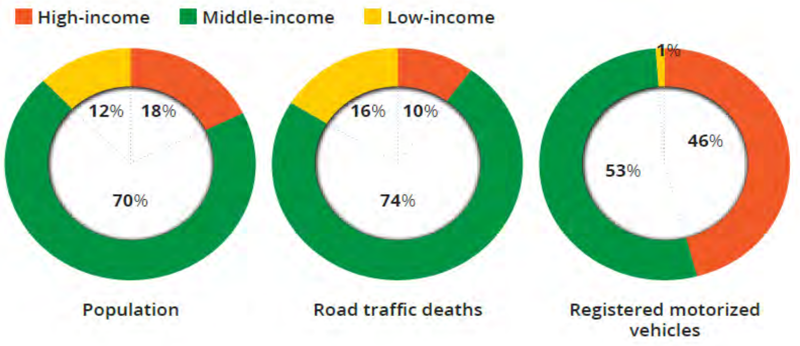


Figure 1.2: Relationship between population, vehicles and road traffic deaths (Source: World Health Organization, 2015).

The WHO studies relationship between population, road deaths and recorded vehicles in the three economic categories of the countries. However ,the middle income countries with 70% of total world population has registered 53% of vehicles that caused 74% of traffic deaths total average , as shown in Figure 1.2.

On the other hand, the high income countries recording 18% of world total population owned 46% recorded vehicles that caused 10% of traffic deaths. While, the remaining 12% of world population in low income countries owned 1% of vehicles that caused 16% of traffic accidents. (World Health Organization, 2015).

The organization addressed top ten death leading causes in 2004 and it future projection by 2030, as shown in Table 1.1. The most death cause in 2004 with 12.2 % was Ischemic heart disease. While the less death cause was with 2% in 2004.

On the other hand, the death causes future projection by 2030, addressed increase rate with 2% in Ischemic heart disease as 14.2 %. While HIV/AIDS scored the less rate of the death causes by 2030 with 1.8%. Road traffic illustrated different between 2004 and future projection by 2030 from ninth ranked by 2004 into fifth ranked by 2030. (World Health Organization, 2015).

Table 1.1: Death leading causes in 2004 and projection in 2030

(Source: World Health Organization, 2015).

Rank	Leading cause2004	%
1	Ischemic heart disease	12.2
2	Cerebrovascular disease	9.7
3	Lower respiratory infection	7
4	Chronic obstructive pulmonary disease	5.1
5	Diarrheal diseases	3.6
6	HIV/AIDS	3.5
7	Tuberculosis	2.5
8	Trachea, bronchus, lung cancers	2.3
9	**Road traffic injuries**	**2.2**
10	Prematurity and low birth weight	2

Rank	Leading cause 2030	%
1	Ischemic heart disease	14.2
2	Cerebrovascular disease	12.1
3	Chronic obstructive pulmonary disease	8.6
4	Lower respiratory infection	3.8
5	**Road traffic injuries**	**3.6**
6	Trachea, bronchus, lung cancers	3.4
7	Diabetes mellitus	3.3
8	Hypertensive heart disease	2.1
9	Stomach cancer	1.9
10	HIV/AIDS	1.8

The most ideal example road safety was in Sweden which got a model initiative of "Vision Zero" in the 1990s, which adapted legislation and policies that modified the factors and parameters that can support decrease or prevent the traffic deaths rate. The first steps of the initiative were establish sustainable road policy, aims and strategy to enhance the quality of roadways for all types of transportations. (World Health Organization, 2017).

According to Council of Ministers for Transportation and Highway Safety of Canada roadway network features are significant component in safety manner. The roadways tend to be the area of the divers in which their attitude behavior and its impact regarding to the designing of the roadways network associate with the regularity using roadways rates in daily travelling , effectiveness of crashes into drivers, vehicles and environments.(Comt.ca, 2017)

In addition, Transportation Association of Canada (TAC) clarified the risk causes of car crashes due to the visibility, 90% of information followed by the drivers is visual. As a results of that, the drivers don't have the abilities to know or distinguish all the traffic signs and information from the road surrounding environments in a way to prevent any fatal errors and impacts. Fatal crashes can be assigned in its locations where several options and choices require to be in safe times. Ongoing environment with different group of users could be crowded and hard to have the correct decision to prevent any crashes. The absence of suitable and comforTable lighting system in the road networks can influence on the driver response in unexpected situation. (Cripps, 2016)

Most of the traffic roadways in Lebanon in roadways with 48% while, 25% of pedestrians accidents, 17% of the front seat and 10% of the back seat passengers. The reasons of that were lack of pedestrian walks and crossing, as shown in Figure 1.3 (Choueiri, et al., 2010).

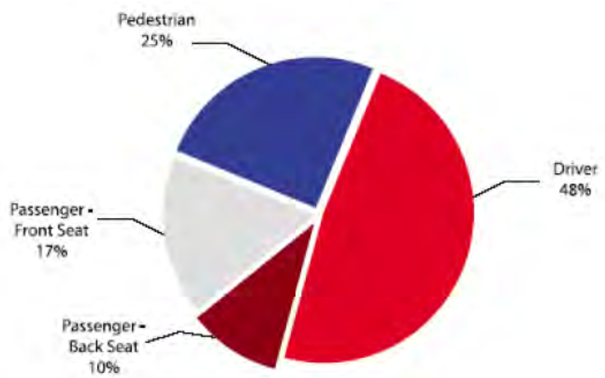


Figure 1.3: Traffic accidents victims in Lebanon
(Source : Choueiri, et al., 2010)

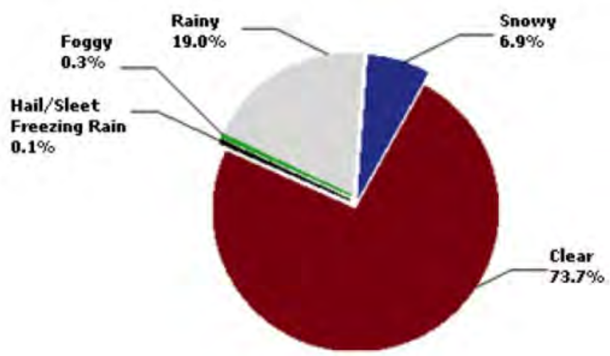


Figure 1.4: Lebanese's traffic accidents according to the weather
(Source : Choueiri, et al., 2010)

Most of traffic accident located on single lane with 50% in Lebanon. On the other hand, as shown in Figure 1.4, 21 % of traffic accidents happened on double lanes. The weather condition play a role in Lebanese's traffic accidents with maximum percentage was 73.7% in clean dry weathers followed by 19% in wet weather. In addition the minimum percentage was in hail and sleet freezing rain. (Choueiri, et al., 2010).

The question of whether the illuminance rates on the roadway network can effect on the risk of traffic crashes at night time. This was good scope investigate in most of the studies and researches such as Box 1970, who established a study of 203 miles of lighting and non-lighting segments of roadways in different areas of United State of America (USA) with assumption of 25% of daily traffic volume at night from total traffic volume on an urban roadways at night. The results of this study was 40% of reduction on crashes at night time due to the examined light levels during the study. (Box, 1970)

On the other hand , another researcher Wilde ,1994 who deliberate the effect of light levels enhancements within two years as ‘before ‘ and one year late as ‘ after’ for 5.3 miles length of free way with six lanes. The outputs signposted that lighting levels at night time improvements were useful to roadway safety with ratio of crashes between night and day times as three to one. (Graham, 1998). The recent study of lighting levels on roadway was in New Zeeland through the selecting different roadways that got the same lighting levels along its length which defined results of non-significant values of uniformity ratios. The outputs showed the relationship between reduction of traffic crashes and lighting levels which has been captured through especial cameras. (Jackett and Frith, 2013)

Roadways safety control by variety of parameters that cause car accidents such as driver attitude, transportations and environment. These parameters need to be contribute to enhance and reduce the risk of death as well as injury in roadways. The ideal method in dealing with parameters is a framework analysis the causes and results. The diver attitude through following traffic laws and instructions in parallel with safe and good quality roadway design can predict the harm from car accidents. The three parameters of diver attitude, transportation technical aspects and environment of implementing the roadways need to be study, analysis and evaluate in a way to prevent the accidents, as shown in Figure 1.5. (Kemeh, 2010).

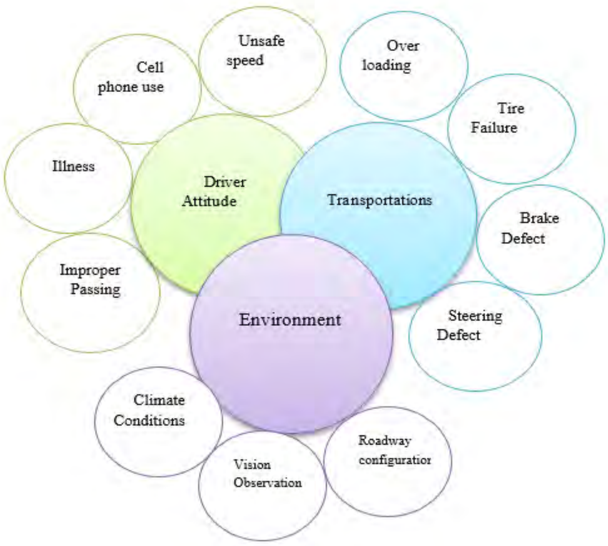


Figure 1.5: Causes of traffic accidents

(Source: Kemah, 2010)

Since the study focus on the roadways in UAE, the first steps were through the roadways stakeholders and entities that contribute reduction in the rate of deaths. Besides that, address an awareness of sustainable and safe use of roadways. Most of the traffic claims in 2016, were in Ramadan due to regional cultural behavior. Total number was 1,845 traffic accidents. These accidents are presented by day and time of the accidents in Table 1.2 below.

Table 1.2: Accidents on weekdays during Ramadan,2016

(Source: Road way safetyuae.com, 2017).

Day	% average claims/day
Monday	3.3%
Tuesday	3.2%
Wednesday	3.9%
Thursday	3.7%
Friday	3.4%
Saturday	3.8%
Sunday	2.7%

The most hazardous days were on Wednesdays with 3.9%. This due to the working travelling behavior where northern emirates military employees return to their residents from their location in Dubai and Abu Dhabi .While the less hazardous days were on Sundays with

2.7%.The analysis witness crush timing was from 9-10 AM with 16.1% , as shown in Table 1.2. (Roadway safety uae.com, 2017).

On the other hand, accidents timing during Ramadan in 2016 were recorded between 8am to midnight. It was found that the most accidents timing were during daytime between 10am -12 pm with 29.5% while drivers are fasten and smokers are not allowed to smoke which raise timber level. While the night time of 17.5% after Iftar as many families stay at home, as shown in Table 1.3.

Table 1.3: Traffic accident timing during Ramadan, 2016

(Source: Roadway Safety UAE, 2017).

Traffic accident timing	Claims (%)
Midnight–8 AM	2.9%
8 AM–9 AM	6.7%
9 AM–10 AM	16.1%
10 AM–11 AM	14.6%
11 AM–12 PM	14.9%
12 PM–1 PM	11.4%
1 PM–2 PM	11.6%
2 PM–3 PM	8.5%
4 PM–midnight	6.1%
No time captured	7.2%

1.3.Lighting Performance

Indicators can play role in improve, upgrade and maintain the level of performance. It also can be as guide line to future vision in long term of life span. For example, weak lighting level at night with relation to traffic accidents indicate the numbers of changing the lights and establish new procedures of safety. The illuminance levels from weak to strong can be adjusted by human eyes which have the ability to recognize the color in details. The photoreceptors are sensitive elements that are divided into two categories high and low light levels. (Hamrle, 2014).

On the other hand, brightness is a compound system that rely on a variety group of features and evaluating these feature have a clear value on performance of luminous flux, luminous intensity, glare, contrast and etc.These features can be describe and give clear understanding of brightness system.

The first feature is luminous flux which defines the amount of luminous from the source. It can be measured by lighting measurements lumen unit (lm). The other feature is luminous intensity which is related to the energy that is released by illuminance source at a specific wavelength in specific direction which is measured by candela unit (cd). Besides that, total of luminous flux into a superficial term called Illuminance which is measured by lighting measurements per square meter (lm/m^2) or lux (lx). On the other hand, luminance relates to the light that goes on a space and reflect within a certain angle. It designates the amount of luminous energy that the eye can indicate through looking into a certain point in an area. This can be measured by candela per square meter (cd/m^2). The lighting system can be summarize as shown in Figure 1.6. (Hamrle, 2014)

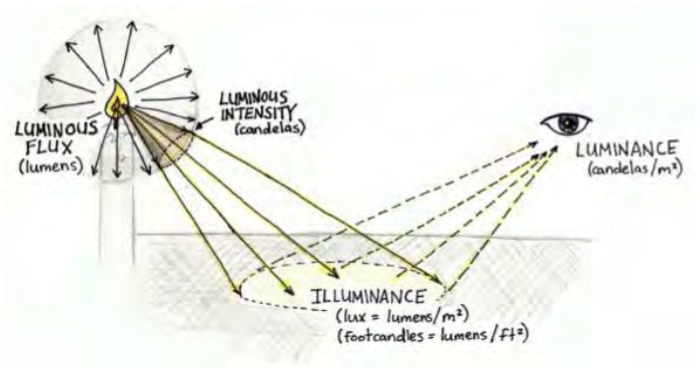


Figure 1.6: Lighting system features
(Source: Hamble, 2014)

In addition, glare is the visual observation of bright luminance. It can be identify through three groups which are: discomfort glare which lead to bad visualization.

The second is incapacity glare which is generated when the glare source emits a light that covers the whole vision space which minimize the visibility of the objects. The third group is reflected glare which occurs when the intensity of light maximize the appearance rate that is noticed by the human eye. This feature should not exceed more than 15%, the minimum the glare is the better the lighting measurements output. Another lighting characteristic is contrast (C) which describe the relationbetween the luminance of a matter (L_o) , its background (L_b) and disability glare (L_{seq}),the higher the differences between lighting levels the higher the results of contrast. (Hamrle, 2014). On the other hand, color rendering defines the impacts of light source on a matter. It highlights on the criteria's of generating colors of matters with the original light source. The color rendering index (CRI) present the maximum of color rendering of 100 which can be minimized in relation to its quality. For example, comforTable colors can be identified through the light sources that recognized more than 20.The colors addressed through group of colors that start with red color, orange, yellow that hierarchy until the blue, white and black.

Moreover, Adequate Uniformity (U) which defines the ratio of minimum light to average light on a section of roadway under specific circumstances which affect by the frequency of visualization in roadways. As long as the uniformity value great as much the lighting measurements is good. It has the ability of sequence observing situations without unexpected disruptions by lighting level. Minimum uniformity ratios can be adjusted according to contrast in particular roadway sections that may effect on the comforTable visual which can assist extra stress that got negative attitude on driver's safety in the roadway network. (Hamrle, 2014).

Another feather is correlated color temperature (CCT) which identifies the appearance of colors as the feel of light as being 'warm' or 'cool'. It also can be defined as a temperature of a body which is heat, this temperature of lighting is measured by Kelvin. The colors are between red, orange and white or yellow white and blue white according to the light reference. Several lamps can give the same appearance in the same colors, but their impact on objects can be identified.

In addition, color translation and appearance of all light sources which contributes to the quality of light distribution which is measured by correlated color temperature (CCT) in Kalvin degrees is recognized in five different categories as shown in Figure 1.7. It evaluate the light status between yellow until blue colors. It evaluate the black objects according to their heat levels to be between the colors ranges of orange, red, yellow. (Hamrle, 2014).

Figure 1.7: Correlated color temperature (CCT)
(Source: Hamble, 2014)

That feature relate with color rendering index (CRI) explains the clear color of the matters which are rendered by light. The scale of (CRI) between 0 up to 100.The great the value of (CRI) the better clearness of matters renders by light. According to U.S. Department of Energy LEDs lights in roadways with (CCT) more than 5000 ^{o}K, (CRI) between 85-90, with white light. This appearance is helpful for driving at nights. (Hamrle, 2014).

1.4. International Codes for Roadway Lighting

Standards, specifications and codes are suggested to be used on all branches of manufacturing and operation examination especially in the construction field. Using clear guidelines and benchmarks can aid in determining whether materials and techniques are effective, and it can help users set minimum and maximum requirements to safeguard the progress of their work. Generally, codes contain procedural systems that identify the minimum suitable safety levels for industrial or manufactured products and substances.Codes can be integrated with requirements related to details that are not mentioned in the codes. Standards are technical requirements and specifications for processes or approaches, and they can be used to monitor performance indicators. To ensure the quality of light levels on roadways, several codes and standards exist, including International Commission on Illumination CIE 115 and CIE 140 and British standards discussed in detail in section 1.5.2.(American Society for Nondestructive Testing (ASNT), 2017).

As shown in Table 1.4, most developed countries and regions have adopted guiding principles, based studies and best practice, including the United States of America and Canada (North America), Europe, Australia and New Zealand, and Japan.

Table 1.4: Lighting systems through the World regions
(Source: Asnt.org, 2017).

Element	North America	Europe	Japan	Australia/Nz
Illuminance	Per functional classification and presence of non-motorized vehicles, uses pavement reflectance.	Per traffic flow, operating speeds, type of users and environmental characteristics. Includes a surrounding value just outside edges of road.	For road with pedestrians and intersections (average maintained), for segments consider Illuminance-based uniformity	For intersections. Functional classification based on operational characteristics (Jackett, Consulting and Firth 2012)
Luminance	Per functional classification and presence of non-motorized vehicles	Per traffic flow, operating speeds, type of users and environmental characteristics	For type of vehicles, depending on characteristics leading to functional classification	Specific consideration for straight segments and curves less than 100m and intersections
Longitudinal Uniformity	Per functional classification and presence of non-motorized users. Two ratios for luminance, max to min and average to min.	Wet and dry circumstances for the classes defined for luminance/Illuminance. One ratio: average to min.	Dry only, per functional classification	Yes per subcategory
Transversal Uniformity	Not considered	Considered per road category (AADT)	Per road functional classification	Yes per subcategory
Glare	Veiling Luminance ratio	Threshold Increment: light from luminaire shining on drivers eyes	Glare control mark	Threshold Increment
Other – specific elements	Pavement type, four design approaches	Face recognition(presence of pedestrians), color rendering	Modification of values when environment around road is dark (land use)	Does include underpass, tunnels and tree lining roads. Luminaire Asset Management maintenance. Control upward waste lighting (sky glow).

The above Table present the lighting element according to the country such as illuminance in North America which per functional classification and presence of non-motorize vehicles, longitudinal uniformity (Ul) value is pre functional classification and conduct minimum and maximum luminance ratios .While the glare play role on veiling luminance ratio and effect on the vision of the drivers at night times. This is obtain with respect into specifications of roadways. (Asnt.org, 2017). All countries mentioned got similar guidelines concern the pavement categories according to its functional and technical configurations. Both Australia and New Zealand got specific functional guidelines regarding to the straight, curves with less radians of 100 m and interconnections in the road networks. This influence on the four design pillars: luminance, computer simulation, curve Charts and design adjustment rule that suitable to control the lighting. While In Europe, a complex method is used to evaluate road performance with respect to daily traffic volume, road speed limit, road users (including drivers, cyclists, and passengers), road features (including interchanges, roundabouts, lane distribution, and problem areas), and environmental conditions such as climate and topography. These countries got a traditional pattern with minimum uniformity deviations and maximum average illuminance for any kind of roadways. For example, according to American National Standards Institute (ANSI) the recommended maximum average illuminance is 34 lux at interjections, while the European regulations can go further until 50 lux. Either glare or unreceptive uniformity may cause the higher values. Furthermore, weather conditions, either wet or dry, can affect the level of illuminance and the structure of lighting; thus, Canada accounts for changing weather in its requirements to safeguard safety standards. The American Association of State Highway and Transportation Officials (AASHTO) and the Illuminating Engineering Society of North America (IESNA; AASHTO and IESNA, 2005) developed a 5-point evaluation grid to perfect lighting, as shown in Table 1.5. This system elaborates the structure of the execution, operating, and safety requirements (Al-Dulaimi, 2015).

Table 1.5: Evaluation grid (Source: Al-Dulaimi, 2015)

Evaluation Grid (G1)									
Evaluated Element									
Length of Segment					Level (1, 2 or 3)				
Description of Analysed Criteria		Real Value	Classification Points (PT)					Score (PD)	Scored Value = PD*PT
			1	2	3	4	5		
Geometry									
1	Total number of lanes		≤4	5	6	7	≥8	0.15	
2	Lanes width		>3.6	3.4 to 3.6	3.2 to 3.4	3.0 to 3.2	<3.0	0.30	
3	Median Width		>12	7.5 to 12	3.5 to 7.5	1.2 to 3.5	<1.2	0.30	
4	shoulder width		>3.0	2.5 to 3.0	1.8 to 2.5	1.2 to 1.8	<1.2	0.30	
5	Slope (from 0 to 7)		>6:1	6:1	4:1	3:1	<3:1	0.30	
6	Horizontal curve radius		>3500	1750 to 3500	875 to 1750	575 to 875	<575	4.90	
7	Vertical gradient		<3.0	3.0 to 4.0	4.0 to 5.0	5.0 to 7.0	>7.0	0.25	
8	Frequent interchange distance		>6.5	5.0 to 6.5	3.5 to 5.0	1.5 to 3.5	<1.5	1.85	
Subtotal									0
Operational									
9	Level of Service (Night-time)		A	B	C	D	≥E	3.05	
Subtotal									0
Environment									
10	% of Developments		0	0 to 24	25 to 50	50 to 75	>75	1.85	
11	Distance to developments (e.g. residential, commercial, or industrial buildings)		>60	45 to 60	30 to 45	15 to 30	<15	1.85	
Subtotal									0
Security (Accidents)									
12	Night-to-day accident ratio		<1.0	1.0 to 1.2	1.2 to 1.5	1.5 to 2.0	>2.0 (see Note 1)	4.90	
Subtotal									0
Notes: 1.Provision of lighting 2. Current speed: 80kph (95% of night-time operational speed if available, otherwise use the posted speed) 3. Development is defined based on the presence of commercial, industrial, or residential buildings. 4. Use the most deficient geometrical characteristics for road segments.						Grand Total			
						Required Scoring to provide lighting			60

The lighting system recommended features and criteria's for the best and perfect lighting levels with respect to pavement types and roadways type, as shown in Tables 1.6. This evaluate the illuminance regarding to the roadways network structures with the benefit of the maximum rate of uniformity.

Table 1.6: Recommended lighting levels according to the type of the roadways

(Source: Al-Dulaimi, 2015)

Road and Pedestrian Conflict Area		Average Luminance (L_{avg}) (cd/m^2)	Uniformity Ratio L_{avg}/L_{min} (Maximum Allowed)	Uniformity Ratio L_{Max}/L_{min} (Maximum Allowed)	Veiling Luminance Ratio L_{Vmax}/L_{avg} (Maximum Allowed)
Road	Pedestrian Conflict Area				
Freeway Class A		0.6	3.5	6.0	0.3
Freeway Class B		0.4	3.5	6.0	0.3
Expressway	High	1.0	3.0	5.0	0.3
	Medium	0.8	3.0	5.0	0.3
	Low	0.6	3.5	6.0	0.3
Major	High	1.2	3.0	5.0	0.3
	Medium	0.9	3.0	5.0	0.3
	Low	0.6	3.5	6.0	0.3
Collector	High	0.8	3.0	5.0	0.4
	Medium	0.6	3.5	6.0	0.4
	Low	0.4	4.0	8.0	0.4
Local	High	0.6	6.0	10.0	0.4
	Medium	0.5	6.0	10.0	0.4
	Low	0.3	6.0	10.0	0.4

The above Table indicate the classification of roadways such as expressway with high pedestrian conflict area that produce 1 cd/m^2 as average luminance with maximum allowed uniformity ratio of 3 that present the average luminance and minimum luminance while the other parameter ratio of maximum luminance and minimum luminance of 5. So it's important to adjust the classification of the roadways to understand the lighting measurements outputs for better visibility.

On the other hand, the standards of IESNA establish the relation between classification of roadways, pavement classification and pedestrian conflict areas such as expressway with high pedestrian conflict and pavement classification to reach the uniformity ratio of 3. Most of UAE federal roadways considered as expressways with differnet distribution of pedestrains which depend on the urban pattern. Most of the pedestrains take placed on main cities such as Abu Dhabi and Dubai . On the other hand , less padestrain were located in the remote ares. As a results the lightning output should be achive the targets.(Bitar, 2017).

These results depend on the pedestrian distributions and pavement classification , as shown in Table 1.7.

Table 1.7: Lighting levels according to the type of the roadways various pavements types.

(Source: Al-Dulaimi, 2015)

Road and Pedestrian Conflict Area		Pavement Classification (Minimum Maintained Average Values)			Uniformity Ratio E_{avg}/E_{min}	Veiling Luminance Ratio L_{vmax}/L_{avg}
Road	Pedestrian Conflict Area	R1 lux/fc	R2 & R3 lux/fc	R4 lux/fc		
Freeway Class A		6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Freeway Class B		4.0/0.4	6.0/0.6	5.0/0.5	3.0	0.3
Expressway	High	10.0/1.0	14.0/1.4	13.0/1.3	3.0	0.3
	Medium	8.0/0.8	12.0/1.2	10.0/1.0	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Major	High	12.0/1.2	17.0/1.7	15.0/1.5	3.0	0.3
	Medium	9.0/0.9	13.0/1.3	11.0/1.1	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Collector	High	8.0/0.8	12.0/1.2	10.0/1.0	4.0	0.4
	Medium	6.0/0.6	9.0/0.9	8.0/0.8	4.0	0.4
	Low	4.0/0.4	6.0/0.6	5.0/0.5	4.0	0.4
Local	High	6.0/0.6	9.0/0.9	8.0/0.8	4.0	0.4
	Medium	5.0/0.5	7.0/0.7	6.0/0.6	4.0	0.4
	Low	3.0/0.3	4.0/0.4	4.0/0.4	4.0	0.4

The other guidelines and regulation that related to the lighting systems in the roadway as shown below:

1.4.1.International Commission on Illumination Standards (CIE)

The organization was established in 1995 with new recommendation and enhancements to lighting especially with the revolution of taking care of environment and saving energy. Group of 40 national committees from different countries in the International Commission on illumination (CIE). Improvements on the lighting performance introduced and solve constrains in classification of lights, areas and features based on variables of traffic rates and climate conditions. (Scribd, 2010).

The concern of this organization is to establish forum that discuss all the subjects that relate into technology , science and art in the lighting aspects in roadways for both motors and pedestrians to be integrate with the exiting information in the countries. Enhance and develop the procedures and codes on both levels national and international in lighting field. Besides that, develop the technical properties that relate to the CIE subjects. The organization work on all types of lights and its techniques from the basics. Reports and serials of reviews are made to ensure the quality and examination of the new standards and codes.

The framework of technique aspects adapt the efficient lighting system though experiences. The document of CIE 115 document divided into seven chapters which consisted of general knowledge of the standard, definitions of lighting, and the goal of road lighting as spot of concern of the standards, visual circumstances, and quality principles of lighting classifications, actual studies that examine the relationship between different lighting surfaces and relationship with environment characteristics. Later on, another technical document CIE 140, was established that relate with lighting and signage for roadways by the CIE Commission. It focus on the description of lighting, elements and subsequent of lighting effect on the transportations in roadways. (Scribd, 2010).

The document consists of ten chapters which focus on recognize the sign symbols, data analysis of lighting levels with respect of roadways specifications and lighting quality characteristics. The CIE 140 is an update of CIE 30.2-1982, feedback of the calculations the lighting data which need to both CIE 115 -1995 and CIE 136-2000. It introduce the data of lighting with the grid points in different locations with an observation location to adjust the suitable data that integrate with the computer analyzing program. The CIE standards are establish as shown in Table 1.8. (Scribd, 2010).

Table 1.8: Lighting categories for roadway according to CIE standards.
(Source: Scribd, 2010)

Lighting class	Road surface				Threshold increment	Surround ratio
	Dry			Wet *		
	L_{av} in cd·m^{-2}	U_o	U_l	U_o	f_{TI} in %	R_s
M1	2,0	0,40	0,70	0,15	10	0,5
M2	1,5	0,40	0,70	0,15	10	0,5
M3	1,0	0,40	0,60	0,15	15	0,5
M4	0,75	0,40	0,60	0,15	15	0,5
M5	0,50	0,35	0,40	0,15	15	0,5
M6	0,30	0,35	0,40	0,15	20	0,5

1.4.2. British Standards (BS)

The British standards were made to organize the process in order to ensure the quality of the services. There were variety of British standards (BS) that relater into different subjects. For example, BS 5489-1:2013 is relate to the designing lighting in roadways. The standards are update to the previous version of BS-EN 13201 series. The standard integrate the government sector, large construction and lighting companies. It offer guideline in choosing the appropriate lighting classifications especially in design stage to control the value amount of energy and evaluate the main principles of lighting in roadways according to its land categories. (Shop.bsigroup.com, 2012)

On the other hand , BS-EN 40:Lighting columns standards were established on1992 .The standards focus on the technical relationship between columns and luminaires with respect to the height of the columns. This ensure the appropriate lighting level to be spread to introduce good vision. It also, evaluate the efficiency of the electrical lighting devices such as HPS, LED and others. (Shop.bsigroup.com, 2012).

Moreover, the British standards (BS) frequently change and update the standards according to the Economic changes in the field of construction and its products. Since the scope of the study is federal roadways in UAE, there is no specific standard establish by the country nor the Gulf countries. The UAE follow the British standards in their scope of work, as shown in Table 1.9.

Table 1.9: BS lighting standards in roadways

(Source: Shop.bsigroup.com, 2012).

Road Class	Maintained average luminance (Lav)	Overall Uniformity Ratio (Minimum)U0	Longitudinal Uniformity Ratio (Minimum)UI	Maximal Threshold Increment (TI %)	Surrounding Ratio (SR) (Minimum)
ME1	2	0.4	0.7	10	0.5
ME2	1.5	0.4	0.7	10	0.5
ME3a	1	0.4	0.7	15	0.5
ME3b	1	0.4	0.6	15	0.5
ME3c	1	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

1.4.3. American Association of State Highway and Transportation Officials (AASHTO)

The American Association of State Highway and Transportation Officials (AASHTO) published standards in 2005, which it updated in 2010. The standards focus on guidance related to roadway lighting during the design stage of roadways. The organization based its recommendations on studies of factors that distract drivers and contribute to collisions and accidents. Among the studies discussed is the Elvik Study (1992), conducted by the Norwegian Institute of Transportation Economics, which established the ‘criterion of safety’ metric calculated by dividing the ratio of the number of accidents before and after lighting is provided at night divided by the ratio of the number of accidents before and after lighting is provided during the day. This ratio clarifies the probability of accidents, calculated by dividing the number of accidents at night by the total numbers of cars traversing the roadway, as mentioned on the Box Study of 1970. (AASHTO, 2010).

1.5. Research Motivation

The motivation behind this research is to provide the roadways’ planners and designers as much detailed data and analysis as possible regarding the effective parameters that controls the strength of LED in the roadways networks such as color rendering index, amount of lighting outputs and others. The different analysis, which will be conducted, will clarify the relationships between parameters, holistic analysis of causes and effect of the parameters. This is in order to provide stakeholders with a strong literature review that will help decision-makers in the selection process based on detailed data and solid analysis that covers the different parameters in the field of LED lightings in general and LED roadway lightings in specific. Recently Ministry of Interior (MoI) and Ministry of Infrastructure Development (MoID) elaborate studies which analysis the black spots on the federal roadways. The black spots where the fatal accidents were happened. New initiatives has been done such as determine the timing of the passage of trucks, study the impact of traffic congestion and others.

This can help in designing and implement whole neighborhood communities that provide roadways and building facilities to ensure the best future towards secure areas and comforTable living areas. MoID believes on the balance pillars in infrastructure through the life cycle of its projects from planning, execution , maintenance by obtain the world codes and properties with partnership from local , government , and international stakeholders.

1.6. Aim and Objectives

This study evaluates selected LED-lit federal roadways as retrofit case studies to highlight the impacts of using LED lighting on roadway networks. The results suggest innovative methods and improvements for delivering high-quality infrastructure. The researcher elaborates on the emerging knowledge of LED lighting in roadways and the related challenges and sustainable opportunities, as revealed by replacing the existing HPS roadway lights with LED technology. The technology is explored within the federal roadways in the United Arab Emirates while considering the multi-functional parameters in urban spaces. The data, quantitative and qualitative, were collected from the Ministry of Infrastructure Development (MoID) from previous and existing projects, with a focus on reducing operation and maintenance costs and energy consumption.

In addition, the research addresses the lack of data on the contribution of LED roadway lighting to sustainability, and its advantages and disadvantages, especially in the Gulf region. Several studies, lighting companies, and academic institutions have emphasized the superiority of the life cycle, characteristics, and operational properties of LEDs. Moreover, the study addresses the value resulting from the impact of exploiting LED roadway lighting in the safety of the drivers in the UAE federal roadways.

The objectives of this thesis are to

1. Develop a framework for implementing sustainable roadway lighting on UAE federal highways to reduce night-time traffic accidents and improve road safety

2. Design LED roadway lighting retrofit system for federal highways to reduce night-time accidents percentage.
3. Develop proper UAE Federal roadway priority index that establish the improvement and development on lighting prepective.
4. Evaluate the current lighting system parameters and compare with the followed standards in the UAE (British Standards).

The outcome of the data analysis is highlighted through three different phases. The first phase involves examining the existing HPS lighting system and the proposed LED system, the second a comparison of the values of the results of HPS and LED lighting systems, and the third the evaluation of parameters to identify the optimum model of each parameter.

1.7. Research Questions

This thesis addresses five research questions which guide and elaborate the investigation and implementation for new technologies and innovative design of lighting systems in roadways.

Question 1: What lighting system is currently used in UAE federal roadways? Answering this question involves the analysis of techniqual parameter in both current and future used of lighting systems in roadways.

Question 2: Is there priority index that can be used to evaluate the federal way status and the areas in need for urgent inhancement? Can a priority index factors help evaluating the status of the roadways and indicate major problems facing users of these roadways?

Question 3: How can the replacement of HPS with LED roadway lights be beneficial? Because each lighting type has advantages and disadvantages, a comparison of the two types can clarify and guide roadway planners and designers in selecting the appropriate type in terms of suitability for particular communities and typographical case.

Question 4: How can LED lighting on roadways reduce the rate of traffic accidents at night? Illumination levels that maintain uniformity reduces accidents at night, and night-time visibility can be enhanced effectively by controlling various roadway lighting control parameters such as the distance between lighting poles.

Question 5: How can the maximum advantages be achieved in terms of savings on costs, maintenance, and energy using LED lighting on existing and future roadways? This question is addressed by examining the various parameters that influence the effectiveness of LED roadway lighting.

1.8. Scope and Limitations of the Research

The research scope of work includes federal roadways in the UAE within the responsibilities and duties in ministry of Infrastructure Development. These roadways connect the main emirates and settlements to each other's. The investigation will cover one kilometer length of selected federal roadway as case study of the research which got HPS as existing lighting system. The research will focuses on enhancing and developing lighting system in terms of comforTable visibility at night time that is believed to prevent traffic accidents at same time.

After a review of articles and previous investigations that dealed with lighting in roadways with relationship to traffic accidents at nigh time, it was important to mention some of the limitations that are facing the author of this research. Starting with the history of the traffic accidents at night time that was collected from 2016 until august 2017 from Ministry of Infrastructure Development. This document didn't include other details related to the traffic accidents such as, type of the traffic accidents, causes of the traffic accidents, numbers of injurers and deaths...etc.

The lake of previous studies that are based on software simulation methodology for similar studies this sets a challenge in understanding the efficiency of vertuale model simulation compared to site visite and real case measurements.

1.9. Research Framework

The research focused on studying and examining two types of lighting systems on federal roadways in terms of technical measurements, power consumption, and economic status. The research report contains six chapters on the influence of lighting in reducing traffic accidents and on improving road safety.

The first chapter contains background information on traffic accidents considered a leading cause of death globally in the world and in the United Arab Emirates and a discussion of roadway lighting systems, lighting terminology and definitions, and international codes and standards. Chapter 2 features a literature review of previous studies and investigations that involved similar comprehensive techniques before moving on to the types of roadway lighting systems and system best suited to the UAE roadway environment.

In Chapter 3, the researcher discusses the suggested methodologies and software and describes the methodology and software deemed most suitable for achieving the aims and objectives of the research by evaluating various categories to address the research requirements.

Chapter 4 follows, with an explanation of the selected methodology and software through a series of steps related to the parameters of selecting the federal roadway as case study. It then examines the existing HPS lighting system on the roadway in terms of the technical aspects derived from the inputs and outputs and the impact of changing the HPS to the LED system.

In Chapter 5, future technical details are discussed using the HPS system as a base case and expanding three scenarios related to LED lighting. Chapter six concludes the research with recommendations for future work.

Chapter 2: Research Literature Review

2.1. Literature Review Introduction

In order to comply with the research objectives discussed earlier in chapter one it is essential to read and study different papers covering similar topics. This helps in understanding different parameters effects the research scope of work in addition to different benchmarks and limitations that other researchers faced while studing similar topics.

This chapter present and discuse different research papers linked to the topic of this study in addition to national and international codes and regulations that control the final decision that shell comply and fullfil the research questions that were highlighted earlier in chapter one.

2.2.The Relationship Between Illuminance and Night-Time Traffic Accidents

Road lighting is an important traffic safety factor, and several studies have shown that adequate roadway lighting can play a role in reducing the rate of car accidents. To promote transportation safety and security, illuminance levels should meet the minimum standards, which set out the conditions that must be met to create the best possible traffic conditions. While most countries are concerned with measuring traffic safety, it is important not to overlook factors such as economic status and energy consumption that affect consumer comfort when setting safety guidelines.

This research suggests that the insufficient lighting of roadways is the main cause of accidents. Most of the world countries are concerned on measuring the traffic safety, but most issues that are facing traffic safety which relate to economic status and energy consumption that affect the comforTable condition of consumers.

On the other hand, roadway safety assessments can be used to evaluate the effects of changes to lighting systems by identifying whether these changes improved or worsened accident rates., and accident statistics collected by traffic police can be a valuable tool in the creation of effective long-term strategies. Previous data drawn from vehicle accident records in New Zealand, displayed according to degree of dangerousness, are shown in Figure 2.1.

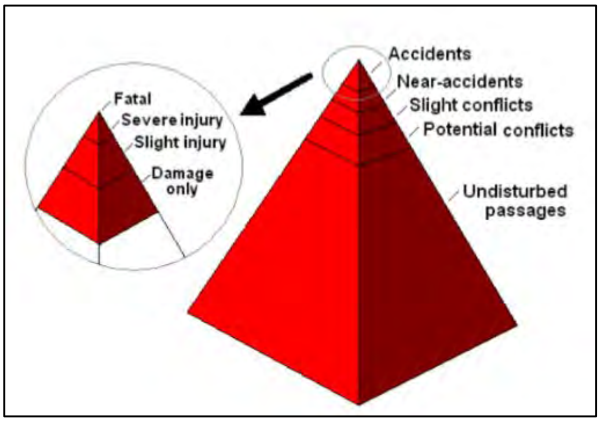


Figure 2.1: Accident categorize according dangerous level
(Source: Jackett and Jackett, 2015)

This can be helpful as its available and accurate that integrate to study and evaluate the trend, then compare that overall enhancement with the new lighting system and evaluate the quality and quantity of accidents especially at night, this will clearly improve the efficient of roadways lighting as major parameters that affect the user's safety. (Jackett and Jackett, 2015)

According to Scott 1980, there is a relationship between two parameters which are lighting level in the roadways and rate of car accidents at night compared to the daylight. The data was used on 1 kilometer roadway length with speed limitation of 30 mph on 89 locations.

On the other hand, Scott 1980 Figured out that the amount of accidents at nights dropped with respect of the increasing of light level in a linear trend relationship. Generally, Scott 1980, adapt hypothesis of lighting growth that equal to ($1cd/m^2$) is attended with 35% reduction of night accidents rates.

A group of Dutch researchers subsequently conducted a similar study with a larger sample group of data collected from Dutch roadways, and analyses from this study were included in the work of Schreuder et al. (1998, cited in Frith and Jackett, 2015, p. 21). Schreuder et al. used this data and 'their own re-analyses of previously published work' to determine an updated 'night-to-day crash ratio'.(Frith and Jackett, 2015, p. 21).

Table 2.1: Accident ratio and lighting levels

(Source: Frith and Jackett, 2015, p. 21)

Luminance	L<0.4	0.4<L<0.73	L>0.73
Night/delay crash rural roads	0.33	0.27	0.23

There are another factors that affects the roadways safety such as the stream of traffic but this can be measured easily through pacific roadways, concentration on one particular roadway to organize, analysis and indicating the cause in clear status. As a result a modification in roadways users attitude will be obtained, which integrate and analyse the roadways safety. The study has been done based on a hypothesis evaluation. This type of method has been obtained on collecting data before and after applying the illuminance system.

Inadequate roadway lighting is equally hazardous to pedestrians, as shown in a study conducted by Zhou and Hsu (2010, as cited in Hamrle, 2014) between 2000 and 2005 in Florida in the United States. Zhou and Hsu collected illuminance data along a 50 km stretch of U.S. 19 and found that of the 199 crashes the involved pedestrians, 105 occurred at night, with 18 taking place in areas without street lighting and the remaining 87 occurring in areas where streetlights had been installed. Figure 2.2 shows the relationship between illuminance systems and the rate of pedestrian accidents that occur at night (Zhou and Hsu, 2010, as cited in Hamrle, 2014).

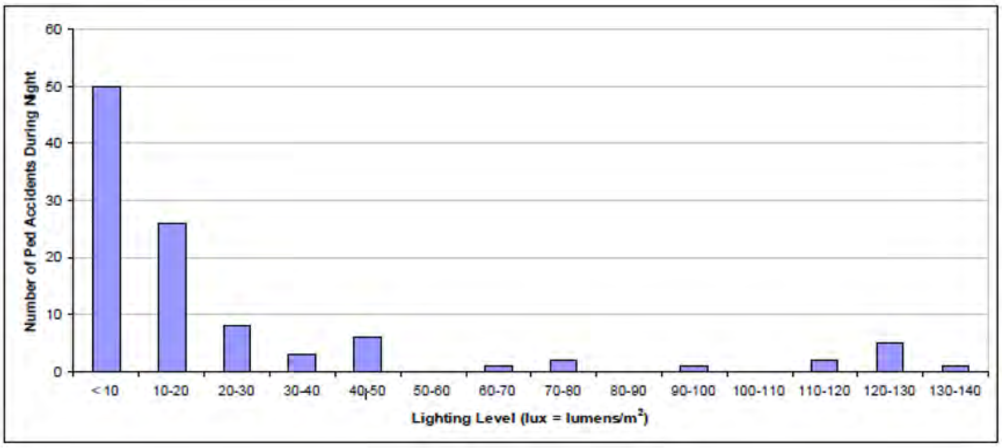


Figure 2.2: Number of pedestrian accidents at night for different lighting conditions

(Source: Zhou and Hsu, 2010, as cited in Hamrle, 2014, p. 50).

Similar results were reported in a Federal Highway Administration (FHWA) report (Wilken et al., 2001, as cited in Frith and Jackett, 2015, p. 18) on experiments conducted in Finland. Lighting levels were reduced from 1.5 cd/m^2 to no lighting, and the accident rate increased by 25%. When the lighting level was reduced from 1.5 cd/m^2 to 0.75 cd/m^2, the accident rate increased by 13%. Likewise, according to Hasson and Lutkevich (2002, as cited in Frith and Jackett, 2015, p. 22) when half the lighting in Austin, Texas, was turned off on an 11.3 km stretch of roadway, accidents increased by 22% and the ‘crash rate also increased from 1.51 to 1.91 crashes per million vehicle miles. The relationship between lighting and night-time accident rate was further confirmed by the findings of Monsere et al. (2008, as cited in Frith and Jackett, 2015, p. 22). When the Oregon Department of Transportation reduced lighting at 44 interchanges and along approximately 8.9 km of roadway, an increase of 2.46% in total night crashes occurred. The findings of these studies confirm the importance of lighting levels for road safety and highlight the importance of identifying optimum lighting levels at night to ensure safe travel on roadways (Frith and Jackett, 2015).

In 2009, Elvik et al. (2009, as cited in Frith and Jackett, p. 22) conducted a meta-analysis of 25 ‘before and after’ studies (i.e., studies comparing accident rates before and after changes were made to lighting levels) on roadway lighting. The results appear in Table 2.2.

Table 2.2: Effects of improved road lighting on the number of crashes
(Source: Frith and Jackett, 2015, p. 23)

	Percentage change in number of accidents		
Accident severity	**Accident types affected**	**Best estimate**	**95% confidence interval**
Increasing the level of lighting by up to double the previous level of lighting			
Injury accidents	Accidents in darkness	-8	(-20;+6)
Property damage only	Accidents in darkness		(-4;+3)
Increasing the level of lighting by up to 2.5 times the previous level of lighting			
Injury accidents	Accidents in darkness	-13	(-17;-9)
Property damage only	Accidents in darkness	-9	(-14;-4)
Increasing the level of lighting by 5 times the previous level of lighting or more			
Fatal accidents	Accidents in darkness	-50	(-79;+15)
Injury accidents	Accidents in darkness	-32	(-39;-25)
Property damage only	Accidents in darkness	-47	(-62;-25)

In addition , both Jackett and Frith (2012, as cited in Frith and Jackett, 2015, p. 16), in their study on urban crashes, used a digital camera to evaluate the lighting levels of urban roadways with higher speed limits in New Zealand. They determined that 6.1% of fatal accidents and 5.5% of accidents in which people were injured occurred at 'higher-speed road intersections in 2011'. Figure 2.3 shows the relationship between road lighting and urban road safety in New Zealand.

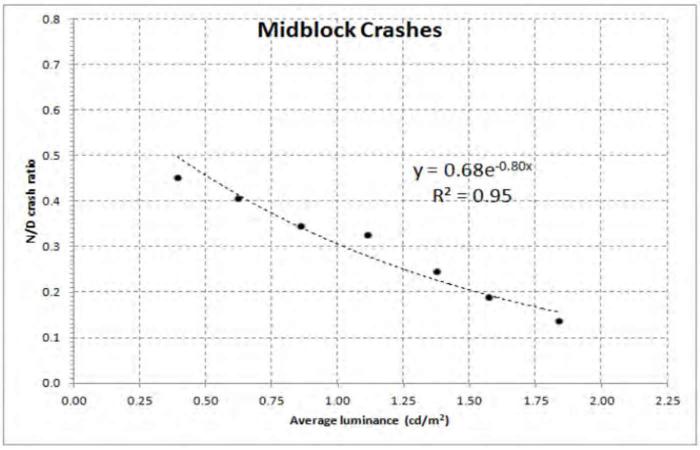


Figure 2.3: Night-to-day crash ratio for all reported urban crashes against average luminance

(Source: Frith and Jackett, 2015, p. 17)

Inaddition, there was difficulty in recording data of switching off the lights of the roadways as Jackman 2012, explained in his study of 2,700 lights were switch off in roadways of Milton Keynes, UK. It was ignoring specific segments of roadways such as the networks of junctions, roundabouts, bus and cycling tracks. As a results, a 30 % accidents were resulted in these segments at nights. Later on, the lights on the roadways were switched on of 2,597 out 2,700 with some modification in the dimming scheme. This helped to the enhancement of user's visibility at night. (Jackett and Jackett, 2015)

Also, Gibbons 2014, worked hard in researching the manufactured vehicles to understand the connection of light levels, quality and accidents percentages. The vehicle recorded both horizontal and vertical of reflection, incident light and uniformity. It was measuring the average of illuminance in four categories of at the top and behind the wind direction and calculated the effectiveness of windscreen, as a result 30% of the accidents has been reduced. The relation between horizontal illuminance and night to day crash rate ratio is in decreasing. For example the horizontal illuminance is 5 lux that illustrate with approximately 1.42 night to day crash rate ratio , moreover horizontal illuminance is 15 lux that illustrate with approximately 1.1 night to day crash rate ratio, as shown in Figure 2.4. (Jackett and Jackett, 2015).

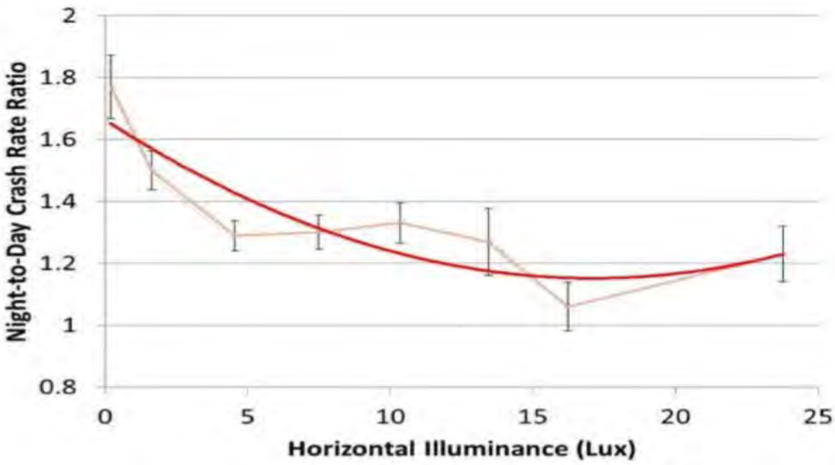


Figure 2.4 : Horizontal lighting level and accidents ratio.
(Source : Jackett and Jackett, 2015)

Although the findings showed that increased horizontal illuminance led to increased safety, safety began to decline when lux reached 16 and higher. Gibbons et al. (2014, as cited in Frith and Jackett, 2015, p. 19) found a similar curve for vertical lighting level, as shown in Fig(2.5).

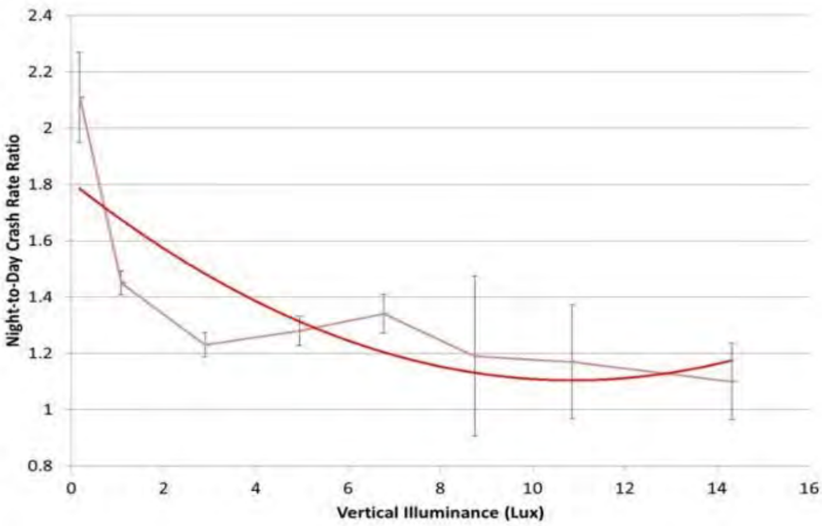


Figure 2.5: Relationship between vertical illuminance and night-to-day crash ratio
(Source: Frith and Jackett, 2015, p. 19)

In a study conducted by Jackett and Frith (2012, as cited by Hamrle, 2014, p. 51) in New Zealand, which focused on street lighting in nine territorial local authorities, the researchers measured various lighting parameters, at night, using instruments such as a luminance meter and a calibrated digital camera. Their analysis identified average luminance as being the most important parameter, and they then grouped the data in bands 0.25 cd/m^2 wide for more comprehensive analysis. Further analysis confirmed the link between luminance and road safety, with responses remaining similar across roads categorized according to traffic flow (less than 9,000; 9,000–12,000; 12,000–30,000 vehicles/day) and positive for both wet and dry roads (Hamrle, 2014). In contrast, Bacelar and Beaucamp (2002, as cited in Hamrle, 2014, p. 52), in an experiment on the influence of luminous flux on human behaviour and on the minimum visibility levels for safety and comfort, found that reduced lighting did not change a person's ability to recognize objects in the road.

Several lighting features need to be studied to evaluate lighting distribution quality; according to the CIE (1995, as cited in Edirisinghe, 2012, p. 11), these are luminous efficacy and colour rendering. Colour rendering refers to how natural the colours of an object appear under certain illumination, and light sources that produce poor colour rendering are not fit for general lighting (CIE, 1995, as cited in Edirisinghe, 2012, p. 12). The luminous efficiency of a light source relies on two factors: 'the conversion efficiency from electrical power to optical power and the conversion factor from optical power to luminous flux' (CIE, 1995, as cited in Edirisinghe, 2012, p. 12).

As discussed in Chapter 1, from the 1970s until 1995 LED technology underwent significant development, with the light output and efficiency of red LEDs increasing by a factor of approximately 45. Subsequently, between 1995 and 2003, the efficiency of LEDs increased by an average factor of 16, with 'light output per LED package' leaping ahead by a factor of 430 (Edirisinghe, 2012, p. 12). Consequently, contemporary LEDs are suitable for a range of uses, including road signs, signals, and lighting, and improvements since 2005 have led to this technology being used for higher levels of illumination (Edirisinghe, 2012).

Numerous studies have addressed the parameters that influence the quality of roadway lighting and the measurement of lighting output. Marinoa, Leccese, and Pizzuti conducted a study in 2017 in L'Aquila, Italy, involving an urban district road (classified as ME3c, according to EN-13201-2 with '800 vehicles as equivalent nominal flow' (Marinoa, Leccese, and Pizzuti, 2017, p. 796). The required luminance for a dry roadway surface of this type, as set out in EN-13201-2, is shown in Table 2.3 (Marinoa, Leccese, and Pizzuti, 2017, p. 796).

Table 2.3: EN-13201-2 standards

(Source: Marinoa, Leccese, and Pizzuti, 2017, p. 796)

Class	Luminance of the road surface of the carriageway for the dry road surface condition			Disability glare	Lighting of surroundings
	L in cd/m² [minimum maintained]	U_0 [minimum]	U_l [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

For the road to be downgraded to ME4b or ME5, and the attendant lighting levels, the nominal flow of vehicles would have to decrease by 50% or 25% respectively. These reduced lighting levels correspond to luminance values of 0.75 cd/m^2 and 0.5 cd/m^2, which would allow the 'installed power of the point lights' to be decreased based on the projected traffic flow (Marinoa, Leccese, and Pizzuti, 2017, p. 796). The researchers used DIALux software to obtain lighting measurement data, and used 0.217 as the asphalt reflectance coefficient and 0.8 as the maintenance factor, with 137 W light sources with 10,275 lm luminous flux. An average luminance value of 1.02 cd/m^2 was calculated. Furthermore, Marinoa, Leccese, and Pizzuti considered a wide range of parameters, including

- Roadway specifications
- Roadway lanes
- Pole spacing
- Asphalt surface of the roadways
- Luminaire tilt
- Pole height
- Boom angle

The algorithm the researchers proposed can reduce power up to 67% for a one-level downgrade and up to 45% for a two-level downgrade (Marinoa, Leccese, and Pizzuti, 2017).

In another study, Jackett and Frith (2013) measured ‘values for the CIE light technical parameters’ in situ and compared them with the five-year crash history for the same section of road. The researchers measured the following parameters:

- Average luminance
- Overall uniformity
- Longitudinal uniformity
- Threshold increment

In addition, another study was done by Saraiji, Hamadan and Harb, (2014), which evaluated the lighting measurments of LED road, partically in Al Ain city in UAE. This city considered as one of the hottest cities in the world .The data collection temperture , relative humidity and lighting outputs were recorded over 300 days ,every 10 minutes. The results showed that LED lighting levels were properly constant in the summer days. The relation between temperature ans lux level was transulate temperature range of 20° C - 40° C inside the driver partition as drop in lux level of 4.5% per 10°C which lead to sTable lux levels within 12% in the test duration.While the lighting measurments of 1.1 cd/m2 as average luminance and uniformity ratios of 1.6 – 1 .

In September 2015, Firth and Jackett published a further report, titled 'The relationship between road lighting and night-time crashes in areas with speed limits between 80 and 100 km/h', which has been discussed previously in this thesis. The study was conducted on roads on the edges of urban areas in New Zealand roadways with speed limits in the target range, with the data on traffic accidents on these roads collected from the Transport Agency Street Lighting Inventory Management (SLIM) database. Data included

- State highway and route position
- Luminaire type
- Light source and wattage
- Installation dates for both poles and luminaires
- Traffic volume

This information was used in conjunction with data collected using a calibrated camera mounted on a moving car. The analysis of the photographs taken produced data on

- Average luminance (L_{avg})
- Overall uniformity (U_o)
- Longitudinal uniformity (U_l)

Frith and Jackett (2015) found no proof that increasing average luminance to more than the existing 0.75 cd/m^2 on high-speed roadways in the areas studied would reduce accident frequency. Moreover, the night vision required on highways outside urban areas differs from that required on roadways in urban areas. Higher lighting levels in urban areas are essential, as they allow drivers to readily identify hazards, but in non-urban areas, it seems more important to improve drivers' ability to judge speed and distance to avoid rear-end crashes.

Furthermore, Frith and Jackett (2015) found overall uniformity to be a significant variable, concluding that greater lighting uniformity promoted increased safety. This is a key finding, as it suggests that effective roadway lighting depends on adequate overall uniformity rather than higher levels of average luminance.

The third parameter studied, namely longitudinal uniformity, was not found to be significant in either urban or non-urban areas, which aligns with the findings of Jackett and Frith (2012). Although longitudinal uniformity was shown to be a less important safety factor, it should not be dismissed entirely, as low longitudinal uniformity has been shown to increase driver fatigue, which in turn increases traffic accidents (Frith and Jackett, 2015).

In 2010, Kemeh published a report on the safety features of a 42 km section of the newly reconstructed Route N6 in Ghana, the Accra–Kumasi–Gonokrom Highway. To monitor the traffic volume on the section of road studied, Kemeh collected data on the traffic volume between 6:00 AM and 6:00 PM daily, as recorded by the Road Safety and Environment Division from 2004 to 2009. He further obtained the as-built design drawings from the Ghana Planning Division. The measurements collected included data on the number of accidents and the times at which they occurred, daily average traffic, and types of vehicles using the roadway under study.

This research enabled Kemeh to identify dangerous sections of the roadway and formulate strategies to improve road safety on this highway. The recommendations included reducing speed limits to 80 km/h in towns and 50 km/h in settlements, with warning signs to reduce speed well before reaching these areas.This study recommended that road planners should introduce safety features in the design phase of roads and that the authorities should conduct pilot studies to evaluate the effectiveness of road safety initiatives (Kemeh, 2010).

A summary of studies and reports with objectives that align with those of this thesis appears in Table 2.4.

Table 2.4: Literature review summary
(Source: Author,2018)

References		Studied summary	Measurements	Conclusion
1	Hamrle, 2014	Examined quality of roadway in France through the university of Sao Paulo Campus in Brazil	• Luminous flux • Average luminance	Road safety assessment need to be in long period of time such as one year to study the influence of traffic accidents with its relation with lighting in roadways.
2	Edirisinghe, 2012	Evaluation of the effectiveness of LED lighting in commercial buildings	• Color rendering • LED efficiency	Color rendering presents the color of subject expression under the effect of certain illumination.
3	Marinoa, Leccese and Pizzuti, 2017	Study of the quality of lighting on roadways in Italy	• Roadway specifications • Roadway lanes • Pole spacing • Asphalt surface of the roadways • Luminaire type • Pole height • Boom angle	Evaluate the lighting performance in the roadways in comparison with CIE technical measurements and in relation to traffic accidents at night time.
4	Saraiji, Hamadan and Harb, 2014	Evaluated the lighting measurements of LED roadlights in hot zones.	• Average luminance. • Overall uniformity	Relation between Thermal measurement details such as temperature and lighting output rated by the average luminance and overall uniformity
5	Jackett and Frith, 2013	Evaluation of lighting performance on New Zealand's roadways in reference to CIE standards	• Average luminance • Overall uniformity • Longitudinal uniformity • Threshold increment	Average luminance of (0.75 cd/m^2) is needed in the high speed ways in remote areas
6	Jackett and Jackett, 2015	Detailed assessment of lighting levels of roadways in New Zealand in details	• State highway and route position • Luminaire type • Light source and wattage • Installation dates for both poles and luminaires • Traffic volume • Average luminance (L) • Overall uniformity (Uo) • Longitudinal uniformity (Ul)	Longitudinal uniformity ratio doesn't effect in both urban and remote areas.

References		Studied summary	Measurements	Conclusion
7	Kemeh, 2010	Study of lighting measurements on Ghana’s roadways with the aim of reducing traffic accidents at night and identifying solutions to improve roadways	• Number of traffic accidents • Speed limits • Traffic volume	Study of lighting measurements on Ghana’s roadways with the aim of reducing traffic accidents at night and identifying solutions to improve roadways

2.3. Types of Lights Used on Roadways

Lighting used outdoors, and its characteristics, advantages, and disadvantages, differs from lighting used indoors. Types of outdoor lighting systems include metal halide, high-pressure sodium (HPS), low-pressure sodium (LPS), and light-emitting diode (LED) lamps.

Metal halide lamps, developed in the 1960s, consist of arc tubes that contain a mixture of mercury, argon or xenon, and metal halides in a vaporized form, which creates a gaseous mixture. Once the lamp reaches operating temperature, the gas separates into metal atoms and halogen, and as the temperature increases within the central core, the process produces a white light. Metal atoms and halogen interact, moving continuously through the arc tube and creating a continuing reaction (Avrenli, Benekohal, and Medina, 2012). Because the process does not rely on mercury evaporation to produce light, metal halide lights are 60–110 lm/W more efficient than mercury-vapor lamps.

Metal halide lighting is used in parking areas, in stadiums, and on roadways. It is considered an environmentally friendly, bright light with fair colour rendering, as shown in Figure 2.6 (Oh, Do, and Yang, 2014).

Figure 2.6 : Metal Halide lights

(Source : Hye Oh, Rag Do and Yang, 2014)

The second type of roadways lighting fixtures is High Pressure Sodium (HPS) which was established since 1968 and has been used in the roadways since then. It contains longitude ceramic arc tube with other elements such as xenon, mercury, electrodes, amalgam and sodium. This can be seen today in US roadways.

The level of efficacy for (HPS) are more than 120 lighting measurmentss per watt,(Avrenli, Benekohal and Medina, 2012) It is the most popular light in the roadways which generate light through the combination of gases and electricity in order to produce yellow/ orange glare as shown in Figure 2.7. (Oh, Do and Yang, 2014).

Figure 2.7: High Pressure Sodium (HPS)
(Source : Hye Oh, Rag Do and Yang, 2014)

On the other hand, the third type of lights is Low Pressure Sodium (LPS): The (LPS) witness continues development since the industrial revolution in 1932 in the efficacy parameters as shown in the element of the light as in Figure 2.8. It work similarly to (HPS), instead of generating white color light. Yellow light gives the illuminance of the objects another color appearance or grey color. (Oh, Do and Yang, 2014).

Figure 2.8 : Low Pressure Sodium
(Source : Hye Oh, Rag Do and Yang, 2014)

To improve efficiency, in LPS lamps the sodium evaporates at a lower pressure, and a lower operating temperature is required. These lamps produce light due to wavelength sensitivity, and 30% of the energy they release is converted into light, as shown in Fig.2.9 (Hooker, 2011).

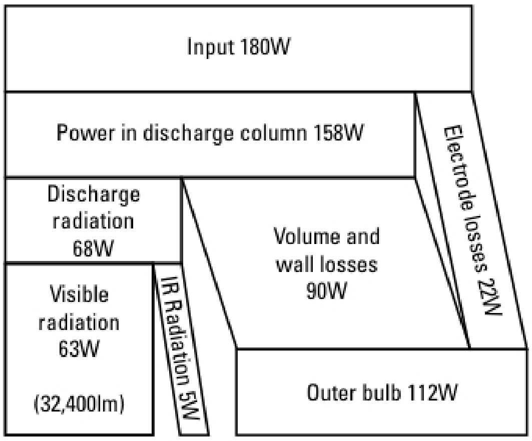


Figure 2.9: Low Pressure Sodium energy equilibrium distribution
(Source : Hooker, 2011)

Both relative response and wavelength affect the light, as shown in Figure 2.10, with relative response lying between 0 and 1 and the wavelength being between 400 and 700 nm and between violet and red. The perfect light colour is yellow (Hooker, 2011).

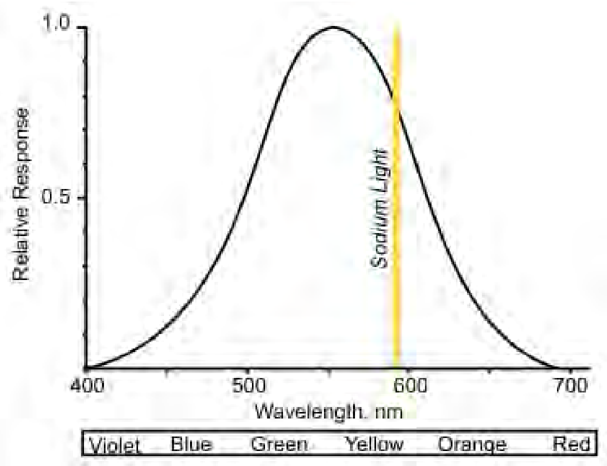


Figure 2.10: Low Pressure Sodium wave length
(Source : Hooker, 2011)

Over the years, continuous improvements have been made in terms of LPS lamp materials and manufacturing techniques, allowing this type of lighting to remain competitive. The benefits of LPS lighting include the physical size of the lamps, which reduces glare and makes it suitable for narrow spaces. In Japan and Korea, where tunnels can extend for up to 16 km, LPS lighting is popular, and it has been proven to reduce accident rates in tunnels. In addition, because the lamps can be installed end-to-end, they generate constant, uniform lighting, which is ideal for roadways, as it drastically reduces driver fatigue. Furthermore, LPS lamps carry relatively low manufacturing costs and do not require expensive control systems. It do not contain mercury, do they can be disposed of as non-hazardous waste. Finally, LPS lamps do not need to cool down after power interruptions and can restrike the moment power is restored.

LPS lighting also comes with several disadvantages. Its main disadvantage is that colour rendering is impossible because it casts a monochromatic light, which is particularly noticeable on roadways. In addition, it has a shorter lifespan than other lights, and lamps must be changed every two years. This schedule can be lengthened to three to four years by using HPS lamps, and the reduced maintenance cost can make up for the costs lost due to a reduction of energy efficiency when changing to HPS lamps (Hooker, 2011).

Figure 2.11: LED lights
(Source : Hye Oh, Rag Do and Yang, 2014).

LED lamps generate a high level of blue light and are cost and energy efficient (Hye Oh, Rag Do and Yang, 2014). Phosphor-converted amber LED lamps, developed in 2009, produce longer-wavelength light to address the high level of blue in LED lighting. They have been on the market for only a few years, and although they offer excellent colour rendition and energy efficiency, they remain expensive, as shown in Figure 2.12. (Hye Oh, Rag Do and Yang, 2014).

Figure 2.12 : Phosphor-Converted Amber lambs lights
(Source : Hye Oh, Rag Do and Yang, 2014).

Similarly, narrow-band amber (NBA) LED lights, a new technology, emit mostly yellow in place of all colours and a great deal of blue light. Although these bulbs, shown in Figure 2.13, are very efficient, they are expensive and not yet widely available (Oh, Do, and Yang, 2014).

Figure 2.13 : Narrow-Band Amber lights
(Source : Hye Oh, Rag Do and Yang, 2014).

LEDs can be considered as talented choice to be obtain in the roadways due to its extended life span, clear and great color features, dimming abilities , vibration confrontation and suitable with all types of weather either cold or hot. (A. Avrenli, Benekohal and Medina, 2012).

The summary of types of roadways lights ,as shown in Table 2.5: The Table addressed the types of lighting systems in roadways with power energy, level of lighting measurmentss and color rendering index . For example : HPS lighting system got 250 W that generate 16 000 lighting measurmentss with CRI of 20-24 , On the other hand LEDs with 25 W generate 2772 luman which minimum amount of energy and CRI 80 – 98 much higher than HPS which better visibility. (A. Avrenli, Benekohal and Medina, 2012).

Table 2.5 : Type of roadways lights

(Source : A. Avrenli, Benekohal and Medina, 2012).

Type of roadways lights :	Wattage	lumens	CRI
Metal Halide	250	22,000	85-94
	400	36,000	
	1000	110,000	
High Pressure Sodium (HPS):	250	16,000	20-24
	400	24,000	
	1000	50,000	
Low Pressure Sodium (LPS)	18	1800	-44
	35	4550	
	55	7800	
light-emitting diode (LEDs)	25	2772	80-98
	42	3648	
	146	12,642	
	202	13,620	
Phosphor-Converted Amber (PCA)	0.9	140	>80
	1.8	77	
Narrow-Band Amber (NBA)	16.4	1147	67
	20.6	1460	
	42.3	3311	

2.4. Types of Lights Preferred on Roadways

LED lights have the potential to be an excellent choice for roadway lighting due to their light emission and output characteristics. Equally attractive is their extended lifespan of up to 15 years, which promises savings in terms of replacement and maintenance costs. Lifespan is the amount of time until a lamp’s light output reaches a specific percentage of its initial output. For metal halide lamps, this is 40%; for HPS lamps, 50%; and for LEDs, 70%. The lifespan of LEDs can be up to 60,000 hours, although some manufacturers claim it is as low as 10,000 hours, compared to the lifespan of HPS lamps at 20,000–30,000 hours. (Lumileds.com, 2016).

Table 2.6: Comparison of Lumileds's Luxeon Rebel LEDs and HPS lights .
(Source :Lumileds.com, 2016).

	LUXEON REBEL	HIGH PRESSURE SODIUM
Flux (lm)	3325	5510
Power consumption	67W	90W
System Efficacy (lm/W)	50	61 *
Average lux	14	19
Utilization	0.0042	0.0034
Lux/W	0.21	0.21 **
Min/avg lux ratio	0.40	0.32
Lifetime (hours)	60,000	20,000 to 30,000

According to the data in Table 2.6, LEDs offer superior power consumption (67 W vs 90 W), while HPS has superior efficacy (61 lm/W vs 50 lm/W). However, Lumileds (2016) contends that the efficacy score for HPS lamps is skewed due to the amount of light wasted. Similarly, according to Lumileds (2016), although LEDs and HPS lamps appear to offer the same lux/W, hot spots on HPS lamps artificially increasing their rating and causing undesirable glare and visibility problems. Moreover, LED lights produce superior distribution (0.4 vs 0.32), and in the test reported by Lumileds (2016), LEDs were the only lights that conformed to European roadway lighting specifications due to their ability to direct light.(Lumileds.com, 2016).

Furthermore, LEDs have a low environmental impact. Sustainability benefits include

- Energy consumption that is 20–50% lower than that of compared HPS and mercury-vapor lights. Efficiency is expected to improve as the technology advances.
- The capability to reduce wasted light, as engineers can control light distribution for individual LED lights
- The absence of mercury, which ensures safe disposal and adheres to European Union standards on mercury bans
- Reduced pollution and a smaller carbon footprint. In addition to energy efficiency, LEDs require less maintenance and less related travel (Lumileds, 2016).

Moreover, LEDs are more compact than other types of roadway lights, which gives them flexibility and ease of installation advantages, as installers do not have to rely on standard measurements. The ability to customize patterns is equally advantageous for manufacturers of luminaires. Colours can be mixed in a small space to enhance optical characteristics and control optical efficiency, which can reach up to 90%.

Energy can be further conserved through judicious control and dimming, and dimming can lead to energy savings of up to 30%. Energy consumption decreases when lighting levels are reduced to the minimum required for maintaining road safety and reducing night-time accidents. Both mercury-vapour and metal-halide lights have poor dimming abilities, but HPS dimming can be accomplished using multilevel lighting ballasts. In addition, LEDs can be adjusted for the virtual time period and time period between pulses, which allows the LED dimming scheme to be minimized to 10% of the maximum output (Avrenli, Benekohal, and Medina, 2012).

2.5. LED Structure and Operation

An LED is a small p–n semiconductor diode that emits light when energy is 'converted into radiation in the semi-conductor crystal' (licht.de, 2017). When current passes through the crystal, it produces electroluminescence. An LED works like a semiconductor diode, allowing current to flow in one direction only (Edirisinghe, 2012). Unlike other types of lights, LEDs do not generate heat. The components of a single LED are shown in Figure 2.14 (licht.de, 2017).

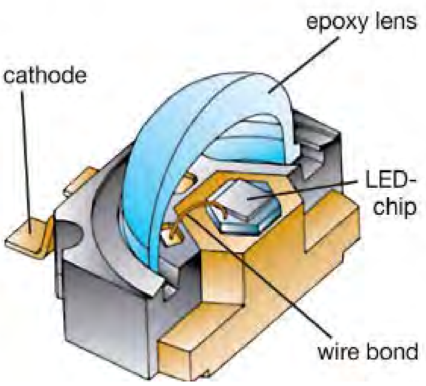


Figure 2.14: LED light components

(Source : licht.de, 2017)

The above Figure present the component of LED which is are seated on a heat sink and covered with a plastic housing for protection. The LED contains reflectors that radiate light upwards at a 180° angle. (licht.de, 2017)

On the other , Edirisinghe (2012) offers a more detailed explanation of how an LED works. The diode is formed by creating a p–n junction by transporting p- and n-type semiconductor materials together. To obtain p-type materials, an intrinsic semiconductor material is ‘doped’ to produce excess positive charges, which creates ‘holes’, while n-type materials are obtained by using donor impurities to create additional negative charges. When the p and n materials ‘form a diminution region at the junction’, ionized acceptors and donors are collected from the p- and n-sides respectively (Edirisinghe, 2012, p. 10).

When current is introduced, the extra electrons and holes move towards each other. However, by applying current across the junction, electrons—which are more mobile carriers than holes—can enter the conduction band, which allows them to generate enough energy to traverse the gap and combine with holes on the opposite side of the junction. The reduction in energy from the conduction to the valence band emits a photon. While radiative transmission are possible in indirect bandgap semiconductors, it is far less likely to occur than in direct gap semiconductors. Thus, direct gap semiconductors are commonly used in optoelectronic products such as LEDs (Edirisinghe, 2012).

Chapter 3: Methodology of the Research

3.1. Introdution

The term *methodology* refers to verified approaches to data collection and analysis, with consideration of techniques used in previous studies. If a researcher chooses to modify an established methodology, he or she must describe it detail to allow others to replicate the study and to use the methodology in future studies.(University of Manchester, 2017).

This chapter highlights suggested methodologies to facilitate the comparison of the study findings with British roadway lighting standards.Diagram3.1 illustrates the methodology roadmap.

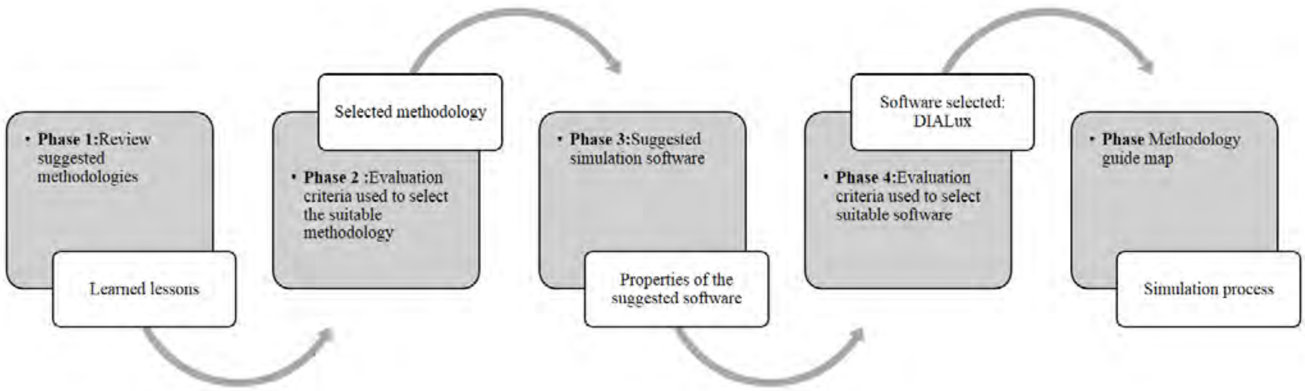


Diagram 3.1: Process used to select a suitable methodology
(Source : Author , 2018)

The methodology selection process began with reviewing the suitable of case study, field measurement, and simulation methodologies. These techniques integrate lessons learned, which would support the objectives of this research. To select the most suitable methodology, evaluation criteria were established, and the simulation methodology was selected. Subsequently, potential simulation software packages were identified, selection criteria established, and the DIALux program selected. As the lessons learned from both the literature review and suggested methodologies emphasized the scope of the research, this was integrated into the methodology guide map.

3.2. Research Methodologies in Similar Topics

Published articles and studies revealed several methodologies that might have been suitable for this research. These methodologies were summarized to clarify their features and benefits. The case study, field measurements, and simulation methodologies were identified as the most suitable for the achieving the aim and objectives of this research.

3.2.1. Case Study Methodology

The case study method allows researchers to gain in-depth knowledge on a topic, with clear conditions and standards the describe positive and/or negative views, describe new research subjects to facilitate further analysis, and form the basis of new methods or ideas that allow researchers to discover evidence that supports, or disproves, their hypotheses. Mapping the results of data collected from different sources can answer questions or establish a logical framework (Thomas, 2014).

In 2011, the German Ministry of Traffic began an initiative to increase traffic safety awareness, with the aim to reduce the number of fatal accidents by 40% by 2020. The strategy was based on the results of a case study. Statistics related to accident severity were collected from Landesbetrieb Straßenbau Nordrhein-Westfalen for the period 2009–2011, with 58,078 accidents recorded. The Ministry of Traffic, which is responsible for planning, designing, building, and maintaining highways in Germany, used the data to conduct a case study and analyse the factors that potentially affect the severity of traffic accidents, such as

- Types of traffic accidents according to the level of damage—major or minor
- Weather conditions, season, and time of day
- Types of road users involved—motorcycles, vehicles, trucks, or pedestrians

- Road construction condition

In addition, the researchers considered the locations of the accidents, for example, whether they occurred in interchanges, on minor roads, or near roadworks. Other factors considered included Average Daily Traffic (ADT) and Average Hourly Traffic (AHT), which were described using a mixed-logic model. Correlation variables were set for dry road (-0.60), site, road conditions (0.38), daylight (0.34), and so forth.

The results indicated that 73% of accidents took place during the day, typically in winter and in dry conditions, with 7% resulting in minor injury. Slippery road conditions decreased the rate of death and injury. Of roadside crashes, 186% resulted in fatalities and 147% in injury, while 269% of accidents at interchanges were fatal and 132% resulted in injuries.

These factors revealed positive and negative aspects that clarified the causes of the increased number of deaths and injuries due to traffic accidents in Germany since 2006. In addition, the study confirmed the accuracy of variables that affect road safety and before-and-after analyses. The results were used to map solutions to refine the factors that affect accident severity and traffic flow, with previous years' trends used to ensure the accuracy and effectiveness of the strategy in the future. After this study, the German Ministry of Traffic announced the launch of its new traffic safety programme (Manner and Wünsch-Ziegler, 2013).

Similarly, Zimbabwe based revisions of its traffic safety strategy on a 2012 case study on the network roadway in Zimbabwe. The network contained 88,300 km of roadway, with 15,000 km paved. Roadways were classified as primary (5%), secondary (14%), tertiary (70%), and urban (11%). Primary roadways act as conduits between neighbouring countries to support trade, while secondary roadways allow movement within the country to connect communities. Tertiary roadways link remote areas within the rest of the country, and urban roadways allow movement in urban areas and link communities with hospitals, schools, commercial buildings, and other critical infrastructure within dynamic catchment areas (Muvuringi, 2012).

According to the United Nation Economic Commission for Africa (UNECA, 2011), vehicle accidents continue to increase. In 2011, the caused the death of 1.2 million people and injuries to 30–50 million people in various countries. Furthermore, most traffic accidents (850) during this period involved young people (26–34 years old), with those over 50 being responsible for the lowest number of accidents (147; Muvuringi, 2012). In Zimbabwe, the government continues to raise awareness of the impact of traffic accidents. The Traffic Safety Council of Zimbabwe (TSCZ) has undertaken three initiatives focused on education, administrative logistics, and roadway structure engineering to improve traffic safety in the country.

In 2012, the TSCZ, in conjunction with the Zimbabwe Republic Police (ZRP) and Zimbabwe Hospital Doctors' Association, launched an initiative to highlight the importance of traffic safety for drivers and passengers. Driver licensing laws were amended, with those older than 70 required to renew their licences every five years, and new drivers (over the age of 16) being required to take written and practical tests to obtain their licences. In addition, mandatory vehicle servicing intervals were implemented, as well as minimum requirements for vehicle condition and accessories, such as requirements regarding tyres, lights, reflective breakdown triangles, and so forth.

Furthermore, Zimbabwe began working on a national transport masterplan aimed at improving road safety and the quality of the roadway network. This included reducing speed limits to 60 km/h in urban areas and setting a speed limit of 120 km/h on freeways. Moreover, an audit of the condition of new and old roadway infrastructure was undertaken to identify the need for new roads, for improvements to existing roads, and for minor infrastructure problems (Muvuringi, 2012). According to the Foreign Commonwealth Office (FCO, 2012), bushes and tall trees on roadsides can affect drivers' vision; thus, short grass, shrubs, and trees should be planted to maintain visibility and improve safety, especially at night.

Muvuringi (2012) found that, in Zimbabwe, road safety was affected by poor design, high traffic volumes on narrow roadways, foliage surrounding the roadways, missing or poorly placed traffic signage, and a lack of traffic lanes for cyclists and pedestrians. The study emphasized the value of using accurate traffic data to make design, strategy, and evaluation decisions that promote road safety and awareness of the causes of serious traffic accidents (Muvuringi, 2012).

In addition, Jackett and Frith (2013), in a study conducted in New Zealand, examined the impact of roadway lighting on road safety, as briefly mentioned in section 2.1. According to the New Zealand Transport Authority (NZTA) Economic Evaluation Manual (EEM, as cited in Jackett and Frith, 2013), improving or upgrading poor roadway lighting leads to a reduction of 35% in accidents. The researchers compared lighting measurements collected at existing sites with the CIE standards and matched the measurements to a five-year crash history of the same sections of road. Regression methods were then applied to identify the key predictor variables of the night-to-day crash ratio. The main parameters measured were average luminance, overall uniformity, longitudinal uniformity, and threshold increment.

Jackett and Frith (2013) used the crash and road asset databases to select their study site. Criteria included that at least 10 crashes had occurred at the site between 2006 and 2010, that no significant lighting changes had occurred at the site during that period, and that lighting was consistent along the length of the section of roadway. The database used contained 7,944 crashes that occurred on 152 segments of road with a total length of 270 km. The risk of nigh-time accidents was determined from the night-to-day crash ratio for each road segment (Jackett and Frith, 2013).

Jackett and Frith (2013) clarified the effects of lighting quality and quantity by examining the relationship between daytime and night-time crashes. They suggested that this information be used to revised New Zealand lighting standards, and that before-and-after studies be conducted to evaluate the effects of any changes that are implemented.

Moreover, in 2014, a study was conducted on two sections of roadway: the 39 km stretch of roadway from King Fahd Bin Abdul Aziz Road, via the Abu Dhabi highway, to King Fahad Bridge (Bahrain Bridge), which is the main link between the cities of Dammam and Khobar, and 42 km section of the Abu Dhabi highway (Abu Hadhariyah), which included the Nabiyeh area to the King Fahd Causeway (Bahrain Bridge). These sections were selected because of the high rate of traffic accidents. The purpose of the study was to evaluate the safety on these highways and suggest procedures that may help to reduce the accident rate.

All traffic safety data, such as geographic data related to economic, social, and land use factors; traffic accident reports; and other relevant data and information, were analysed using a Geographical Information System (GIS), statistical analysis programs, and road safety manuals. The researchers attempted to develop a road network model of the Gulf area to evaluate various planning and engineering features in the study area, to measure their impact on traffic safety, and to propose amendments to improve safety. Traffic volumes, the most important factor associated with the traffic rate, were analysed at specific points, sectors, and intersections, both on roadways and in relation to traffic accident sites in the study area to evaluate the rate of traffic flow. Data on traffic accidents were analysed and evaluated based on the spatial coordinates of accidents. Of the 42,517 incidents collected for the city of Dammam, only 62% were associated with geographic coordinates, while 26,538 resulted in injury or death and were associated with coordinates.

The top ten causes of accidents were found to be driver distraction, speeding, running red lights, illegal passing, right-of-way errors, sudden changes of direction, illegal turns, unsafe following distances between vehicles, jaywalking, and a lack of regard for pedestrians and others. Drivers being distracted was a major cause of accidents, accounting for 26% of the total. Speeding accounted for 14%, running red lights for 3%, and sudden changes of direction for 26%.

A total of 860 traffic accidents with geographic coordinates were identified on the two roadways under study, and these were subjected to further analysis to identify the most dangerous accident sites (where fatalities occurred) and their relationships to traffic volume and average vehicle speeds. The data analysis data showed that long travelling times and delays occurred on the sections of King Fahad Highway due to the high volume of vehicles during the peak period in the Dammam area and the presence of large number of pedestrians at the traffic signals in Al Khobar. It was also noted that the level of service on highways in Gulf Cooperation Council countries (Abu Hadria) is high, as indicated by average travelling speeds and the lack of congestion. Additionally, it was found that travel times and delays during the evening rush hour were higher longer than those during the morning.

The researchers made several recommendations to reduce the accident rate:

- The heavy traffic on the links and intersections of King Fahad Road inside Dammam and Khobar should be studied, and signs and safe crossing options should be provided for pedestrian traffic.
- Studies should be conducted to gather data on the behaviour of road users, as this will aid in the identification of the actual causes of accidents.
- Sites of fatal crashes identified in the research should be analysed to find potential solutions and determine whether roadway maintenance is required.
- Stricter controls should be implemented at the entrances to tunnels and bridges to avoid problems in high-volume areas that cause delays, especially during peak hours.
- The specified speed limits on the road network in the area should be checked and reviewed, and speed signs should possibly be updated (Al Mojil et al., 2017).

Al Mojil et al. (2017) emphasized the important of studying and analysing the inputs that affect vehicle accidents, such as traffic volume and speed, travelling time, areas where vehicles obstruct each other, causes of the accidents, and traffic station concentration points, which have been related to specific geographic coordinates. It would also be helpful if research covers the time of day of accidents to determine whether differences exist due to lighting or other issues. The suggested solutions should be implemented as a pilot projects to allow the evaluation of the results and determine whether they improve road safety on highways.

3.2.2. Field Measurements Methodology

Field measurements, or field study, can aid in collecting data and with observing and interviewing study subjects. This method allows researchers to take notes while observing the study subject, and they can ask subjects direct questions during these observations. Once researchers' questions have been answered or data have been collected, they can use the information for statistical analysis or to create workflow Charts to solve specific problems. This methodology is useful in the earlier stages of the research process, as it can capture ongoing observations, enhance the analysis, or facilitate the identification of important variables (Usability Body of Knowledge, 2012).

According to Design and Engineering Services (DES; 2009), field assessments had been done to evaluate the performance of roadway lighting at four test sites in the United States. The test sites covered four climatic zones: coastal area, metropolitan, central valley, and desert. The data was used to compare the performance of LED and HPS lighting (DES, 2009). Specialized equipment was installed on street light poles, and the data was downloaded via a Global System for Mobile communications (GSM) cellular connection (DES, 2009). The testing involved continuous spot measurements, as well as monitoring of ambient temperature, relative humidity, internal luminaire temperatures, and power (DES, 2009).

At each of the four test sites, two sets of monitoring equipment were installed, with one measuring the baseline HPS and both the LED luminaire types studied. The baseline luminaires at the coastal area test site in Ventura were 70 W HPS at 240 V, while the baseline luminaires at the metropolitan test site in Rosemead were 100 W HPS at 120 V. For the central valley site in Tulare, the baseline luminaires were 70 W HPS at 120 V, and for the desert site at Palm

Springs, the baseline luminaires were 200 W HPS at 120 V. The field measurements revealed the overall differences between HPS lighting and the two types of LED luminaire. The maximum average footcandles observed for HPS was 1.07 fc at Palm Springs, and the minimum was 0.31 fc at Tulare. The maximum average footcandles observed for the LEDs was for luminaire H, at 1.21 at Palm Springs, and the minimum was for luminaire A at Tulare and H at Palm Springs, at 0.21 fc (DES, 2009)

This paper highlighted the different between HPS lighting and two types of LED lighting systems in various climates and in terms of cost and efficiency. The lighting measurements underscore the importance of lighting distribution and reveal that the best lighting levels were observed in the moderate climate of Palm Springs. It was also found that LED lighting was 40% more efficient than HPS, but that installation and maintenance were identical for LED and HPS lighting, although over a relatively short period of 11.4 years (DES, 2009).

In their 2012 study, Haans and Kort conducted an experiment to evaluate women's perceptions of personal safety in areas with dynamic street lighting. The experiment involved 29 pedestrians between the ages of 19 and 30, and it took place on the De Zaale campus of Eindhoven University of Technology in the Netherlands, one a main road open to vehicles, cyclists, and pedestrians. The test site featured several 10 m located approximately 30 m apart. Each lamppost was fitted with a Philips CitySoul BGP431 GRN88 LED luminaire installed next to an HPS lamp. The LED luminaires featured 84 LEDs with 106 W of combined power and 8,820 lm of luminous flux at full power. The test roadway was divided into two parts: the western section had buildings and parking lots on either side, while the eastern section had buildings on one side and a lawn and square on the other. Each section was about 150 m long, with five LED luminaires. Several lights on and adjacent to the test site were switched off. The weather was rainy to dry, and temperatures were between 8 and 17 °C.

The researchers conducted a 2 by 3 within-subject experimental design involving conventional, ascending, and descending lighting distributions). For the conventional lighting distribution, the lampposts were adjusted to 40% of their maximum illuminance output (E), which generated an illuminance of 7 lux. For the ascending condition, the light in participants' immediate area was reduced and the light on the road ahead increased. Thus, the light nearest the participant was set to 1% of E, which equated to 0.5 lux, and gradually increased for each subsequent lamppost, eventually reaching 80% of E and 12.5 lux. The opposite was done for the descending condition.

Participants, with a maximum of four taking part per session, were asked to stand at the centre of the test site and to point out which lighting scheme they preferred in terms of perceived personal safety by observing the western and eastern roadways. Participants also completed questionnaires about personality characteristics and the lighting schemes they observed. They were asked to rate their level of comfort with walking along the roadways at night on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), with the mean of the presenting the mean representing the aggregated safety measure. The data collected was analysed using the Rasch model, through Facets software. This type of analysis yields results similar to that of conventual Thurstonian scaling. The findings of the study indicate the site conditions such as lighting play a significant role in the comfort levels of pedestrians.

In 2012, Bullough, Rea, and Zhang, after conducting field assessments as part of their study, proposed a novel bollard lighting technique for pedestrian walkways to raise the focus of the light from the roadway surface to make pedestrians more visible to drivers and to thus reduce traffic accidents. Their experiment assessed illuminance levels with various vehicle headlight configurations. Photometric imitation was used to recreate lighting scenarios such as high lighting levels that obscure vision and lighting on curved walkways. The Relative Visual Performance (RVP) model, a quantitative model based on the accuracy and speed of visual processing, was used to enhance lighting levels and integrate the data obtained through field measurements, such as that relating to driving speeds. The variables of contrast, luminance, size, and age of the driver were changed in the model, with the latter necessitated by the changes that take place in the human eye between the ages of 20 and 60. RVP results closer to 0 demonstrate poor visibility, such as viewing an object on the roadway in thick fog, while 1 tends towards maximum clarity.

The proposed lighting configurations were evaluated using four groups of four participants each (16 participants). For the first condition (A), lighting was sited 100 ft away from the crosswalk; for the second (B), the lighting was set 18 ft away on temporary poles, with 60 W metal halide lights; for the third condition (C), lighting was placed 20 ft from each end of the crosswalk but within the traffic stream; and for condition four (D), 28 W fluorescent downlights were placed 7 ft from the ends of the cross walk. For all scenarios, the approaching vehicle had low-beam headlamps. (Bullough, Rea, and Zhang, 2012).

The RVP results were in the lower half of the estimated target of (3 ft × 1.8 ft for the adult target, and 1.5 ft × 0.8 ft for the child target). The results were derived from the four lighting conditions and three positions used to calibrate luminance, luminance contrast, RVP, and time period. RVP values of 0.8 or more were taken to indicate adequate visibility, and if this value was maintained in multiple lighting scenarios, the lighting technique was deemed suitable. RVP values of 0.79 were obtained for halogen and 0.77 for HID on the left side of the road, and 0.78 for halogen and 0.76 for HID on the right. In this study, the field measurements emphasized the impact of RVP on different sides of the road to clarify the effects of changing the parameters that affect roadway lighting to create different scenarios and to identify the most suitable luminance level and lighting scheme (Bullough, Rea, and Zhang, 2012).

Although the study by Bullough, Rea, and Zhang (2012) is interesting because it covers a six-year test period and focuses on highways, it did not address the incidence of car accidents at night or examine the cause of these accidents

In addition , Frith and Jackett (2015), illustrated study on the relationship between roadway lighting and night-time traffic accidents, discussed in detail in Chapter 2 , measured the luminance of roadway lighting in Auckland and Hamilton using a fixed digital camera installed on the roof of a car. Conditions faced during data collection included various types of traffic areas, speed limits, flat and level ground, the presence and absence of roadway lighting, and stopping at intervals. To identify the possible influence of the survey vehicle's lights on the measurements obtained, several measurements were taken on a flat, level surface. The vehicle's dipped beams produced luminance below 0.1 cd/m^2, 32 m in front of the driver's left and 20 m in front of the driver's right. Because CIE calculations of surface luminance begin at a point 60 m in front of the observer, the vehicle's headlights did not interfere with the measurements. The researchers undertook not to take measurements within 40 m of the driver on level roads, 'or for a correspondingly greater distance if crest curves were involved' (Frith and Jackett, 2015,). The second consideration was finding the ideal place to mount the camera. Inside the vehicle it would be protected from the elements and from contaminants such as dust, but the windscreen would act as a barrier during data collection due to characteristics such as curvature and the reduction of light transmission due to the rake of the windscreen. The alternative was mounting the camera on the roof of the vehicle, which would be technically superior yet challenging in terms of installation, weatherproofing, and wind loading. Consequently, the researchers decided to mount the camera in a weatherproof container, with a small video camera mounted in the car to continuously record the general forward scene and to allow the researcher to record notes while driving (Frith and Jackett, 2015).

The user monitored the video feed through using a dash-mounted Tablet equipped with the Auckland Motorways Alliance's 'Mobile Road' application. This software validated the process by capturing roadway routes, locations, and geocoding information that could be integrated with the data. In addition, the camera was connected by cable to a digital 'notebook' inside the car that allowed the researchers to take photos remotely. The photos were relayed back to the notebook to allow the researchers to monitor the functioning of the camera. Furthermore, a Global Positioning System (GPS) recording was taken at 1 second intervals to ensure that all photos were geocoded. The final database consisted of 97 locations with roadway lighting where 9,978 accidents occurred, and 27 locations without roadway lighting where 851 accidents occurred (Frith and Jackett, 2015).

Frith and Jackett (2015) is a continuation of their previous work on the relationship between roadway lighting and night-time accidents. The analytical methods used in the 2015 study include a before-and-after study, generalized linear modelling, a corridor study, and a relational study. The data collection method had been refined over roughly 18 months, from September 2014, when the pilot study was conducted, to March 2015.

3.2.3. Simulation Methodology

According to regulations published by the Department of Municipal Affairs and Transport in Abu Dhabi, United Arab Emirates, in 2016 on roadway lighting systems, luminance calculations must be made using the DIALux software program (Department of Municipal Affairs and Transport, 2016). Similarly, in their study on selecting indoor and outdoor lighting systems by considering design, structure, and lighting properties, Malliga, Preetha, and Merlin (2017) highlighted the benefits of DIALux software. One of its main benefits is that its recognized worldwide among leading manufacturers, partly because of readily available free online versions (Malliga, Preetha, and Merlin, 2017).

DIALux software allows users to collect data about daylight, the intensity of lighting, and energy consumption and savings. It can be used to overcome research constraints related to space and climate. Software features include energy analysis and light level comparison to other types of lighting elements. In addition, DIALux allows users to compare luminaires by manufacturer and cost (Airfal, 2014).

Several researchers have chosen Autodesk Ecotect Analysis to study lighting and energy consumption. Somboonwit (2011) found Autodesk Ecotect Analysis helpful for analysing energy performance in light of environmental factors at the site such as humidity, temperature, and wind speed. Similarly, Reinhart and Wienold (2011) contend that Autodesk Ecotect Analysis can be used to conduct daylight analyses for the spaces of any buildings because the program captures brightness data that can be formatted according to both simple and complex spaces (Reinhart and Wienold, 2011). Aksamija (2013) stated that Autodesk Ecotect is helpful in studying various types of building façades and envelope designs that influence indoor energy consumption and affect the efficacy of daylight in indoor spaces.

Autodesk Ecotect Analysis can draw guide maps for designers by helping them visualize buildings envelopes from the initial design stages, and it manages the complexity of the structural form in the final stages. It measures solar radiation for the features of the building, from walls and windows to roofs. Other software features include the ability to set zones, materials, directions, and space sizes, with performance evaluations that cover energy consumption, lighting levels, and shade. Results can be calculated using daily or yearly statistics (Web.archive.org, 2016; Autodesk, 2017).

However, the advantages of Autodesk Ecotect Analysis do not extend to this case study, as federal roadways and their attendant environments differ vastly from the sites studied by Somboonwit, Reinhart and Wienold, and Aksamija.

Another alternative to DIALux is AGi32, a simulation program that can be used to conduct quantitative analyses of direct and reflected light on any surfaces and to evaluate the quality of light in any spaces. Program features include a user-friendly interface for lighting analysis and modelling and excellent rendering quality in both interior and exterior spaces. Furthermore, the program can be used to conduct point-by-point, roadway luminance, and ceiling analyses (Lighting Analysts, 2014).

According to Harris, Montes, and Forbes (2015), AGi32 is lighting modelling software that recognises the effects of lighting in external and internal spaces. The lux level analysis and distribution in any spaces can be converted into a daylight factor for comparison with CIE standards (Harris, Montes, and Forbes, 2015).

In addition, the program can calculate the patterns of roadway structures from luminaire coordinates, poles, and visualization lighting levels. This can help users calculate the maintenance and replacement costs of luminaires. Moreover, the software can integrate international codes and standards relevant to roadway lighting such as British and CIE standards through configuration tools that facilitate roadway design. It also be used with programs such as CAD and improve the results of lighting by allowing the use to change the materials, surface features, and lighting layout (Lighting Analysts, 2017).

3.3. Research Methodology Selection

Choosing an appropriate methodology that can be used to achieve the aims and objectives of research, and to answer the research questions, is a crucial aspect of conducting a valuable study. In this case, choosing an appropriate methodology was achieved by comparing the suggested methodologies of case studies, field measurements, and simulation and asking key questions:

- Which methodology relates to facts, data, and reality?
- What is the percentage of accuracy of the results that support the research?
- How can the selected methodology support the variables of the parameters?
- What are the considerations and limitations that affect the data flow of the research?

Thus, the strengths and weaknesses of each methodology were evaluated while considering the efficiency of the data analysis. The case study method, and its use in previous studies, was used as a benchmark to guide the researcher, as it can be employed to investigate study subjects to find and observe answers to hypotheses.

The field measurements methodology, which involves using specific instruments to record results and changes to variables in the field to collect and classify data related to the aim of the research, has limitations related to time, climate, and outdoor measuring tools. A prototype can be used to describe the subject under study by testing key variables over time and in certain locations. However, conducting research on a federal highway can cause traffic jams and be subject to delays. Closing a highway to conduct research on it would involve finding an alternative route for road users and calling on local and other authorities for assistance.

With the computer simulation method, researchers can use software to analyse the data and test the variables identified separately. This type of software is typically easy to use, allows continuous changes, and delivers results quickly. The results can be translated to accurate Figures and Tables due to the number of trials and the ease of error correction. Because the subject of the research—a highway—is linear in shape, field measurements and simulation are both suitable for data collection and analysis. Consequently, the following factors were considered when choosing a research methodology:

- Dependability:the quality of the data and information can be used as a benchmark in further studies and research.
- Realism:the results address the research question.
- Time:enough time is available to collect, categorize, and analyse data using this method.
- Value:it opens doors to new research, studies, and even methods built on the foundation of previous works.
- Validity:the method measures what it is supposed to measure, and results do not change when unrelated variables change.
- Cost:the funds are available for the equipment, programs, and consultants' fees required for accurate analysis.

- Flexibility:it is easy to input data, conduct analyses, make changes and adjustments throughout the data collection process to allow more rigorous testing and thus minimize errors and maximize accuracy.
- Accuracy:the basic data is accurate, and advanced tools, techniques, and software is available to ensure accuracy in the data analysis.

The researcher evaluated the proposed methodologies by considering these characteristics, as this allowed him to choose a methodology that supported the objectives of the research and facilitated findings answer to the research questions ,as shown in Table 3.1.

Table 3.1: Characteristics of the methodologies evaluated

(Source : Author , 2018)

Evaluation characteristics	Case study methodology	Field measurements methodology	Simulation methodology
Dependability	×	×	√
Realism	√	√	√
Time	×	×	√
Value	×	√	√
Validity	√	√	√
Cost	×	√	√
Flexibility	×	×	√
Accuracy	×	√	√
Key of evaluation: √ Yes × No			

As can be seen from Table 3.1, the case study method has weaknesses related to accuracy, flexibility, value, and other characteristics that would affect this research. Furthermore, the field measurements methodology would require local and federal approval and a plan to reroute traffic when the measurements would be taken. This was not approved and was considered unaccepTable. Thus, the simulation methodology was found to be the most suitable for this study.

3.4. Research Software Selection

Because the simulation method was selected for this research, it was important to select suitable simulation software that would allow the researcher to study impacts on and changes in the variables by setting a constant variable and adjusting the other variables. At the same time, the researcher had to be able to test the segment of highway under study through a test module using the data collected from the MoID. The characteristics evaluated to choose an appropriate software program were

- Structural simplicity and ease of use: It is easy to learn how to use the software and to input data to generate Figures and statistics, and it has a user-friendly interface.
- Roadway lighting analysis features: It includes a module for analysing the lighting levels on roadways and related data.
- Compatibility with other software: It can read and analyse data from other programs such as Revit and AutoCAD, or the relevant data must come preloaded.
- Compatibility with international standards: It can integrate and evaluate international standards related to roadway lighting, such as British standards, CIE 115, and CIE 140.
- Cost: It is affordable or available for free download.
- Recommended for use in the United Arab Emirates: It is recommended for use in the tendering and contracting phases.

Table 3.2 : Comparative summary of the three software programs considered.

(Source : Author , 2017)

Evaluation characteristics	Ecotect	AGi32	DIALux
Structural simplicity and ease of use	√	√	√
Roadway lighting analysis features	×	√	√
Compatibility with other software	√	√	√
Compatibility with international standards	×	√	√
Cost	√	√	√
Recommended for use in the United Arab Emirates	×	×	√
Key of evaluation: √ Yes × No			

The above Table illustrate the suitable simulation software through evaluation characteristics. All of the three simulation softwares are structural software simple and friendly use , which can identify the features and properties through help menu within the softwares .(Marinoa, Leccese and Pizzuti, 2017).

On the other hand, features analysis lighting in roadways characteristic are aviable in both simulation softwares AGi32 and Dialux that are capable to analys lighting outdoor spaces and linear shapes, while Ecotect simulation software adjust to analysis lighting indoor spaces only (Reinhart and Wienold, 2011).While both AGi32 and Dialux got the ability to compare the measurement outputs with international standards such as CIE,but Ecotec can’t compare the results with the international standards and codes (Agi32.com, 2017).

Beside that , all the simulation softwares are free download from the official website. While, Dialux in the most used in analysis lighting measurements in roadways in UAE which recommened in the infrastructure authorities such as MoID and Department of Municipal Affairs and Transport in Abu Dhabi.

After the evaluation characteristics of the three simulation softwares , Dialux software was selected as simulation program that focus on lighting measurements in federal roadways to addressed the recognizing of lighting levels especially at night time to ensure the safety to the drivers.

3.5. Methodological Map

The methodological map acts as a research guide that sets out the process to follow to collect the research data, process the results, and draw conclusions from the results to generate findings, as shown in Diagram 3.2.

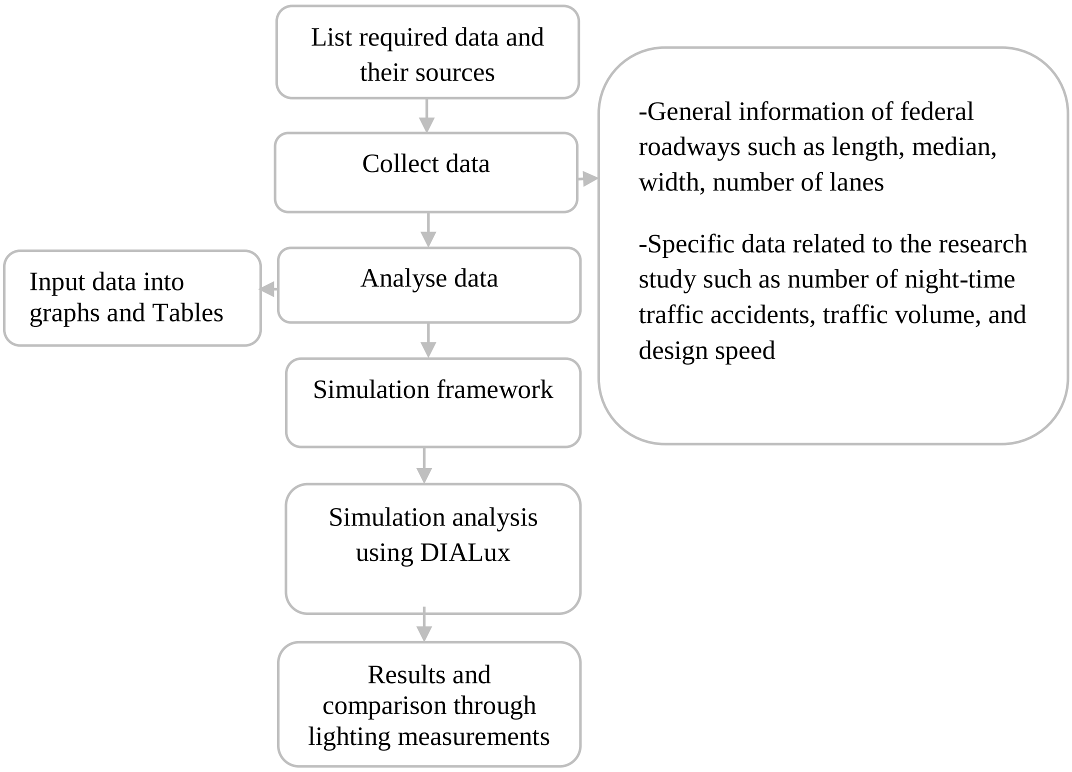


Diagram 3.2 : Methodological guide map
(Source : Author , 2018)

The first step was listing the data required, such as statistics on night-time accidents, a list of federal roadways, and details about the existing roadway lighting system, and the data sources, such as the Ministry of Interior and MoID. The next step was collecting the data using communication tools such as interviews and official correspondence. Then, the data analysis was conducted by creating graphs and Tables to define the relationships between values and establish an evaluation method that supports the selection of the federal roadway as a research case study, as is explained in Chapters 4 and 5.

In addition, a simulation of the existing lighting system and the proposed LED system, using HPS lighting as a baseline, was carried out to compare the two systems with each other and with British standards. Simulation details are discussed in Chapters 4 and 5.

3.6. Justification of Methodology

The research focused on a 1 km segment of one federal roadway, and the existing HPS lighting system and the proposed LED lighting system were studied using a variety of factors that affect several parameters that affect lighting output. Computer simulation was considered the best choice for the research, which involved examining the HPS and LED lighting systems using lighting measurement values, graphical data representation, and comparisons with British standards.

Furthermore, simulation was deemed the most time efficient. Simulation phases, which are explained in detail in Chapters 4 and 5, focused on parameters that can affect lighting results, starting with the base case and then being revised to define the optimum case. Several parameters were adjusted: boom angle, pole height, pole spacing, pole arrangement, and number of luminaires, which have been examined in several scenarios, as mentioned by Marinoa, Leccese, and Pizzuti (2017) and Lee, Moreno, and Sun (2013).

The field measurements method would have been unsuitable, as it would have involved spending a year collecting measurements on the existing HPS roadway lighting system and then waiting for the operating phase of the new LED system to commence. Completion will take around 2 years, depending on the availability of funds and qualified roadway construction consultants, which would have had a significant impact on the time and cost of the study. Thus, computer simulation was the appropriate choice.

3.7.Summary

This section contains a summary of similar studies using the suggested methodologies. The lessons learned from each study had the potential to enhance the evaluation framework of the lighting systems on federal roadways, as shown in Table 3.3.

Table 3.3: Summary of Chapter 3

(Source : Author , 2018)

		Study	Reference	Lessons learned
Methodologies	**Case study**	German Ministry of Traffic, 2011	Manner and Wünsch-Ziegler, 2013	Factors affecting severity of accidents: • Accident type • Weather conditions • Cause of accident • Road condition/presence of construction • Average daily traffic
		Network roadways in Zimbabwe, 2012	Muvuringi, 2012	• Studied reasons for traffic accidents with respect to population growth • Raised awareness of the impact of traffic accidents through three initiatives focused on education, administrative logistics, and roadway engineering • Established draft national transportation masterplan to improve vehicle quality and roadway network
		Study conducted in New Zealand	Jackett and Frith, 2013	Main parameters that influence roadway lighting distribution: • Average luminance • Over all uniformity • Longitudinal uniformity • Threshold increment Created list of guidelines to improve roadway sections through before-and-after studies
		King Fahd Bin Abdul Aziz Road, via the Abu Dhabi highway to King Fahad Bridge	Al Mojil et al., 2017.	• Traffic volume was most important factor in decreasing accident rate • Traffic accidents were analysed and evaluated based on spatial coordinates of accidents • Studied the causes of traffic accidents • Suggested solutions should be implement and impact on roadway safety measured to evaluate effectiveness
	Field Measurements	Design and Engineering Services, USA	DES, 2009	• Evaluated the performance of roadway lighting in four climatic zones, focusing on cost and efficiency • LEDs had 40% lower energy consumption than HPS lights
		Impact of light distribution on pedestrians, Netherlands	Haans and Kort, 2012	• Examined pedestrians' perceptions of roadway lighting and personal safety • Used questionnaire survey to gauge participants' perceptions of night-time pedestrian safety
		Novel bollard lighting techniques	Bullough, Rea, and Zhang, 2012	Tested pedestrian crosswalk illuminance levels with different bollard lighting configurations. Photometric simulation was carried out to test light rendering and the effects of different lightings schemes on drivers Lighting factors that affect lighting distribution levels and visibility: • Contrast • Luminance • Size of pedestrian and age of observer
		Roadway lighting and traffic accidents at night	Frith and Jackett, 2015	Identified factors that affect traffic accidents and lighting distribution: • Traffic areas • Speed limits • Pitch of ground • Absence and presence of roadway lighting GPS used to identify accident locations

		Study	Reference	Lessons learned
Methodologies	Simulation	DIALux software properties	Department of Municipal Affairs and Transport, 2016	The luminance calculation must be considered and must be achieved through DIALux program
			Malliga, Preetha, and Merlin, 2017	DIALux software analysis according to type of lighting system and indoor and outdoor spaces, depending on the structure and design of lighting properties
			Airfal, 2014	Software has specific features and capabilities such as energy analysis and light level comparison with other types of lighting elements
		Autodesk Ecotect	Somboonwit, 2011	• Analyses of energy performance after analysing climate factors of the selected site such as humidity, temperature, and wind speed for building spaces • Program does not offer roadway lighting analysis
			Reinhart and Wienold, 2011)	Program offers daylight analysis for any spaces in any buildings, whether simple or complex
			Aksamija, 2013	Software is capable of analysing various types of façade and building envelope designs that influence indoor energy consumption and affect daylight efficacy in indoor spaces
			Autodesk, 2017; Web.archive.org, 2016	Properties of the software such as zone settings, materials, directions, and space sizes. The performance evaluation covers energy consumption, lighting levels, and shade
		AGi32	Lighting Analysts, 2014	• Calculates numerical analysis of direct and reflected light on any surfaces • Program can perform point-by-point, roadway luminance, and ceiling lighting analysis
			Harris, Montes, and Forbes, 2015	Lux level analysis and distribution in any space can be transformed into daylight factor and compared to CIE standards
			Lighting Analysts, 2017	Calculates the patterns of roadway structures of luminaire coordinates, poles, and visualization lighting levels

Chapter 4: Computer Simulation Model

4.1. Introduction

In this chapter, the researcher explains the analysis process and the parameters selected to test the effects of lighting system outputs on federal roadways. The testing parameters chosen were derived from the literature review and studies that examined HPS and LED lighting systems. The simulation process was divided into five phases that formed a framework to guide the investigation of suitable outputs, as shown in Diagram 4.1.

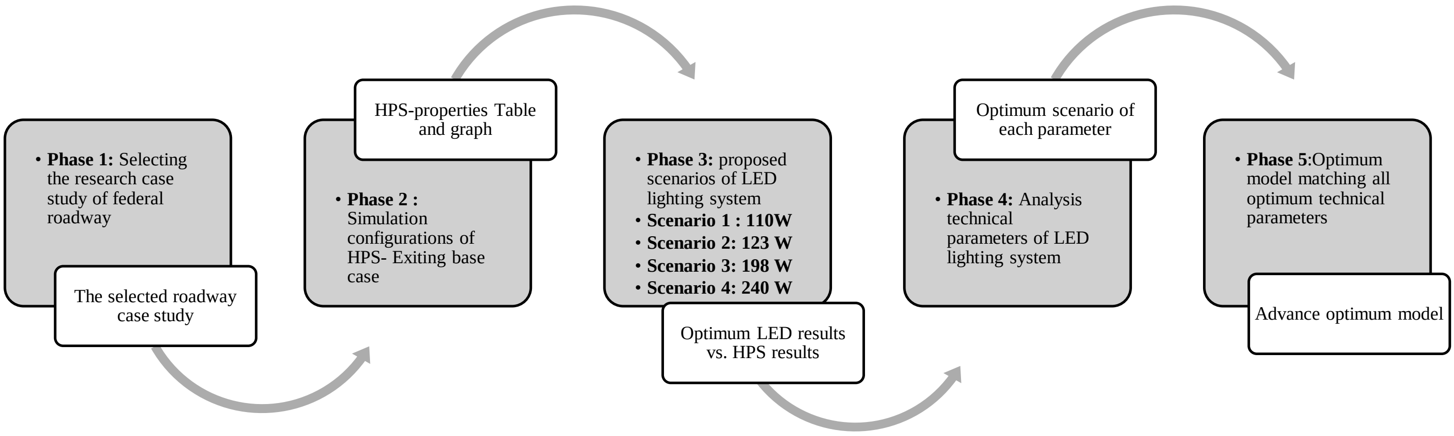


Diagram 4.1: Simulation phases
(Source : Author , 2018)

As shown in Diagram 4.1, the analysis began with phase 1, which involved selecting the research case study from group of federal roadways using factors previously identified. In phase 2, the simulation configurations were set for the existing HPS roadway lighting system, which would serve as a baseline, focusing on the properties of HPS lighting and its output results in graphic and tabular form. During phase 3, four proposed LED lighting scenarios:109 W, 123 W, 198 W, and 240 W were tested to determine the optimum LED results compared to the HPS results. Next, in phase 4, the technical parameters of the LED system were examined and evaluated to identify the optimum scenario for each of the five parameters selected, namely boom angle, pole height, pole spacing (as set out in Marinoa, Leccese, and Pizzuti, 2017), poles proven arrangement as set out in (Lee, Moreno, and Sun, 2013), and number of luminaires.

Number of luminaries were also found to affect the research, and the researcher hypothesized that this parameter could enhance sustainability and reduce the number of poles required. However, whether this was the case depended on the results of the simulation.

These parameters were tested in several trials to determine the optimum parameter choice and combination. The results of local field studies undertaken by the MoID Project Planning Department, which aimed to integrate local requirements with international standards, were also considered (Bitar, 2017). Subsequently, the optimum design identified was simulated to generate an optimum and the final model. Each simulation was summarized to capture the basic input variables and luminance output data and rendered as a graph.

In early 2014, the UAE National Agenda 2021 was established. The agenda, which was developed by more than 300 officials from 90 federal and local government entities, includes a set of national indicators in the sectors of education, healthcare, economy, security, housing, and infrastructure and government services. These indicators are long term, measure performance outcomes in each of the national authorities, and generally compare the performance of the UAE government to similar competitive global benchmarks and best practices. Government leaders are working hard to ensure their targets are achieved by 2021 through periodically monitoring the improvements in these national indicators.

The MoID is responsible for the construction of buildings and for supervising the progress of infrastructure projects such as housing, federal roadways, and federal service buildings. A case study was selected from the federal roadway network (Northern Emirates), as shown in Figure 4.1 below.

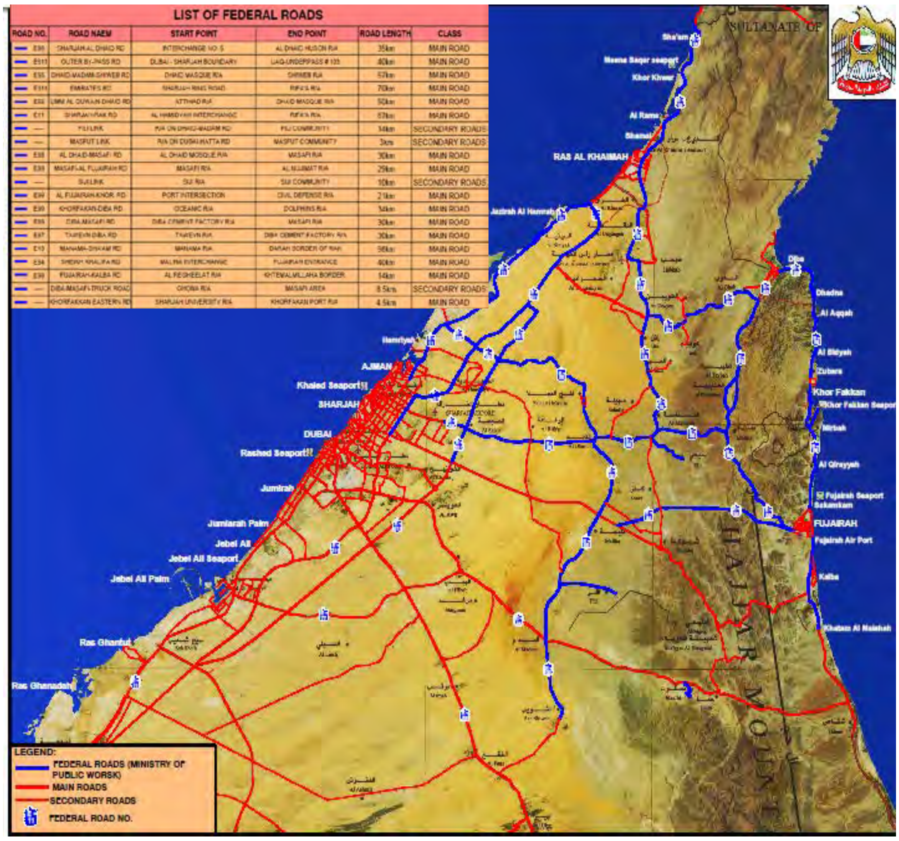


Figure 4.1: Federal roadways network in UAE

(Source : Author ,image from Google Earth, 2018)

These roadways, which include various roadway classifications, cover more than 750 km, and include, for example, major roadways that link different emirates, such as E311 Shaiek Mohammed bin Zayed that runs from Abu Dhabi through Dubai and Sharjah up to Ajman, and other roadways that act as internal connecting roadways linking main settlements, such as Hamad Bin Abdullah Road in Fujairah. The latter falls under the purview of the MoID despite being a local road and not a federal roadway that is directly related to the ministry.

Federal roadways are identified with the initial letter E of the word Emirates, followed by a number (e.g., E55, E18). This federal labelling system is used throughout the United Arab Emirates. The details of the federal roadways are shown in Table 4.1.

Table 4.1: List of federal roadways in the UAE

(Source : Author ,2017)

Federal roadways name		Length (km)	Width (Km)	Median	Shoulder Width (Km)	No. of lane
E11	Ittihad	58	3.65	6	2.5	2,3
E18	Manama-Karan-Shaam	94	3.8	6	2.5	2
E84	Shaiek Khalifa bin Zayed	39	3.65	4	3	3
E87	Dibba–Tawain	30	3.65	4	2.5	2
E88	Sharjah–Al Dhaid–Masafi	35	3.65	6	2.5	1,2
E89	Massafi–Fujerah	28	3.8	6	2.5	2
E99	Dibba–Khorffakan–Fujirah–Kalba	55	3.65	6	2.5	2
E311	Shaiek Mohammed bin Zayed	24	4	8	3	3
E611	Emirates	71	3.8	6	3	3

Table 4.1 indicates the width and length in kilometres of each roadway in addition to shoulder width and number of lanes. The longest roadway is E18 Manama–Karan–Shaam, at 94 km, while the shortest is E311 Shaiek Mohammed bin Zayed, at 24 km.

These roadways were compared and evaluated using the quantitative method based on factors generated from the literature review. The quantitative method allows researchers to evaluate and present data using objective measurements and statistical or mathematical analysis, such as rate of occurrence, and to ascribe weights to factors according to their importance.

4.2. Phase 1: Analysis of Federal Roadways Priority Index

In this study, several factors (F) have been identified and chosen to generate a Federal Roadways Priority Index (FRPI). These factors were used in the selection of a federal roadway as case study by evaluating the roadways through a grading matrix, with a maximum potential score of 100 marks. Number of night-time traffic accidents was assigned the highest potential score of 30 marks due to the importance of this factor in the study. The author based the weight of each factor on the information collected during the literature review and on the objectives of the study.

The factors and potential points used to evaluate the roadways and to select one for the case study are as follows:

List of factors	Weight
1. Number of accidents on the federal roadway at night time	= 30 marks.
2. Traffic Volume	= 20 marks.
3. Speed limit	= 20 marks..
4. Topography	= 15 marks.
5. Number of urban settlements	=15 marks.
6. Pedestrains	= 0 marks
Total marks	**=100 marks**

In addition ,the evaluation equation of the total marks can be identified as shown in quation 1.

$$FRPI = \sum F_i \, Qf_i$$

Where F_i is the factor weight according to its classification, and Qf_i is the quantity factor. Further information about the factors, such as definition, unit of measurement, source of information, and factor weight according to its importance in the study, appears in Table 4.2.

Table 4.2: Federal roadway priority index

(Source : Author ,2017)

No	Factors (Fi)	Definition	Units	Source	Factor weight
F_1	Number of night-time accidents on the federal roadway	When a vehicle driven on a roadway collides with an object or another car at night	Number	MoID Road Department reports of traffic accidents on federal roadways	30
F_2	Traffic Volume	Number of vehicles crossing or using roadways daily	Number	MoID Road Department	20
F_3	Speed limit	Speed driven on roadways, with limits of speeds prescribed and allowed	km/h	UAE traffic laws	20

No	Factors (Fi)	Definition	Units	Source	Factor weight
F_4	Land topography of UAE federal roadways	Geological characteristics of the land, e.g., contours and slope lines on the surface	N/A	UAE Government	15
F_5	Urban settlements	Number of urban settlements served by federal roadways	Number of settlements /federal roadway	MoID Road Department	15
F_6	Pedestrians	People walking and cycling on pedestrian spaces or crossing the roadway	Number	This factor has been omitted from the study because it falls outside the scope of the study.	N/A
Total					100

The first factor (F_1) is the number of night-time traffic accidents. The statistical data was collected from traffic accident reports dated from the end of 2016 to August 2017. This factor is key, as the increase in traffic accidents at night time can be linked to lighting and road safety. The points were distributed into five categories with a quantitative multiplication factor (QF_1) of 6. For F_1, fewer than 20 traffic accidents scored 1, 21–40 accidents scored 2, 41–60 scored 3, 61–80 scored 4 marks, and more than 81 scored 5, as shown in Table 4.3, with further details available in Chapter 5 and Appendix (A).

Table 4.3: Weighted distribution of factor F_1

(Source : Author ,2018)

Number traffic accidents at night	Weight
0-20	1
21-40	2
41-60	3
61-80	4
more than 81	5

Table 4.4: Number of traffic accident at night time ,2016-2017

(Source : Author ,2018)

Federal Roadways Name		Total traffic accidents at night 2016-Auguest 2017
E11	Ittihad	23
E18	Manama-Karan-Shaam	81
E84	Shaiek Khalifa bin Zayed	9
E87	Dibba–Tawain	45
E88	Sharjah–Al Dhaid–Masafi	50
E89	Massafi–Fujerah	12
E99	Dibba–Khorffakan–Fujirah–Kalba	30
E311	Shaiek Mohammed bin Zayed	68
E611	Emirates	44
Total traffic accidents at night time		368

The second factor (F_2) is traffic volume, which was calculated from the instant traffic system that displays traffic data such as average speed, traffic volume, and roadway occupancy percentage, in real time. The data was taken from traffic counting stations distributed all over UAE federal roadways, as shown in Figure 4.2.

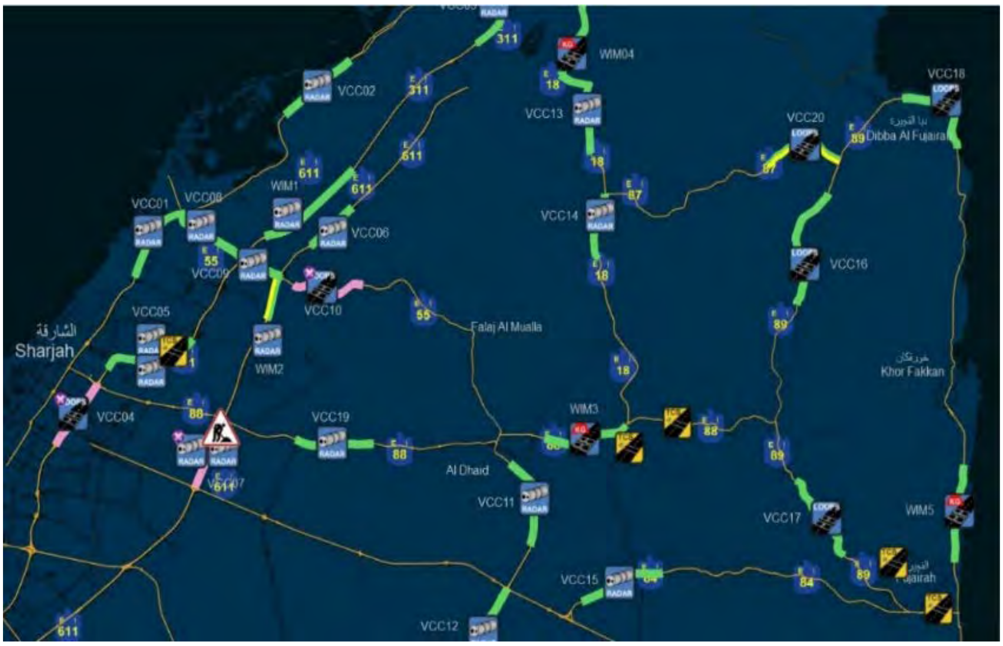


Figure 4.2: Traffic counting stations across UAE federal roadways

(Source : MoID, 2017)

The collected data covers the past three years, with specific codes for the traffic volumes of each road, which allows the system to calculate average daily traffic by number of vehicles, as shown in Figure 4.3 and Appendix (B).

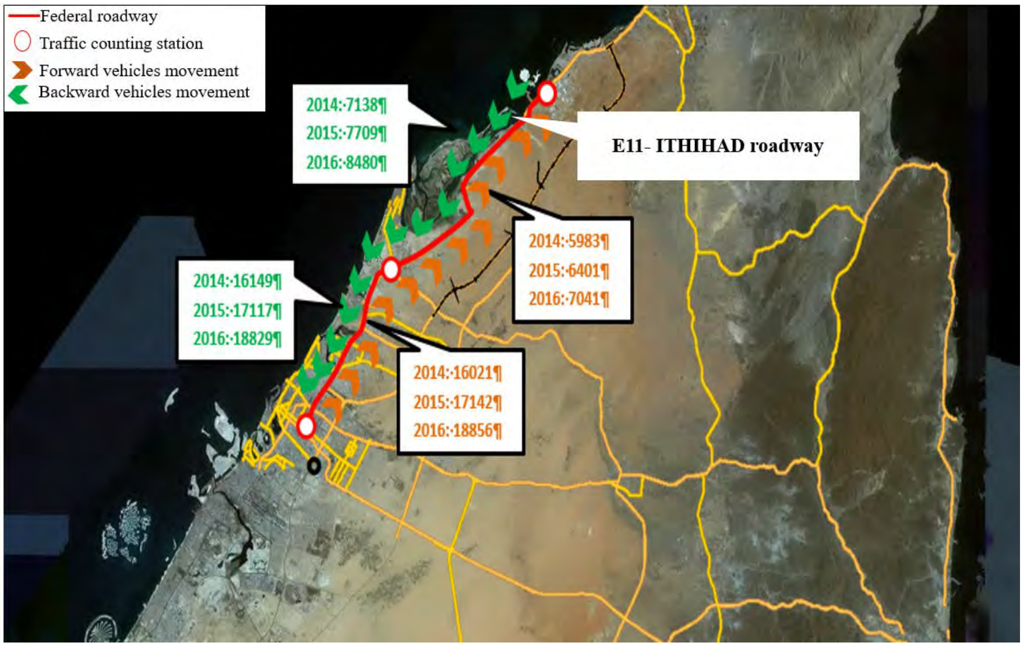


Figure 4.3: E11 Ittihad roadway traffic volume
(Source : Author ,2017)

The latest available data spanned 2014 to 2016, which was one of the limitations of this study, as noted in Chapter 1.The weight points were distributed into five categories, with a quantitative multiplication factor (QF_2) of 4: average daily traffic less than 100,000 vehicles scored 1; 101,000–200,000 vehicles scored 2; 201,000–300,000 scored 3; 301, 000–400,000 scored 4; and more than 401,000 vehicles scored 5, as shown in Table 4.5.

Table 4.5: Distribution of weight points for F_2
(Source : Author ,2018)

Average daily traffic	Weight
Less than 100,000	1
101,000 – 200,000	2
201,000 – 300,000	3
301,000- 400,000	4
more than 401,000	5

The highest average daily traffic were recorded on E311 SHAIEK MOHAMMED BIN ZAYED with 835,968 vehicles passing daily, while the lowest average daily traffic were in E87 DIBBA-TAWAIN with 36,292 vehicles, as shown in Table 4.6 this Table indicates the average total traffic volume over the last 3 years were in E311 SHAIEK MOHAMMED BIN ZAYED found to have highest traffic volume and E611 EMIRATES being second highest roadway, but E89 MASSAFI-FUJERAH is found to have the lowest average of traffic volume.

Table 4.6:Traffic volumes in UAE federal roadways

(Source : MoID ,2017)

Federal Roadways Name		Average daily traffic			Total Average daily traffic within 3 years	Average daily traffic over one year
		2014	2015	2016		
E11	Ittihad	45,291	48,369	93,660	187,320	62,440
E18	Manama-Karan-Shaam	48,073	51,156	99,229	198,458	66,153
E84	Shaiek Khalifa bin Zayed	20,820	21,766	42,586	85,172	28,391
E87	Dibba–Tawain	8,852	9,294	18,146	36,292	12,097
E88	Sharjah–Al Dhaid–Masafi	27,186	28,831	56,017	112,034	37,345
E89	Massafi–Fujerah	18,995	20,203	39,198	78,396	26,132
E99	Dibba–Khorffakan–Fujirah–Kalba	50,458	53,231	103,689	207,378	69,126
E311	Shaiek Mohammed bin Zayed	201,994	215,990	417,984	835,968	278,656
E611	Emirates	118,064	123,563	241,627	483,254	161,085

The third factor (F_3) is speed limit on federal roadways, were the minimum speed is 60 km/h and the maximum speed is 140 km/h. The radar limit is set to 19 km/h extra, as shown in Table 4.7; therefore, it was important to study this factor in conjunction with the traffic volume, as it is related to a potential increase in number of accidents. Jackett and Frith (2013) found that both speed limit and traffic volume are directly proportional to increases in the accident rate.

The speed limit factor was categorised as shown in Table 4.7, with a multiplication factor (QF_3) of 4. The minimum speed of 60 km/h scored 1, 80 km/h scored 2, 100 km/h scored 3, 120 km/h scored 4, and 140 km/h scored 5.

Table 4.7: Distribution of weight points for F_3
(Source : Author ,2018).

Speed limit Km/hr	Weight
60	1
80	2
100	3
120	4
140	5

Most of the main federal roadways, such as E11 Ittihad, E18 Manama–Karan–Shaam, E89 Massafi–Fujerah, and E99 Dibba–Khorffakan–Fujirah–Kalba, have a prescribed speed limit of 120 km/h. The highest speed limit of 140 km/h is permitted on E84 Shaiek Khalifa bin Zayed and E88 Sharjah–Al Dhaid–Masafi. On the other hand, the speed limits on both E311 Shaiek Mohammed bin Zayed and E611 Emirates were reduced in October 2017, according to Fodah (2017). The weights ascribed to speed limits on the roadways are shown in Table 4.8.

Table 4.8: Speed limits in UAE federal roadways
(Source : MoID ,2017)

Federal Roadways Name		Speed limit	Allowed Speed	Average daily traffic over one year
E11	Ittihad	120	140	62,440
E18	Manama-Karan-Shaam	120	140	66,153
E84	Shaiek Khalifa bin Zayed	140	160	28,391
E87	Dibba–Tawain	100	120	12,097
E88	Sharjah–Al Dhaid–Masafi	140	160	37,345
E89	Massafi–Fujerah	120	140	26,132
E99	Dibba–Khorffakan–Fujirah–Kalba	120	140	69,126
E311	Shaiek Mohammed bin Zayed	100	120	278,656
E611	Emirates	100	120	161,085

The fourth factor (F_4) is the nature of the topography of UAE federal roadways. Topography is linked to vehicle accidents. Hilly and mountainous roadways increase accident risk (Lankarani, 2014), while flat roadways create a better driving environment for users. The northern emirates are mostly desert, characterized by hills, mountains, and rocky terrain (UAE Government, 2017). Mountainous terrain is the most difficult for implementing construction projects such as erecting buildings or housing complexes, or building roads, as heavy excavation is required to prepare sites for construction. Topography includes geographic elements such as buildings, roadways, rivers, and seas, and topographical maps feature coordinate grids and contour lines that show the height of the land above sea level.

The topography factor was divided into five categories related to surface characteristics: flat, flat–hilly, hilly, curved, and mountainous, as shown in Table 4.9. Flat refers to level ground, flat–hilly to a combination of flat areas and hills, hilly to the presence of many hills, curved , and mountainous to areas featuring rocks and level surfaces (Geoscience Australia, 2017). F_4 had a multiplication factor of 3.

Table 4.9: Distribution of weight points for F_4

(Source : Author , 2018)

Topography	Weight
Flat	1
Flat - Hilly	2
Hilly	3
Curvy	4
Mountainous	5

It’s known that topography is linked to car accidents since the hilly and mountainous roadways considered of the extremely high risk as proven by (Lankarani ,2014). , while flat roadways allows better driving environment for users at different time of the day. These categories were used to evaluate the federal roadway network, as shown in Table 4.10.

Table 4.10 : Topography of UAE federal roadways

(Source : Author , 2018)

Federal Roadways Name		Topography
E11	Ittihad	Flat
E18	Manama-Karan-Shaam	Flat - Hilly
E84	Shaiek Khalifa bin Zayed	Mountainous
E87	Dibba–Tawain	Mountainous
E88	Sharjah–Al Dhaid–Masafi	Flat - Hilly
E89	Massafi–Fujerah	Mountainous
E99	Dibba–Khorffakan–Fujirah–Kalba	Flat -Hilly
E311	Shaiek Mohammed bin Zayed	Flat
E611	Emirates	Flat

On the other hand, The fifth factor (F_5) refers to the number of urban settlements served by the federal roadways selected. This factors also was divided into five categories, and it had a multiplication factor of 3, as shown in Table 4.11. While Table 4.12 shows the number of urban settlements served by each roadway.

Table 4.11 : Distribution of weight points for F_5

(Source : Author , 2018)

Number Of Urban Settlements	Weight
Less than 3	1
4-7	2
8-11	3
12-15	4
More than 15	5

Table 4.12 : Urban settlements criteria results

(Source : Author , 2018)

Federal Roadways Name		Number Of Urban Settlements
E11	Ittihad	6
E18	Manama-Karan-Shaam	10
E84	Shaiek Khalifa bin Zayed	7
E87	Dibba–Tawain	5
E88	Sharjah–Al Dhaid–Masafi	5
E89	Massafi–Fujerah	10
E99	Dibba–Khorffakan–Fujirah–Kalba	9
E311	Shaiek Mohammed bin Zayed	6
E611	Emirates	6

The analyses of these factors, and the selection of the case study based on the importance of the factors and their impact on the research, are discussed in detail in Chapter 5.

4.3.Phase 2: Simulation Configurations of the HPS Exiting Base Case

In phase 2, the existing HPS lighting system on the roadway selected in phase 1, the baseline case for this study, was examined during phase 2. In building the base case model, the technical specifications provided by the supplier of the existing HPS luminaires (Schréder DZ25: [223837] Bended Smooth Glass Standard 1787 SON-T) were used, with 400 W of power, 5° as the boom angle, 14 m as the pole height that was adjusted on the median, and with 60 m spacing between the poles.

In addition, the lighting output results were represented numerically, focusing on average luminance (L_{av}), uniformity ratios (U_o, U_I), glare, and surround ratio (SR), with two evaluation trials to identify the conditions that yielded the best lighting output results. Furthermore, false colour rendering was used to generate a sequential group of colours, beginning with reddish and moving to black, similar to moving from a comforTable zone to an uncomforTable zone, as shown in Figure 4.4, with more detailed data available in Appendix (C).

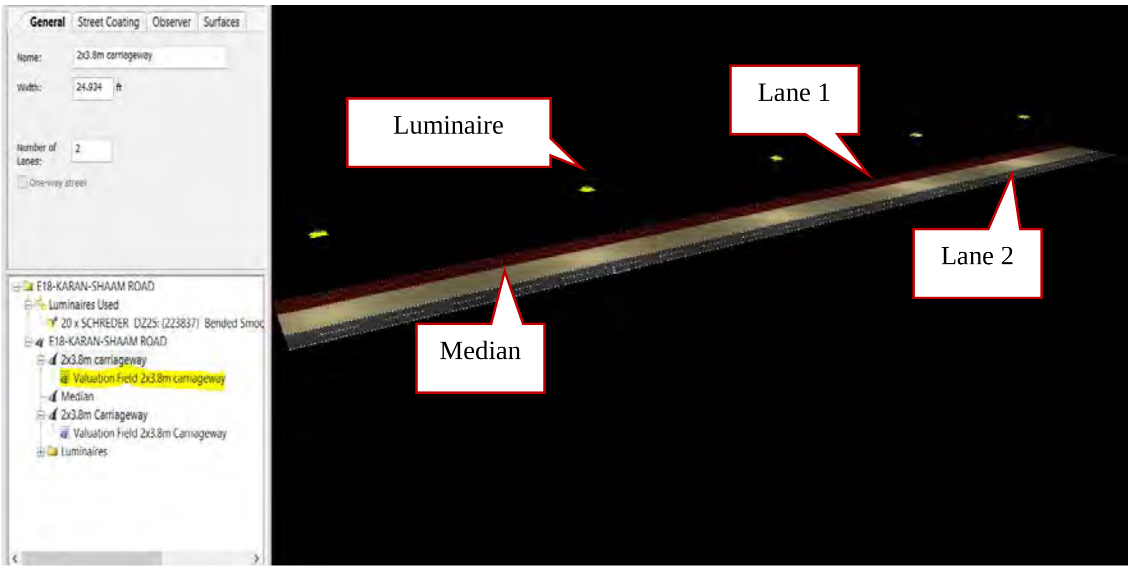


Figure 4.4: Roadway configuration

(Source : Author through DIALux, 2017)

Figure 4.4, created using the DIALux software, represents two sides of the roadway for 1 km, which was the subject of this research. After inputting the required information, such as roadway coating, observer, and surface, DIALux runs the simulation to illustrate the given data. Figure 4.5 shows the Street Coating tab, with tarmac R4 and uniformity coating on wet roadways set to W3.

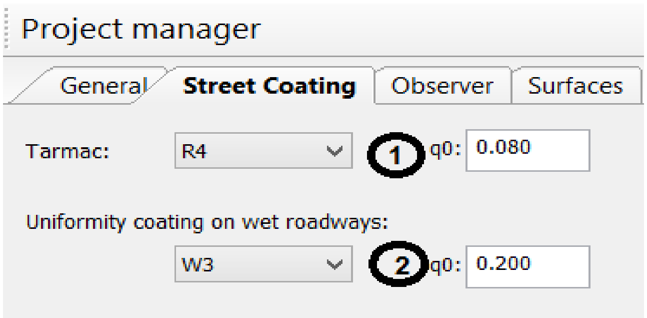


Figure 4.5: Roadways coating details

(Source : Author through DIALux, 2017)

On the other hand, the observer tab Observer tab records the age and position of the observer, as shown in Figure 4.6.

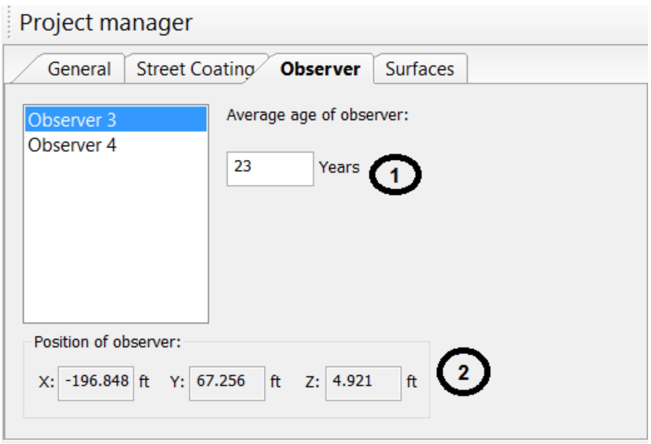


Figure 4.6: Observer details

(Source : Author through DIALux, 2017)

Finally, the Surfaces tab records the colour of the roadway surface, transparency, and material type, as shown in Figure 4.7.

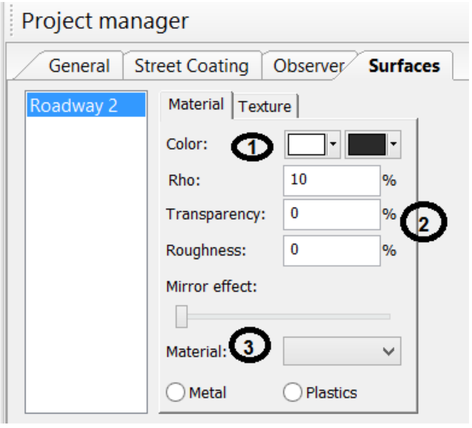


Figure 4.7: Surfaces details

(Source : Author through DIALux, 2017)

Additional details related to the median of the colour and type of materials are shown in Figures 4.8 and 4.9.

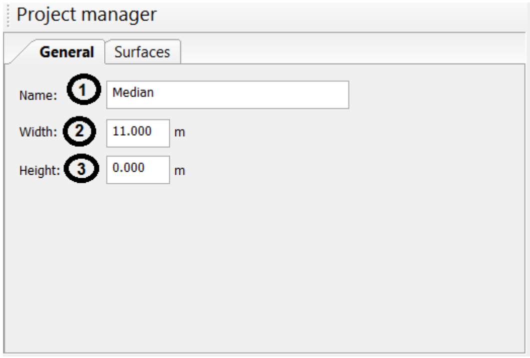


Figure 4.8: Median from the roadway

(Source : Author through DIALux, 2017)

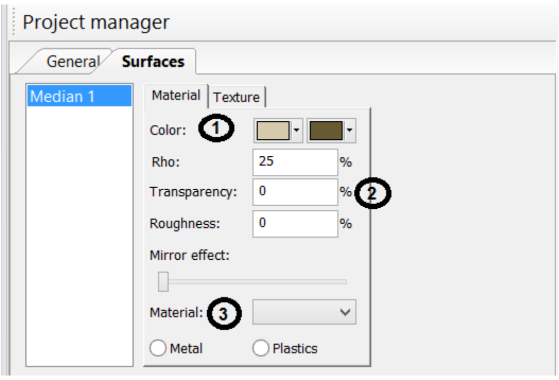


Figure 4.9: Median details from the roadway

(Source : Author through DIALux, 2017)

The technical specification data for the lighting system as base case was HPS of 400 W, as shown in Figure 4.10.

Figure 4.10: Technical specifications of HPS lighting system
(Source : Author through DIALux, 2017)

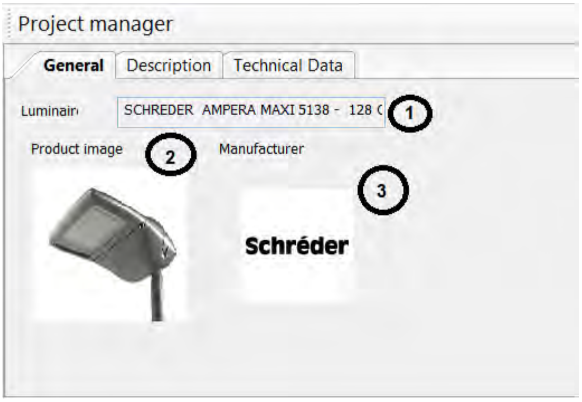


Figure 4.11: General tab
(Source : Author through DIALux, 2017)

The above Figure presents General tab in DIALux, where general information related to the luminaire used, such as manufacturer and product image, were shown.

Furthermore, the Technical Data tab allows the user to input the technical specifications of the luminaire type used, such as luminous flux, power consumed, and correction factor, as shown in Figure 4.12.

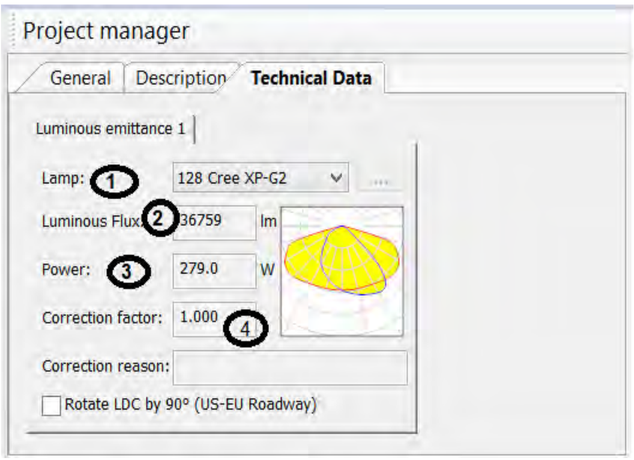


Figure 4.12: Technical data tab

(Source : Author through DIALux, 2017)

In addition to the lighting output results used to evaluate the level of roadway lighting, false colour rendering can be used to determine the level of lighting distribution on the roadway, as mentioned in Chapter 2 and shown in Figure 4.13.

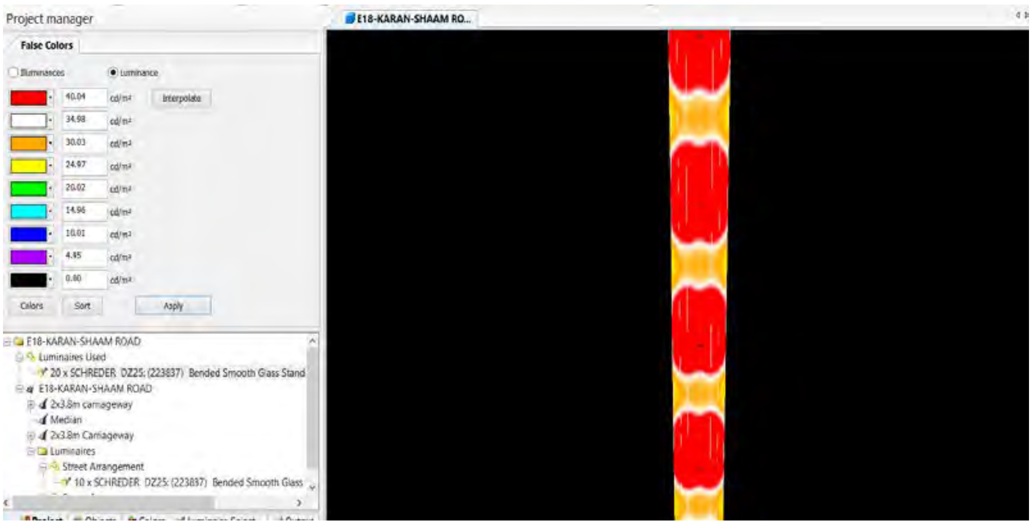


Figure 4.13: False color rendering of HPS lighting system

(Source : Author through DIALux, 2018)

4.4. Phase 3: Proposed Scenarios of LED Lighting System

In this phase, the roadway case study analysed in the previous phase was analysed again after changing the lighting type to LED to produce results for comparison with the HPS lighting system.

To build the model for this phase, the model created in phase 2 was used, but the lighting system was changed from HPS to LED, with product from the same supplier. Four scenarios were run, with boom angle (5°), pole height (14 m), and spacing (60 m) remaining the same: 109 W, 123 W, 198 W, and 240 W , as shown in Table 4.13.

Table 4.13: Parameters of scenarios for phase 3

(Source : Author, 2018)

Phase3: Proposed Scenarios of LED Lighting System						
Scenarios	Fixed Parameters					Variable Parameters
	Pole spacing	Pole height	Boom Angle	Number of luminaires	Arrangement	Luminaire wattage
1	60m	14m	5^0	2	Median	109 W
2						123 W
3						198 W
4						240 W

The lighting outputs were presented as numerical results for average luminance (L_{av}), uniformity ratios (U_0, U_I), glare, and surround ratio (SR). Two evaluation trials were conducted to identify the conditions that yielded the best lighting output results. Additionally, a false colour rendering graph was used to generate a sequential group of colours, beginning with reddish and moving to black, similar to moving from a comforTable zone to an uncomforTable zone, as shown in Appendix (D).

Subsequently, three cases were compared to determine the optimum case based on the lighting output results, as discussed in detail in Chapter 5. The best or optimum case was used to identify optimum case parameters for use in phase 4.

4.5. Phase 4: Analysis Technical Parameters of the LED Lighting System

Phase 4 involved the evaluation of several parameters that were found to be related to the efficiency of the lighting system. These parameters were listed and evaluated to test and examine different scenarios that would finally be used to generate the optimum scenario that complies with the needs and requirements of the selected roadway and ensures the creation of a sustainable lighting system that can be considered a benchmark for others concerned with infrastructure development.

Main parameters that were selected in this phase are related to light system properties.

- Boom angle:luminaire plat adjusted in degrees in a suitable direction to illumine the space
- Pole height:the height of the lighting column
- Pole spacing:the spacing between the poles
- Number of luminaires per pole:number of luminaire elements per pole
- Pole layout:the arrangement or positions of the poles on the roadways

All parameters are shown in Figure 4.14 below, which illustrates the middle island in the roadway. (Integrated Publishing, 2017).

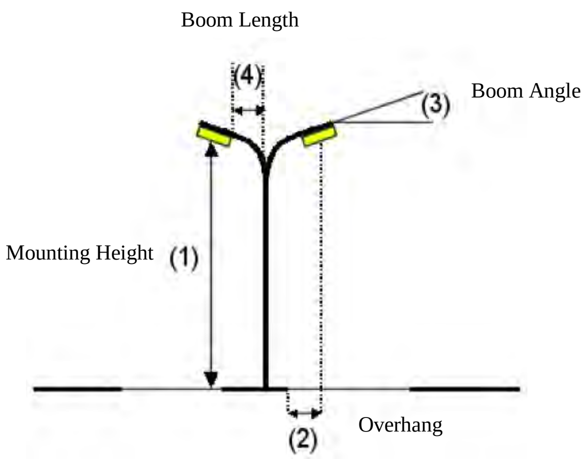


Figure 4.14: Lighting system elements in roadways
(Source : Author through DIALux, 2017)

In this phase, the boom angle, pole height, and pole spacing parameters were set as variable parameters, with luminaire wattage, number of luminaires, and pole arrangement remaining constant. Parameters were changed one by one to assess their individual impact, as shown in Table 4.14.

Table 4.14: Parameters scenarios for phase 4
(Source : Author, 2018)

Phase 4: Analysis Technical Parameters of the LED Lighting System										
Scenarios	Fixed Parameters			Variable Parameters						
	Luminaire wattage	Number of luminaires	Arrangement	Boom Angle	Pole height (m)			Pole spacing (m)		
	W	2	Median	0^0	12	14	16	50	60	70
				2^0						
				5^0						

As example of a detiled a detailed simulation matrix, with boom angle at 0°which considered as parameter group 1 (PG1) as shown in Table 4.15. As well as another simulation with other two boom angles of 2^o as second parameter group (PG2) and 5^o as third parameter group (PG3).

Table 4.15: Parameter matrix of the research case study
(Source : Author, 2018)

LED Specifications of lighting system :										
Luminous flux (Luminaire):										**Parameter Group 1**
Luminous flux (Lamps):										
Luminaire Wattage :										
Number of luminaires :										
Pole arrangement :										
0^o			0^o			0^o			Boom angle	
16			14			12			Pole Height (m)	
70	60	50	70	60	50	70	60	50	Pole Spacing (m)	
									$L_{avg\ (cd/m2)}$	
									U_o	
									U_l	
									TI(%)	
									SR	
PS_9	PS_8	PS_7	PS_6	PS_5	PS_4	PS_3	PS_2	PS_1	Parameters scenarios (PS)	

The lighting output results were presented as a false colour rendering graph for each of the four scenarios tested for each factor. In addition, average luminance (L_{av}), uniformity ratios (U0, UI), glare, and surround ratio (SR) were calculated, with two evaluation trials conducted to identify the conditions that yielded the best lighting output results.

Following the simulations, and based on benchmarks and international standards discussed in Chapter 2, the best specification for each parameter was used as optimum choice for that parameter.

4.6. Phase 5: Analysis and Building of the Advanced Optimum Model

Phase five include creating the advanced optimum model by adding the best-performing specifications for each parameter generated in previous phases to one model to examine the overall improvement and compare it with the base case created in phase 2, as well as the optimum case created in phase 3 after changing the lighting system to LED. The model was tested using the same computer simulation software used previously (DIALux 4.13), while the results were evaluated and compared based on the same evaluation factors used in phase 4 and described in the literature review in Chapter two.

Chapter 5: Results and Discussion

5.1. Introduction

In this chapter, the analysis process and results are presented and elaborated through the different phases, starting with phase 1. During phase 1 various parameters were listed to evaluate roadway lighting, as shown in Table 4.14, Chapter 4, to identify the optimum parameters for the case study. In phase 2, the existing HPS lighting system in the case study area was evaluated using DIALux software and the British standards employed in the United Arab Emirates, as well as lighting supplier specifications, as guidance. In phase 3, the lighting system was re-evaluated using the same software after changing HPS to LED lighting in four scenarios: 109 W, 123 W, 198 W, and 240 W. The comparison between HPS and LED lighting systems appear in this chapter. This data was used to select the optimum lighting system options subjected to further analysis in the subsequent phases. Thus, in phase 4 the optimum option identified in the previous phases was examined using DIALux, with various parameters being changed one at a time. This resulted in the creation of a Table listing the optimum value of each parameter. Finally, phase 5, the advanced optimum model is built using the optimum parameters determined during previouse phase , as shown in Diagram 5.1.

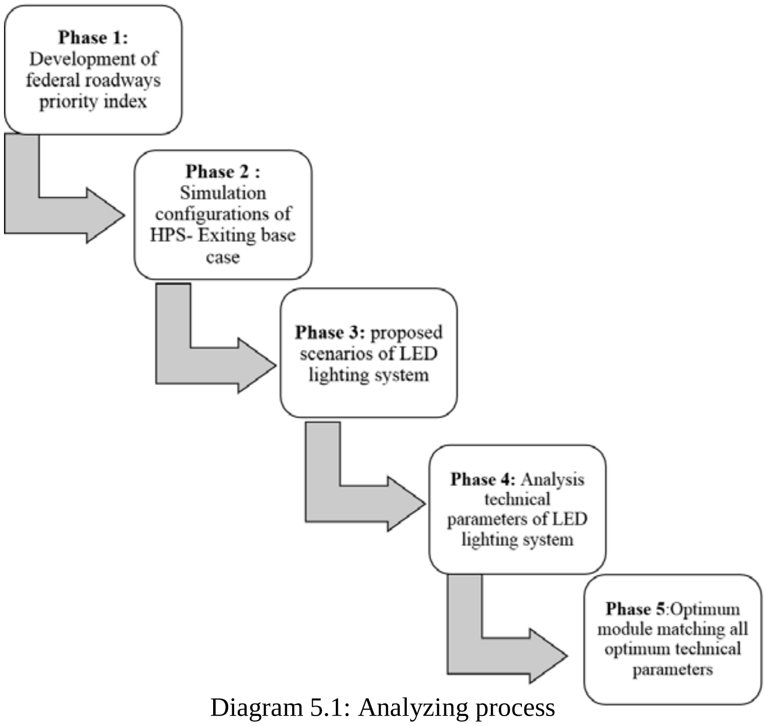


Diagram 5.1: Analyzing process
(Source: Author,2018)

5.2. Phase 1: Results and Discussion of Federal Roadways Priority Index

The first factor (F_1) is the number of accidents with weight of 30 marks according to the quantitative method with 6 as quantitative factor ,as mention in chapter4 in Table 4.2 the factor categories of distribution the marks.

For example: The factor related to the number of traffic accidents at night time that more than 81 is a 5 marks on the factor score, so the total marks of the factor multiply with the number of categories of the factor gives us the evaluated number in which means 5 multiply by 6 = 30 marks, as shown in equation below and mentioned in chapter 4.

$$FRPI = Fi\ Qfi$$

$$= 5*6 = 30$$

On the other hand, the factor of number of accidents at night time that less than 20 accidents which equal to one mark and the quantitive factor (Qf_1)itself worth 6 marks, so the total marks of the factor multiply with the category of the factor which means 1 multiply by 6= 6 marks , as shown in Table 5.1.

Table 5.1: Weight distribution of F_1

(Source : Author , 2018)

No. Accidents at night time	Weight		Total Weight
0-20	1	Multiply by Qf_1 = 6	6
21-40	2		12
41-60	3		18
61-80	4		24
more than 81	5		30

As a results, the highest number of accidents at night time were recorded at E18 Manama-Karan-Shaam with 87 accidents is equivalent to 30 marks, then E311 Shaiek Mohammed bin Zayed with 68 accidents which scored 24 marks .The lowest number of accidents at night time were in E84 Shaiek Khalifa bin Zayedwith 9 accidents which scored one mark with total of 6 marks, the calculation of the final factor results are shown in Table 5.2.

On the same Table below, were the range of accidents in one kilometer distance is presented. E611 Emirates roadway was found to be the highest in total range of traffic accidents, unlike E84 Shaiek Khalifa bin Zayed roadway that recorded the lowest range of accidents at night time within one kilometer. Noted that, this data was collected from recent traffic accidents reports, as shown in Appendix (A)

Table 5.2: Number of traffic accident at night time in UAE federal roadways.

(Source : Author , 2018)

Federal Roadways Name		Total traffic accidents at night time	Weight
E11	Ittihad	23	12
E18	**Manama-Karan-Shaam**	**87**	**30**
E84	Shaiek Khalifa bin Zayed	9	6
E87	Dibba–Tawain	45	18
E88	Sharjah–Al Dhaid–Masafi	50	18
E89	Massafi–Fujerah	12	6
E99	Dibba–Khorffakan–Fujirah–Kalba	30	12
E311	**Shaiek Mohammed bin Zayed**	**68**	**24**
E611	Emirates	44	18
Total accidents		**368**	

Table 5.2 lists the accident rate on a 1 km stretch of each road. However, for total night-time traffic accidents along the entire roadway, E611 Emirates had most. This data was collected from recent traffic accident reports, as shown in Appendix (A).

Moreover, traffic accident distribution on federal roadways can be organized into three categories according the number of fatal accidents, as shown in Figure 5.1. The yellow triangle presents fewer than two fatal traffic accidents, the orange triangle presents three to five fatal traffic accidents, and the red triangle presents more than six.

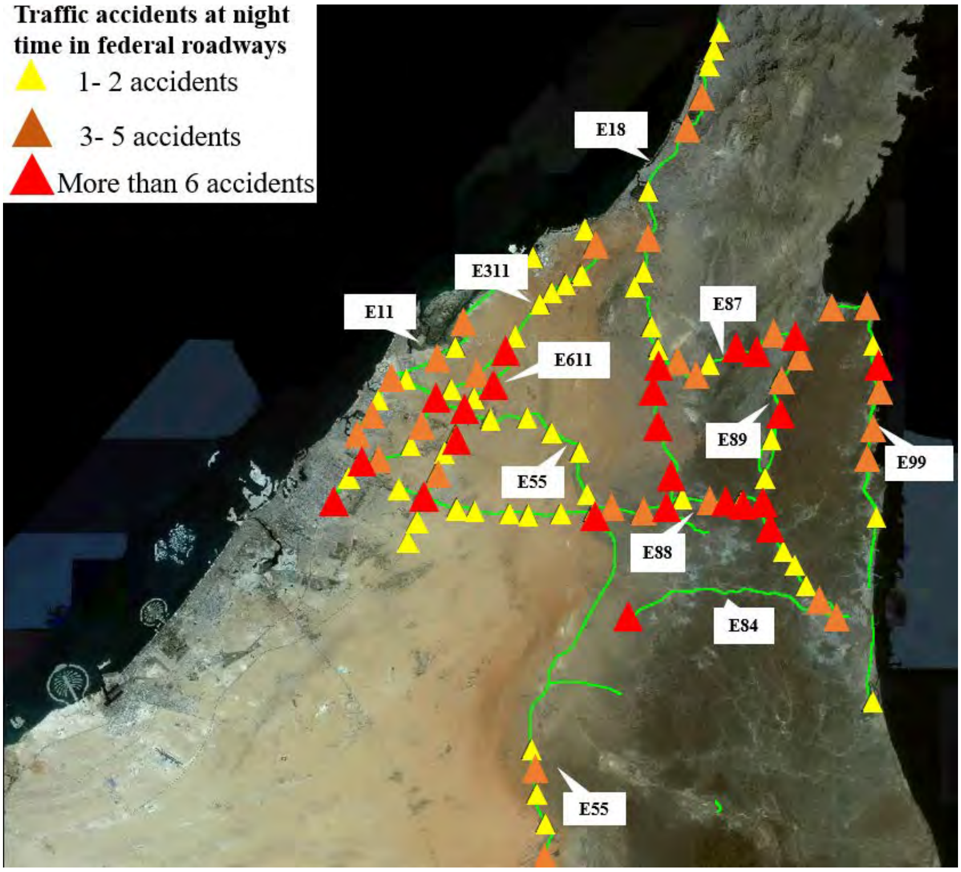


Figure 5.1: Traffic accidents distributions in UAE federal roadways
(Source: Author, image from Google Earth, 2017)

This illustrate the probability of traffic accidents on the federal roadways through the following equation :

probability of traffic accidents =

(Total traffic accidents at night time /Length of federal roadway) * 10 km, where 10 is the distance of rate of the traffic accidents per federal roadway. The results as shown in Table 5.3, establish the maximum traffic accident rate per 10 kilometer in E311 Shaiek Mohammed bin Zayed with 28 traffic accidents while the the minimum traffic accident rate per 10 kilometer in E84 Shaiek Khalifa bin Zayed with 2 traffic accidents per 10 kilometers. This could be more affective in the research if the history sequence of the traffic accidents with its catogries according to the fetal status of the accidents.

Table 5.3: Traffic accident rate per 10 kilometer in UAE federal roadways

(Source : Author , 2018)

Federal Roadways Name		Total traffic accidents at night time	Length of federal roadway	Traffic accident rate per 10 kilometers
E11	Ittihad	23	58	4
E18	Manama-Karan-Shaam	87	94	9
E84	Shaiek Khalifa bin Zayed	9	39	2
E87	**Dibba–Tawain**	**45**	**30**	**15**
E88	Sharjah–Al Dhaid–Masafi	50	35	14
E89	Massafi–Fujerah	12	28	4
E99	Dibba–Khorffakan–Fujirah–Kalba	30	55	5
E311	**Shaiek Mohammed bin Zayed**	**68**	**24**	**28**
E611	Emirates	44	71	6

The second factor (F_2), traffic volume, refers to the highest total average daily traffic in three years, from 2014 to 2016. At the time of writing, the MoID was still in the process of collecting and analysing traffic data for 2017.

The weight scores for F_2 were distributed into five categories, with the first (total average daily traffic of less than 100,000 vehicles) scoring 1. The average daily traffic between 101,000 – 200,000 vehicles have 2 marks on the scale and average daily traffic between 201,000 – 300,000 vehicles have 3 marks, average daily traffic between 301,000- 400,000 vehicles have 4 marks, and the last (more than 401,000 vehicles) scoring 5, as shown in Table 5.4.

Table 5.4: Distribution of marks for the factor of average daily traffic

(Source : Author , 2018)

Total Average daily traffic within 3 years	Weight		Total Weight
Less than 100,000	1	Multiply by $QF_2 = 4$	4
101,000 – 200,000	2		8
201,000 – 300,000	3		12
301,000- 400,000	4		16
more than 401,000	5		20

Traffic volumes on most federal roadways increased, as the roadways connect many of the main areas and settlements in the country. The rate of increase, shown as a multiplier, is similar for all roadways. From 2014 to 2016, average daily traffic on E311 Shaiek Mohammed bin Zayed increased the most, by 2.069, while the smallest increase (2.047), occurred on E611 Emirates, as shown in Table 5.5.

Table 5.5: Results of traffic volumes criteria in UAE federal roadways
(Source : MoID,2017)

Federal Roadways Name		Average daily traffic			Total Average daily traffic within 3 years	Average traffic accidents over one year	Weight
		2014	**2015**	**2016**			
E11	Ittihad	45,291	48,369	93,660	187,320	62,440	8
E18	Manama-Karan-Shaam	48,073	51,156	99,229	198,458	66,153	8
E84	Shaiek Khalifa bin Zayed	20,820	21,766	42,586	85,172	28,391	4
E87	Dibba–Tawain	8,852	9 ,294	18,146	36,292	12,097	4
E88	Sharjah–Al Dhaid–Masafi	27, 186	28 ,831	56,017	112,034	37,345	8
E89	Massafi–Fujerah	18, 995	20 ,203	39,198	78,396	26,132	4
E99	Dibba–Khorffakan–Fujirah–Kalba	50 ,458	53,231	103, 689	207, 378	69,126	12
E311	**Shaiek Mohammed bin Zayed**	**201,994**	**215,990**	**417,984**	**835,968**	**278,656**	**20**
E611	**Emirates**	**118,064**	**123,563**	**241,627**	**483,254**	**161,085**	**20**

Table 5.6 shows the weighted scores of F_3 and the daily average traffic volume over three years for each roadway to facilitate comparison. The daily average traffic volume over three years shows that E311 Shaiek Mohammed bin Zayed has the highest traffic density, increases the risk of traffic accidents despite the E311 having a lower speed limit than E84 Shaiek Khalifa bin Zayed and E88 Sharjah–Al Dhaid–Masafi, as the E84 and E88 have significantly lower traffic density.

Table 5.6:Rate of increase of traffic volumes in UAE federal roadways

(Source : MoID,2017)

Federal Roadways Name		Average daily traffic			Rate of increase in traffic volume
		2014	**2015**	**2016**	
E11	Ittihad	45,291	48,369	93,660	2.1
E18	Manama-Karan-Shaam	48,073	51,156	99,229	2.1
E84	Shaiek Khalifa bin Zayed	20,820	21,766	42,586	2.0
E87	Dibba–Tawain	8,852	9,294	18,146	2.0
E88	Sharjah–Al Dhaid–Masafi	27,186	28,831	56,017	2.1
E89	Massafi–Fujerah	18 995	20,203	39,198	2.1
E99	Dibba–Khorffakan–Fujirah–Kalba	50,458	53,231	103,689	2.1
E311	Shaiek Mohammed bin Zayed	201,994	215,990	417,984	2.1
E611	Emirates	118,064	123,563	241,627	2.0

Since the first and second factors were related to each other , the Table below stated the probbaility of traffic accidents per 1000 vechiles which addressed the maximum probbaility of traffic accidents per 1000 vechiles was in E87 Dibba–Tawain with 24.8 while the mininmum probbaility of traffic accidents per 1000 vechiles was in E311 Shaiek Mohammed bin Zayed with 1.6 , as shown in Table 5.7.

Table 5.7:Rate of probability of traffic accidents per 1000 vehicles .

(Source Autor,2018)

Federal Roadways Name		Average daily traffic 2016	Traffic accidents at night time	probbaility of traffic accidents per 1000 vechiles
E11	Ittihad	93,660	23	2.5
E18	Manama-Karan-Shaam	99,229	87	8.8
E84	Shaiek Khalifa bin Zayed	42,586	9	2.1
E87	**Dibba–Tawain**	**18,146**	**45**	**24.8**
E88	**Sharjah–Al Dhaid–Masafi**	**56,017**	**50**	**8.9**
E89	Massafi–Fujerah	39,198	12	3.1
E99	Dibba–Khorffakan–Fujirah–Kalba	103,689	30	2.9
E311	Shaiek Mohammed bin Zayed	417,984	68	1.6
E611	Emirates	241,627	44	1.8

On the other hand, the third factor (F3) is the speed limit of the federal roadways were the maximum speed allowed on E84 Shaiek Khalifa bin Zayed and E88 Sharjah–Al Dhaid–Masafi while , E87 Dibba–Tawain, 311 Shaiek Mohammed bin Zayed and E611 Emirates has the lowest allowed speed .The marks of this factor were distribution as shown in Table 5.8.

Table 5.8: Speed limits in UAE federal roadways and marking distribution

(Source : Author , 2018)

Speed limit Km/hr	Weight		Total Weight
60	1	Multiply by $QF_3 = 4$	4
80	2		8
100	3		12
120	4		16
140	5		20

However, according to daily average traffic volume over one year it was found that E311 Shaiek Mohammed bin Zayed has the highest traffic density compare to other roads which will impact potential traffic accidents despite the fact that the speed limit is less than E84 Shaiek Khalifa bin Zayed and E88 Sharjah–Al Dhaid–Masafi were the allowed speed is 140 km/h higher. Yet the traffic density much less as shown in Table 5.9.

Table 5.9: Speed limits in UAE federal road results

(Source : MoID,2017)

Federal Roadways Name		Speed limit	Allowed Speed	daily average traffic volume over one year	Weight
E11	Ittihad	120	140	62,440	16
E18	Manama-Karan-Shaam	120	140	66,153	16
E84	**Shaiek Khalifa bin Zayed**	**140**	**160**	**28,391**	**20**
E87	Dibba–Tawain	100	120	12,097	12
E88	**Sharjah–Al Dhaid–Masafi**	**140**	**160**	**37,345**	**20**
E89	Massafi–Fujerah	120	140	26,132	16
E99	Dibba–Khorffakan–Fujirah–Kalba	120	140	69,126	16
E311	Shaiek Mohammed bin Zayed	100	120	278,656	12
E611	Emirates	100	120	161,085	12

The forth factor (F_4) is the nature topography of UAE federal roadways which has been categorize into flat , flat –hilly , hilly , curvy and mountainous which been marked as shown in Table 5.10.

Table 5.10: Topography criteria

(Source : Author , 2018)

Topography	Weight		Total Weight
Flat	1	Multiply by QF_4 = 3	3
Flat - Hilly	2		6
Hilly	3		9
Curvy	4		12
Mountainous	5		15

The following Table describes the topography characteristics of each roadway, as shown in Table 5.11,as per (Lankarani, 2014) .E84 Shaiek Khalifa bin Zayed, E87 Dibba–Tawain and E89 Massafi–Fujerah are considered of high risk compare to other roadways for drivers due to its nature and difficulty of design path of roadways in mountainous areas.

Table 5.11: Topography criteria results

(Source : Author , 2018)

Federal Roadways Name		Topography	Weight
E11	Ittihad	Flat	3
E18	Manama-Karan-Shaam	Flat - Hilly	6
E84	**Shaiek Khalifa bin Zayed**	**Mountainous**	**15**
E87	**Dibba–Tawain**	**Mountainous**	**15**
E88	Sharjah–Al Dhaid–Masafi	Flat - Hilly	6
E89	**Massafi–Fujerah**	**Mountainous**	**15**
E99	Dibba–Khorffakan–Fujirah–Kalba	Flat -Hilly	6
E311	Shaiek Mohammed bin Zayed	Flat	3
E611	Emirates	Flat	3

The fifth factor (F_5) is considering number of urban settlements that are served by federal roadways, as marks were distributed, as shown in Table 5.12.

Table 5.12: Urban settlements weight distribution

(Source : Author , 2018)

Number of Urban settlements	Weight		Total Weight
Less than 3	1	Multiply by $QF_5 = 3$	3
4-7	2		6
8-11	3		9
12-15	4		12
More than 15	5		15

Access to roadways can affect future urban growth; in turn, urban growth can increase traffic density. These are important factors to consider during roadway design. Several roadways served 10 urban settlements, including E18 Manama–Karan–Shaam and E89 Massafi–Fujerah, as shown in Table 5.13.

Table 5.13: Urban settlements criteria results

(Source : Author , 2018)

Federal Roadways Name		Number of urban settlements	Names of the settlements	Weight
E11	Ittihad	6	1. Abu Dhabi 2. Dubai 3. Sharjah 4. Ajman 5. Umm Al Queain 6. Ras Al Khaimah	6
E18	**Manama-Karan-Shaam**	**10**	**1. Seeh Al Heraf** **2. Al Remas** **3. Ghalilah** **4. Shaam** **5. Adhan** **6. Khat** **7. Ras Al Khaimah** **8. Hibhib** **9. Al Geil** **10. Al Manam**	**9**
E84	Shaiek Khalifa bin Zayed	7	1. Khadra 2. Mamdoh 3. Isfeni 4. Asfi 5. Shokah 6. Al Hewilat 7. Fujirah	6
E87	Dibba–Tawain	5	1. Koob 2. Tawain 3. Al Reiamah 4. Daher 5. Dibba	6

Federal Roadways Name		Number of urban settlements	Names of the settlements	Weight
E88	Sharjah–Al Dhaid–Masafi	5	1.Al Thid 2.Al Sajaah 3.Siji 4.Sharjah 5.Masafi	6
E89	**Massafi–Fujerah**	**10**	**1. Fujirah** **2. Al Bethna** **3. Dafta** **4. Masafi fujirah** **5. Masafi Ras Al Khaimah** **6. Khaleibah** **7. Dibbah** **8. Al Abadlah** **9. Al Halaht** **10. Dibba Fujirah**	**9**
E99	**Dibba–Khorffakan–Fujirah–Kalba**	**10**	**1. Al Bediah** **2. Sharm** **3. Al Oquah** **4. Khorfakkan** **5. Qudfa** **6. Merbah** **7. Al Quriah** **8. Sekamkam** **9. Kalba** **10. Dhadna**	**9**
E311	Shaiek Mohammed bin Zayed	6	1. Abu Dhabi 2. Dubai 3. Sharjah 4. Ajman 5. Umm Al Queain 6. Ras Al Khaimah	6
E611	Emirates	7	1. Muhadhab 2. Umm Al Queain 3. Botein Al Summer 4. Ras Al Khaimah 5. Sharjah 6. Dubai 7. Borders of Abu Dhabi	6

As shown in Table 5.14, the weighted values of the factors were added and compared for each roadway with the potential to be a suitable candidate for the case study. E18 Manama–Karan–Shaam scored the highest, with 69 out of 100, while E11 Ittihad scored the lowest, with 45 out of 100.

Table 5.14:UAE Federal roadway priority index results

(Source : Author , 2018)

Federal Roadways Name		Total accidents at night time	Traffic Volume	Speed limit	Topography	Number of Urban settlements	Priority index results
E11	Ittihad	12	8	16	3	6	45
E18	**Manama-Karan-Shaam**	**30**	**8**	**16**	**6**	**9**	**69**
E84	Shaiek Khalifa bin Zayed	6	4	20	15	6	51
E87	Dibba–Tawain	18	4	12	15	6	55
E88	Sharjah–Al Dhaid–Masafi	18	8	20	6	6	58
E89	Massafi–Fujerah	6	4	16	15	9	50
E99	Dibba–Khorffakan–Fujirah–Kalba	12	12	16	6	9	55
E311	Shaiek Mohammed bin Zayed	24	20	12	3	6	65
E611	Emirates	18	20	12	3	6	59

The previous results indicates the critical roadways is E18 Manama-Karan-Shaam as shown in Table 5.15, were the factors analysis shows that urgent need for enhancements at this roadway. Therefore it was selected as the case study for this research. While the second case study was E611 Shaiek Mohammed bin Zayed roadway with 65 marks and the third was E611 Emirates roadway with 59 marks out of 100 as total marks.

Hence, the factor analysis revealed that E18 Manama–Karan–Shaam has the most urgent need for safety enhancement, and it was therefore chosen as the case study for this research. E611 Mohammed bin Zayed was ranked second, with 65 points, and E611 Emirates third, with 59 points, as shown in Table 5.16.

Table 5.15: UAE Federal roadway priority index ranking results

(Source : Author , 2018)

Federal Roadways Name		Results	Rank
E11	Ittihad	45	9
E18	**Manama-Karan-Shaam**	**69**	**1**
E84	Shaiek Khalifa bin Zayed	51	7
E87	Dibba–Tawain	55	5
E88	Sharjah–Al Dhaid–Masafi	58	4
E89	Massafi–Fujerah	50	8
E99	Dibba–Khorffakan–Fujirah–Kalba	55	6
E311	**Shaiek Mohammed bin Zayed**	**65**	**2**
E611	**Emirates**	**59**	**3**

Using the FRPI, the federal roadways were further categorized into three priority groups, as shown in Table 5.16.

Table 5.16: Priority group of UAE federal roadways

(Source : Author , 2018)

Federal Roadways Name		Results	Rank	Priority
E18	Manama-Karan-Shaam	69	1	A
E311	Shaiek Mohammed bin Zayed	65	2	
E611	Emirates	59	3	
E88	Sharjah–Al Dhaid–Masafi	58	4	B
E87	Dibba–Tawain	55	5	
E99	Dibba–Khorffakan–Fujirah–Kalba	55	6	
E89	Massafi–Fujerah	50	8	C
E84	Shaiek Khalifa bin Zayed	51	7	
E11	Ittihad	45	9	

The three priority groups categories according to the results of FRPI, as following: Group A, the highest priority group, is in the most urgent need of revisions to the lighting system, with urgency decreasing for Group B and again for Group C. The priority areas are shown in Figure 5.2.

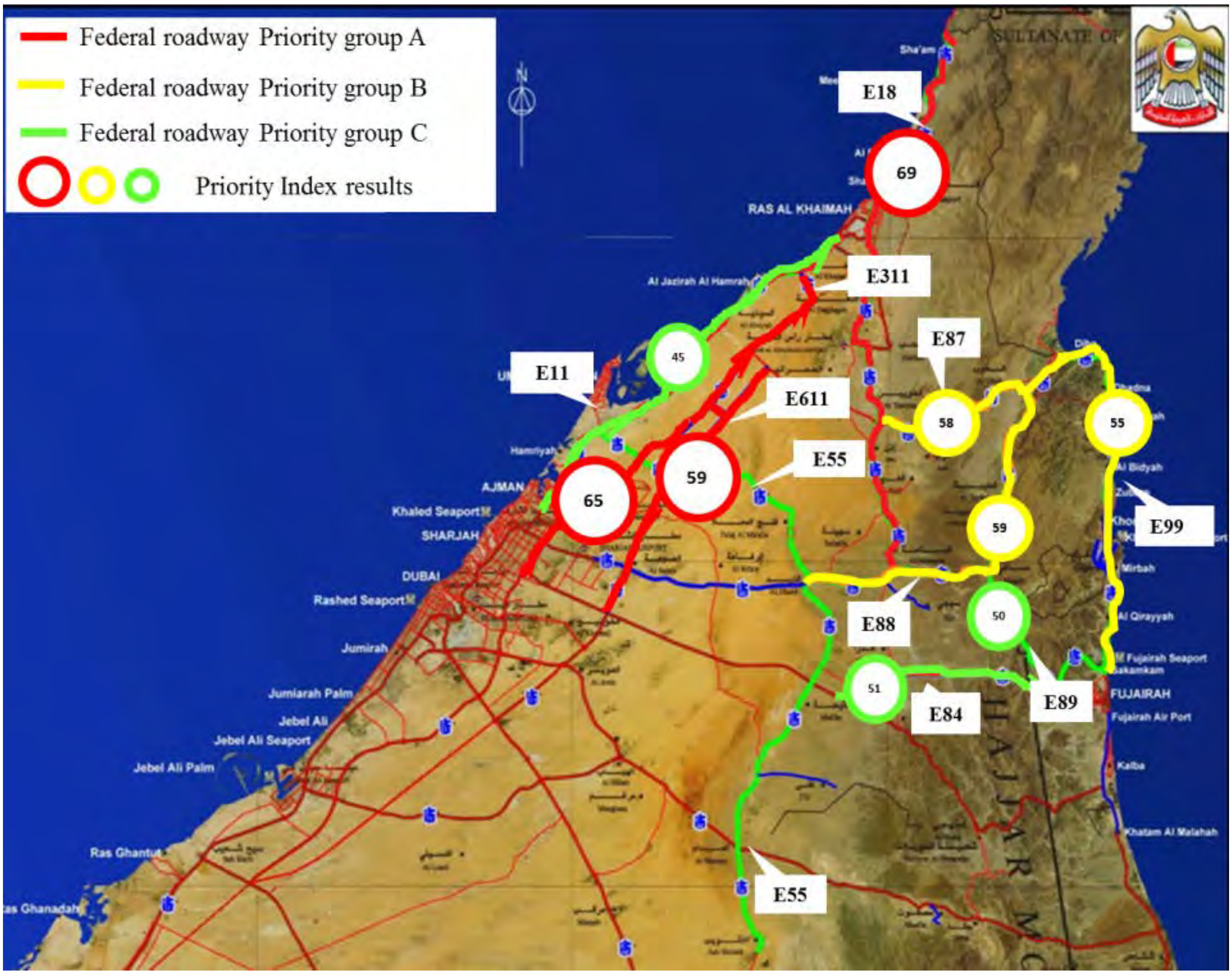


Figure 5.2: Priority groups of UAE federal roadways

(Source: Author, image from Google Earth,2018)

Because replacing the current lighting system would take time, it would be best to focus on high-accident with high-priority areas first. Undertaking the work in segments would allow greater flexibility in terms of time and cost. Figure 5.3 shows a suggested strategy for upgrading the roadway lighting system. Priority segments have been organized into five categories demarcated with different colours: red is the highest priority, orange the second highest, yellow the third highest, green the fourth highest, and blue the lowest.

The future implementing plan of changing the lighting systems in federal roadways by segments much easier and comforTable to achieve due to long period of time implement the new lighting systems and spending budgets.

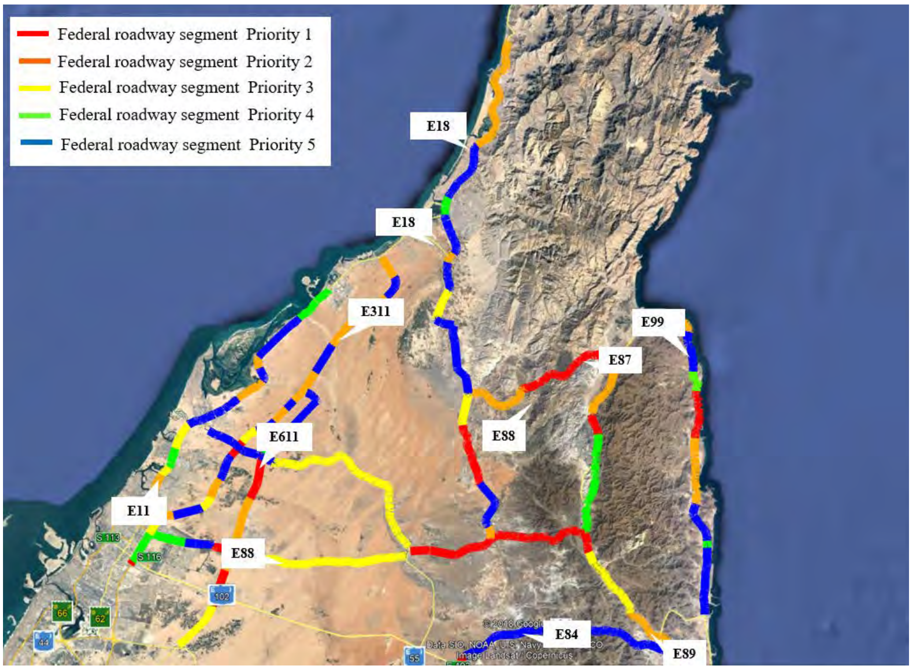


Figure 5.3: Priority segments of UAE federal roadways

(Source: Author, image from Google Earth,2018)

Moreover, E18 Manama–Karan–Shaam was chosen as the roadway for this case study. The 94 km, two-lane roadway is located in Ras Al Khaimah, and it is divided into two sections from Manama to Karan and from Karan to Shaam, as shown in Figure 5.4. The case study focuses on a 1 km section where the most traffic accidents were recorded.

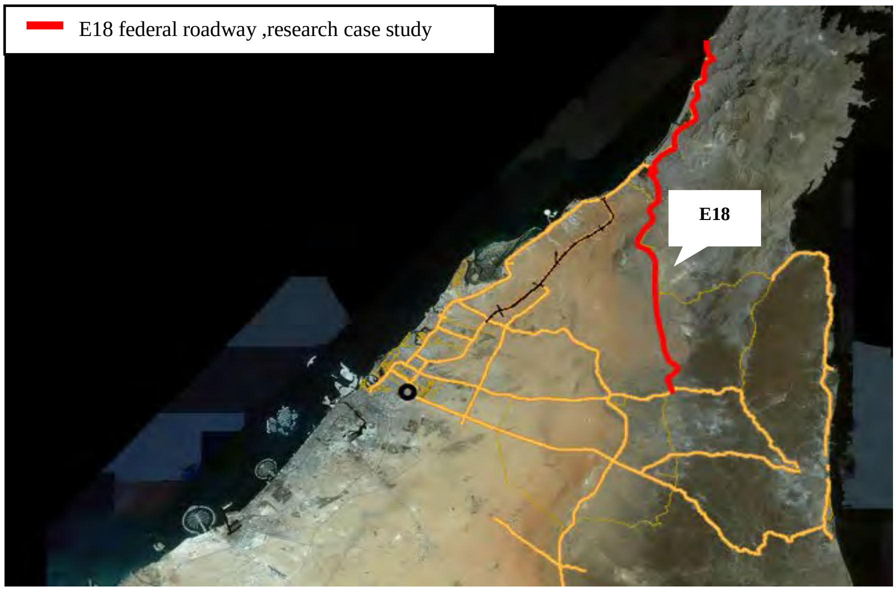


Figure 5.4: E18 federal roadway location

(Source: Author ,image from Google Earth,2018)

The dimensions and features of the roadway were input into DIALux: both lanes are 3.8 m wide, which gives the road an overall width of 7.6 m, and the median has an interlocked width of 11 m.

Each traffic accident was assigned a code (e.g., E18-14-20+0630-inc866) that consists of the road number (e.g., E18), the identification number as a numeral only (e.g., 14-20), the chain age (location on the stretch of roadway; e.g., 0630), and the code of the accident itself (e.g., inc866). The last two digits of the accident reference correspond to the year in which the accident took place (e.g., 14 for 2014, or 15 for 2015), as shown in Figure 5.6 and Appendix A., as shown in Figure 5.5 and Appendix (A).

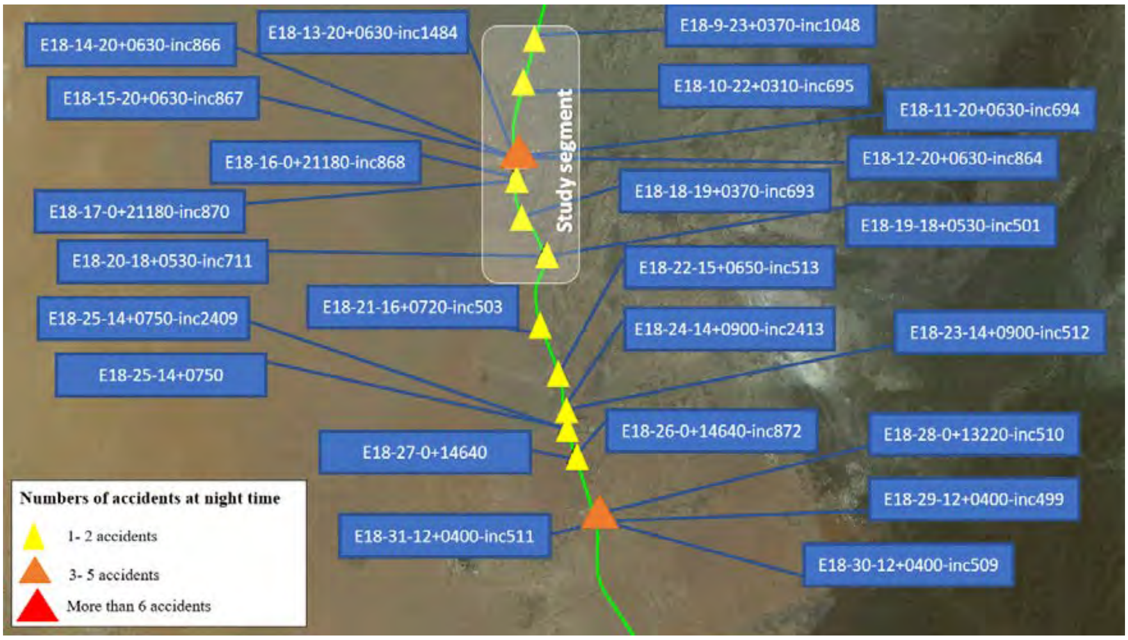


Figure 5.5: One-kilometer segment of E18 with traffic accident distributions
(Source : Author, image from Google Earth,2018)

Roadway properties were identifies using CIE classifications. For example, the surface of E18 Manama–Karan–Shaam is asphalt with a very smooth texture and classified as R4, while the roadway is classified as ME2 considering its traffic volume and service area. This information was employed during the study simulation.

5.3: Phase 2: Results and Discussion of Simulation of Existing HPS Base Case

The technical specifications of the existing HPS lighting system, which features Schréder DZ25: (223837) Bended Smooth Glass Standard 1787 SON-T 400 W, was used as the base case for the simulation. The technical specifications were based on supplier data and approved specifications, as shown Table 5.17.

Table 5.17: Technical specifications of HPS lighting system

(Source : Author through DIALux ,2018)

HPS technical specifications of lighting system	
Luminaire:	SCHREDER DZ25: (223837) Bended Smooth Glass Standard 1787 SON-T 400 W
Luminous flux (Luminaire):	44622 lm
Luminous flux (Lamps):	56500 lm
Luminaire Wattage:	400W
Arrangement:	on Median
Pole Distance:	60 m
Mounting Height	14 m
Height:	13.732 m
Overhang :	-4.988 m
Boom Angle:	5.0 °
Boom Length :	0.500 m

Five poles had been distributed along 1 km, spaced at 60 m. False colour rendering was used to record luminance and indicate cd/m^2 for each colour on the spectrum, from red to black, as shown in Figure 5.6.

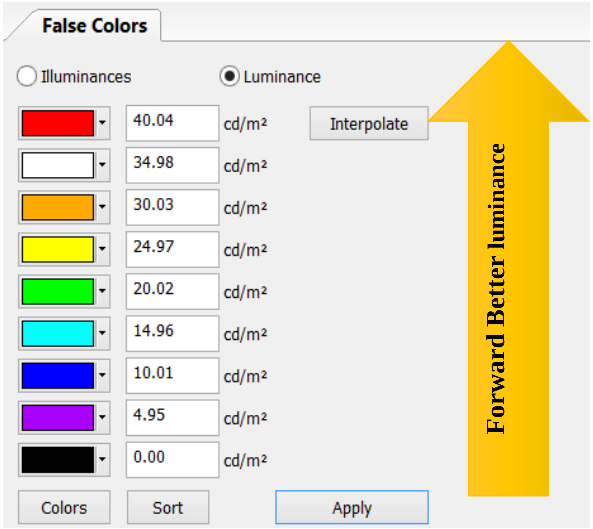


Figure 5.6: False color rendering scale graph

(Source : Author through DIALux ,2018)

On the red-to-black scale, red is the most comforTable viewing colour, while black is the least comforTable. When moving from red to black, comfort levels gradually decrease until their reach zero. For the model tested, red measured 40.04 cd/m^2 at the top end of the scale, with luminance dwindling to 4.95 cd/m^2 at purple and 0 by the time it reaches black. Therefore, the higher the concentration of luminance at the red end of the scale, the more comforTable visibility and the better the luminance, as shown in Figure 5.7.

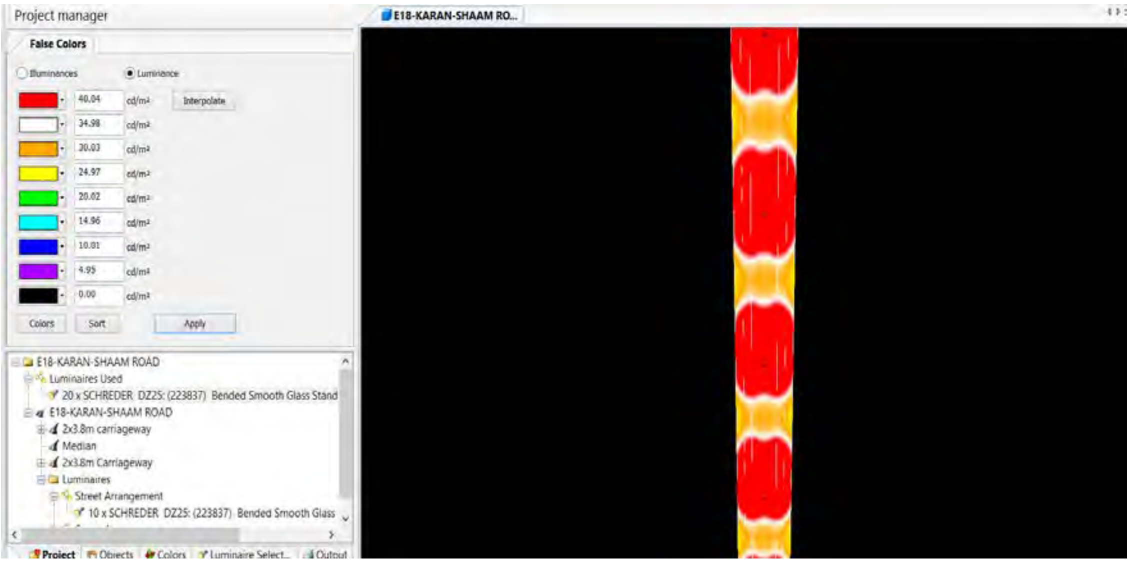


Figure 5.7: HPS lighting system false color rendering

(Source : Author through DIALux ,2018)

Figure 5.8 indicates the level of luminance on the roadway—the red zones are comforTable for drivers and visibility is better. The HPS lighting measurement outputs derived from the simulation yielded average luminance in two observer positions as 2.69 and 3.18 cd/m^2, with overall uniformity (U_o) of 0.42 and 0.47, and longitudinal uniformity (U_l) of 0.63 and 0.68. Moreover, the threshold increments (TI), representing glare percentage, are 12% and 19%, and the surround ratio is 0.96. The glare is higher than the British standard of 10%, which increases the risk of traffic accidents., as shown in Table 5.18 and Appendix (B)

Table 5.18: HPS lighting measurement outputs

(Source : Author through DIALux ,2018)

NO.	Observer	Lav (cd/m^2)	U0	Ul	TI %	SR
1	Observer 1	**3.18**	0.42	0.63	**12**	0.96
2	Observer 2	2.69	**0.47**	**0.68**	19	

Subsequently, the HPS lighting measurements were compared with British standards (BS) for all lighting measurements. HPS average luminance exceeds BS by 1.68 cd/m^2, and there is a difference in of 2% in TI and 0.46 in SR. However, U_o and U_l were near the BS measurements, as shown in Chart 5.1.

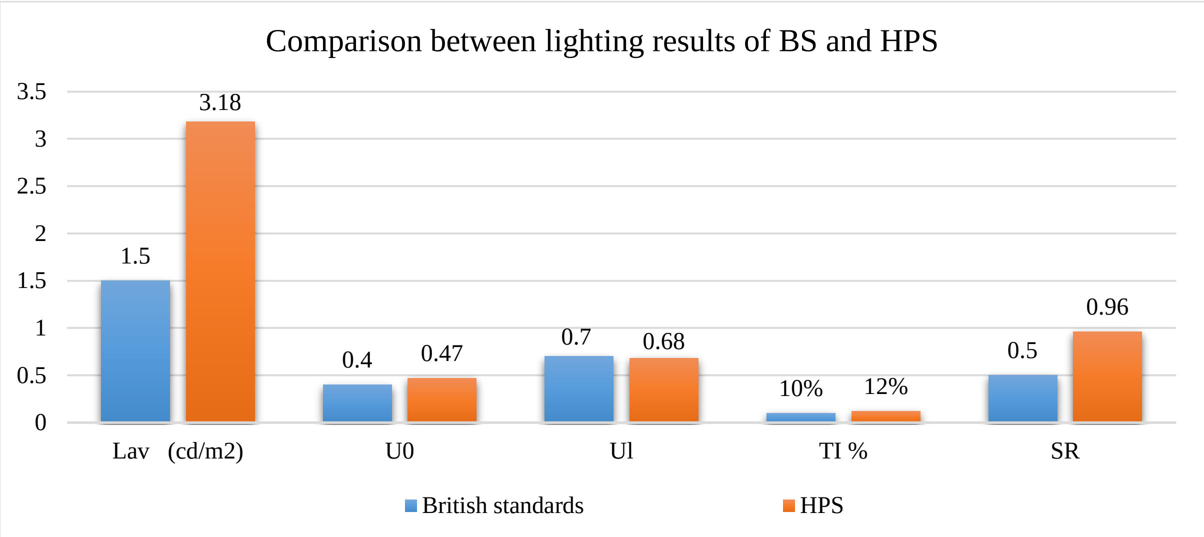


Chart 5.1: Comparison between lighting results of BS and HPS

(Source : Author through DIALux ,2018)

5.4.Phase 3: Results and Discussion Proposed LED Lighting System Scenarios

This phase employed the HPS model after substituting LED lighting features, as specified by suppliers to UAE federal authorities, in four scenarios, as listed below:

1. Schréder Ampera Maxi/5118/96 LEDS, 350 mA CW/356862 with 109 W
2. Trilux LIQ 90-AB7L/13500-730 16G1S ETDD LIQ with 123 W
3. Schréder Ampera MAXI/5117/128 LEDs, 500 mA NW/356852 with 198 W

4. Schréder Ampera MAXI 5138 - 128 Cree XP-G2 700 mA NW 230 V Flat Glass, Extra Clear, Smooth 357172 with 240 W

The simulation was carried out with fixed variables, as explained in the baseline case and shown in Table 4.13, Chapter 4.

The first LED scenario involved Schréder Ampera Maxi/5118/96 LEDS, 350 mA CW/356862 with 109 W. The technical specifications are shown in Table 5.19.

Table 5.19: LED scenario 1 technical specifications
(Source: Author through DIALux ,2018)

LED scenario 1 technical specifications of lighting system	
Luminaire:	SCHREDER AMPERA MAXI / 5118 / 96 LEDS 350mA CW / 356862
Luminous flux (Luminaire):	13249 lm
Luminous flux (Lamps):	15936 lm
Luminaire Wattage:	109.0 W
Arrangement:	on Median
Pole Distance:	60 m
Mounting Height	14 m
Height:	14 m
Overhang :	-4.870 m
Boom Angle:	5.0 °
Boom Length :	0.002 m

The lighting measurement output for L_{av} in two positions is 0.41 and 0.50 cd/m^2, with U_o of 0.53 and 0.47, and U_l of 0.87 and 0.76. Additionally, TI is 11 % and 7%, and SR is 1 ,as shown in Table 5.20.

Table 5.20: LED scenario 1 lighting output results
(Source: Author through DIALux, 2018)

Scenario	SCHREDER AMPERA MAXI / 5118 / 96 LEDS , 350mA CW / 356862 with 109W	Observer	Lav (cd/m^2)	U0	Ul	TI %	SR
1		1	0.41	**0.53**	**0.87**	11	1
		2	**0.50**	0.47	0.76	**7**	

The outputs of scenario 1 were compared with BS to determine whether the outputs adhere to the standards, as shown in Chart 5.2.

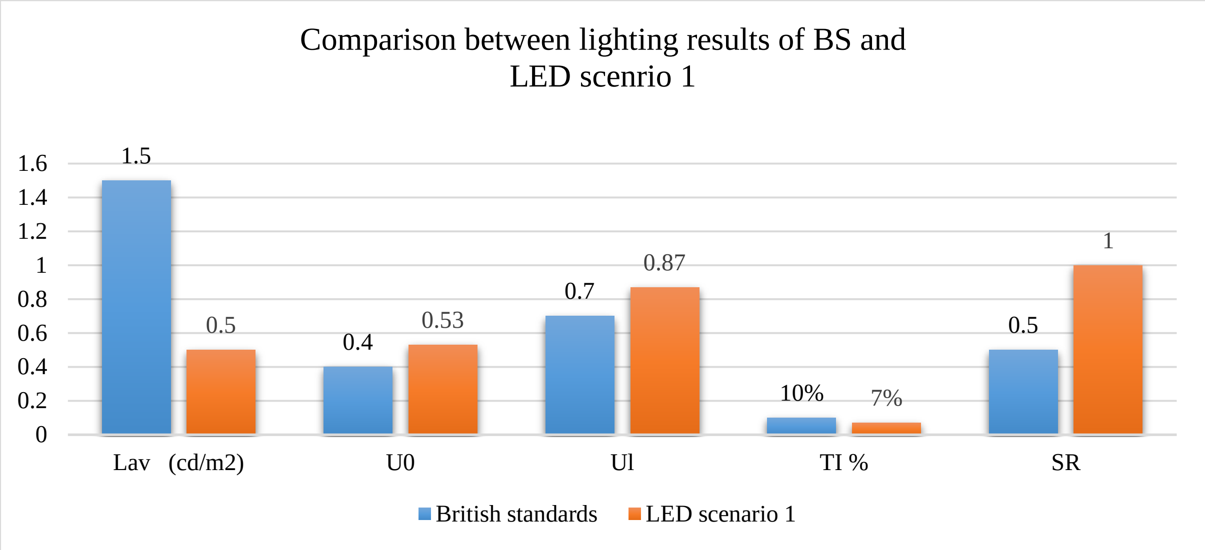


Chart 5.2: Comparison between lighting results of BS and LED scenrio 1

(Source : Author through DIALux ,2018)

Although the results indicate that L_{av} is less than that required by BS by -1 cd/m^2.The false colour rendering graph, which represents lighting level distribution, shows that lighting distribution falls in the dark zones of blue and purple. Thus, compared to HPS, luminance is poor, as shown in Figure: 5.8.

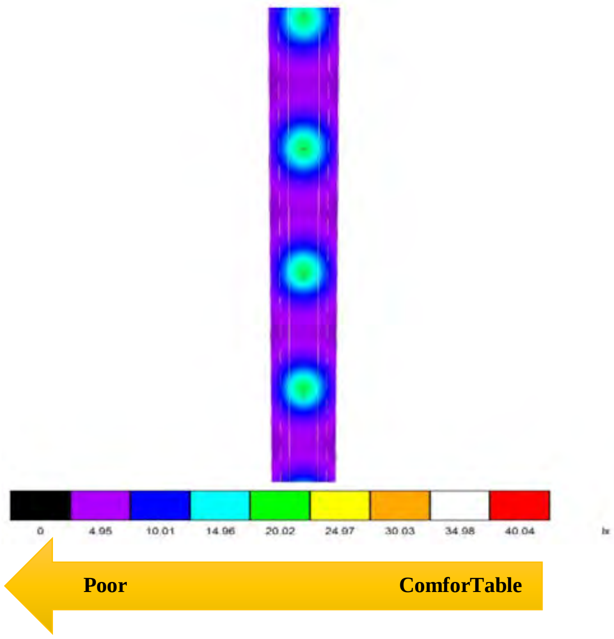


Figure 5.8: LED first scenario of false color rendering with 109 W

(Source : Author through DIALux ,2018)

For the technical specifications of the second LED scenario, which involved Trilux LIQ 90-AB7L/13500-730 16G1S ETDD LIQ with 123 W, are shown in Table 5.21.

Table 5.21: LED scenario 2 technical specifications

(Source : Author through DIALux ,2018)

LED scenario 2 technical specifications of lighting system	
Luminaire:	TRILUX LIQ 90-AB7L/13500-730 16G1S ETDD LIQ
Luminous flux (Luminaire):	13499 lm
Luminous flux (Lamps):	13500 lm
Luminaire Wattage:	123 W
Arrangement:	on Median
Pole Distance:	60 m
Mounting Height	14 m
Height:	13.900 m
Overhang :	-5.500 m
Boom Angle:	5.0 °
Boom Length :	-0.009 m

The lighting measurement outputs are L_{av} in two positions of 0.36 and 0.42 cd/m^2, U_o of 0.53 and 0.50, U_l of 0.74, TI of 10% and 7%, and SR of 1.04, as shown in Table 5.22.

Table 5.22: LED scenario 2 lighting output results

(Source : Author through DIALux ,2018)

Scenario 2	TRILUX LIQ 90-AB7L/13500-730 16G1S ETDD LIQ with 123 W	Observer	Lav (cd/m^2)	U0	Ul	TI %	SR
		1	0.36	**0.53**	0.74	10	1.04
		2	**0.42**	0.50	**0.74**	**7**	

Also measurements were compared with BS as shown in Chart 5.3.

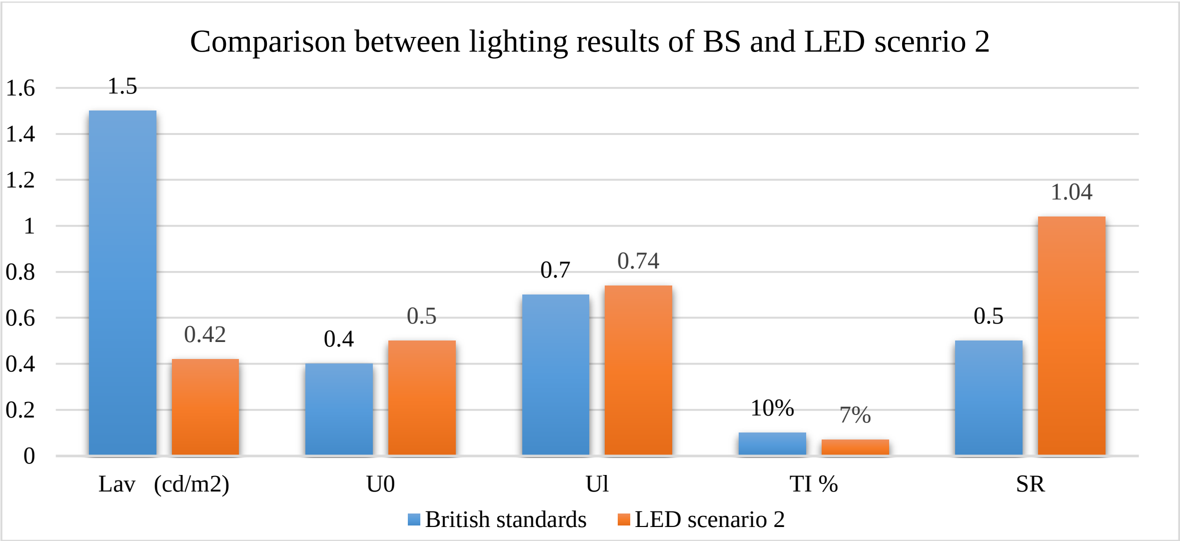


Chart 5.3: Comparison between lighting results of BS and LED scenrio 2

(Source : Author through DIALux ,2018)

The LED scenario 2, average luminance was less than the BS by – 1.08 cd/m^2 and threshold increment less than BS by 3%.Beside that , there were different in surround ratio with 0.54.While both overall uniformity and longitudinal uniformity in LED scenario 2 were below to required BS measurements. On the other hand , false color rendering graph, which present lighting level distribution in light and dark bule colors which indicate as poor luminance compared with HPS graph Figure 5.7,as shown in Figure 5.9

In scenario 2, L_{av} is 1.08 cd/m^2 and TI is 3% lower than recommended, and there is a difference of 0.54 in SR. However, U_o and U_l are close to the BS requirements. Nevertheless, the false colour rendering graph as shown in Figure 5.10, indicates poor luminance compared to HPS lighting as shown in Figure 5.9.

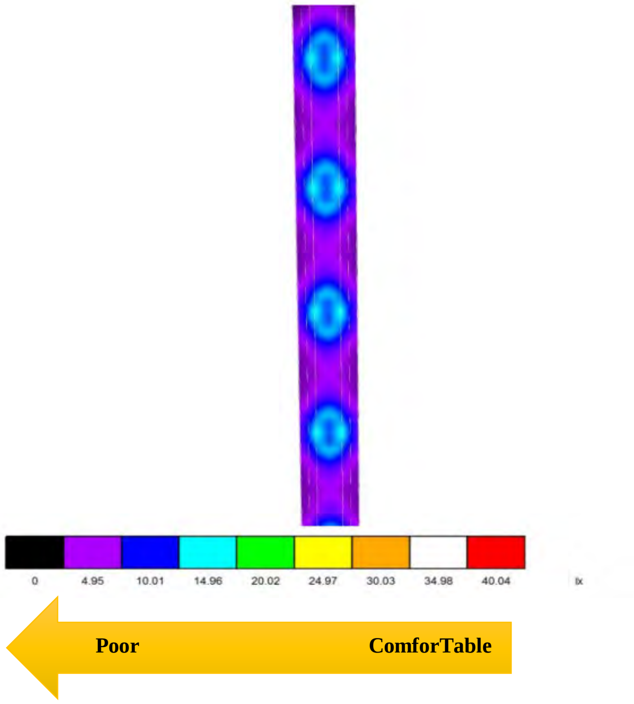


Figure 5.9: LED second scenario of false color rendering with 123 W
(Source : Author through DIALux ,2018)

Following by the third scenario of LED involved Schréder Ampera Maxi/5117/128 LEDS, 500 mA NW/356852 with 198 W, are shown in Table 5.23.

Table 5.23: LED scenario 3 technical specifications

(Source : Author through DIALux ,2018)

LED scenario 3 technical specifications of lighting system	
Luminaire:	SCHREDER AMPERA MAXI / 5117 / 128 LEDS,500mA NW / 356852
Luminous flux (Luminaire):	21428 lm
Luminous flux (Lamps):	28685 lm
Luminaire Wattage:	198 W
Arrangement:	on Median
Pole Distance:	60 m
Mounting Height	14 m
Height:	14.045 m
Overhang :	-4.872 m
Boom Angle:	5.0 °
Boom Length :	0.000 m

The outputs are L_{av} of 0.77 and 0.65 cd/m^2, U_o of 0.63 and 0.68, U_l of 0.80 and 0.82, TI of 10% and 12%, and SR of 0.95, as shown in Table 5.24.

Table 5.24: LED scenario 3 lighting output results

(Source : Author through DIALux ,2018)

Scenario 3	SCHREDER AMPERA MAXI / 5117 / 128 LEDS,500mA NW / 356852	Observer	Lav (cd/m^2)	U0	Ul	TI %	SR
		1	**0.77**	0.63	0.80	**10**	0.95
		2	0.65	**0.68**	**0.82**	12	

These lighting measurements were compared to BS, as shown in Chart 5.4.

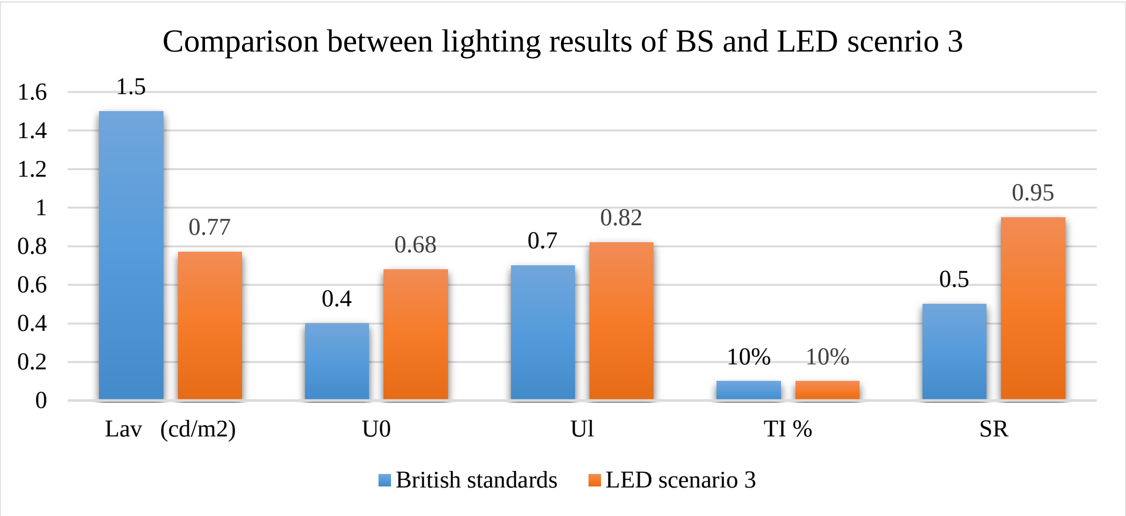


Chart 5.4: Comparison between lighting results of BS and LED scenrio 3

(Source : Author through DIALux ,2018)

For scenario three, lighting measurement outputs varies significantly from BS measurements, and false colour rendering graph as shown in Figure 5.10, indicates poor luminance compared to HPS lighting ,as shown in Figure 5.7.

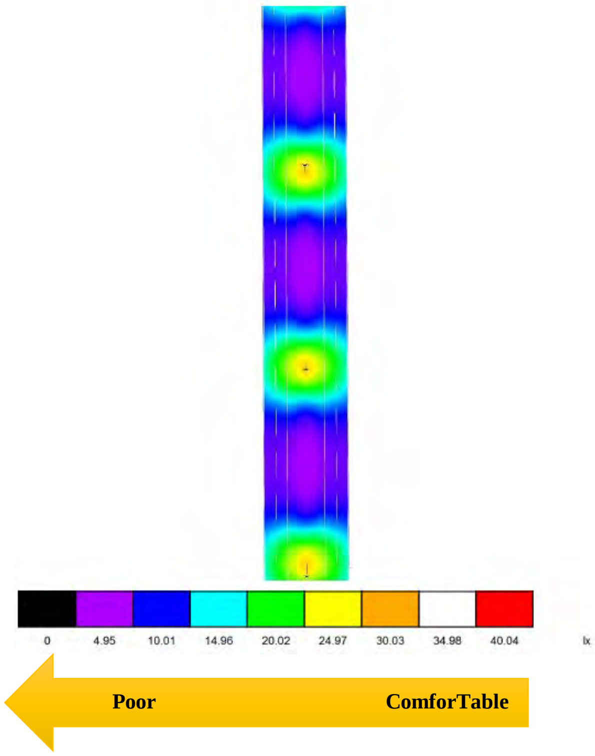


Figure 5.10: LED third scenario of false color rendering with 198 W

(Source : Author through DIALux ,2018)

The final scenario, Schréder Ampera Maxi 5138 - 128 Cree XP-G2 700 mA NW 230 V Flat, Glass, Extra Clear, Smooth 357172 with 240 W, as shown in Table 5.25, was used.

Table 5.25: LED scenario 4 technical specifications

(Source : Author through DIALux ,2018)

LED scenario 4 technical specifications of lighting system	
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Luminous flux (Luminaire):	27927 lm
Luminous flux (Lamps):	33147 lm
Luminaire Wattage:	240 W
Arrangement:	on Median
Pole Distance:	60 m
Mounting Height	14 m
Height:	13.866 m
Overhang :	-4.988 m
Boom Angle:	5.0 °
Boom Length :	0.500 m

The results are as follows: L_{av} in two positions of 1.21 and 1.05 cd/m^2, U_o of 0.52 and 0.58, U_l of 0.71 and 0.79, TI of 8% and 12%, and SR of 0.93, as shown in Table 5.26.

Table 5.26: LED scenario 2 lighting output results

(Source : Author through DIALux ,2018)

Scenario		Observer	Lav (cd/m^2)	U0	Ul	TI %	SR
4	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 with 240 W	1	1.05	**0.56**	**0.79**	12	0.93
		2	**1.21**	0.52	0.71	**8**	

The lighting measurements were compare to BS to determine their adherence to regulations. It was found that L_{av} is 0.29 cd/m^2 and TI 2% slightly below standard. Furthermore, there is an SR difference of 0.45, but U_o and U_l are close to BS requirements, as shown in Chart 5.5.

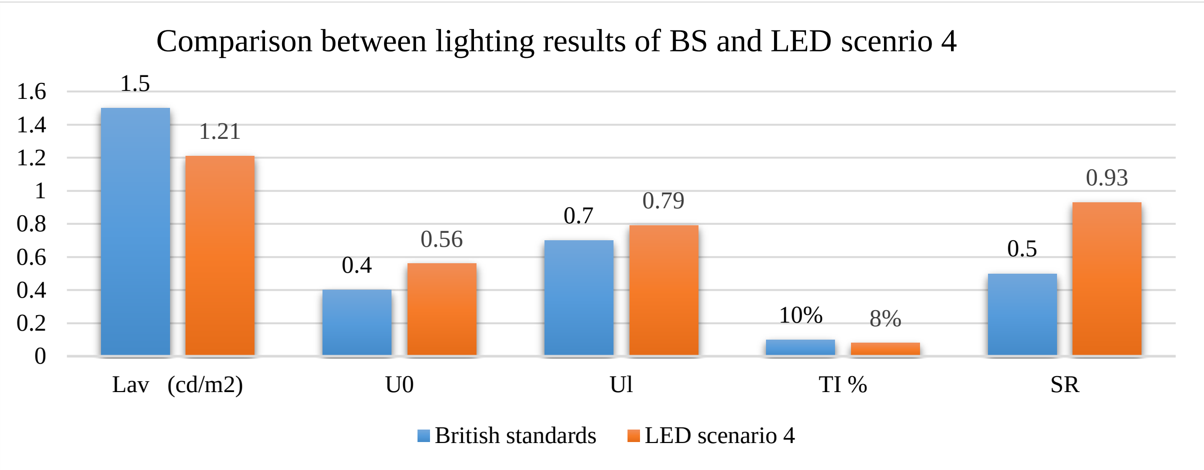


Chart 5.5: Comparison between lighting results of BS and LED scenrio 4

(Source : Author through DIALux ,2018)

On the other hand , the false colour rendering graph as shown in Figure 5.11, indicates that the distribution of red light is concentrated around the lighting poles, with blue light covering the areas between the poles. Therefore, this scenario offers better luminance than the previous three LED scenarios.

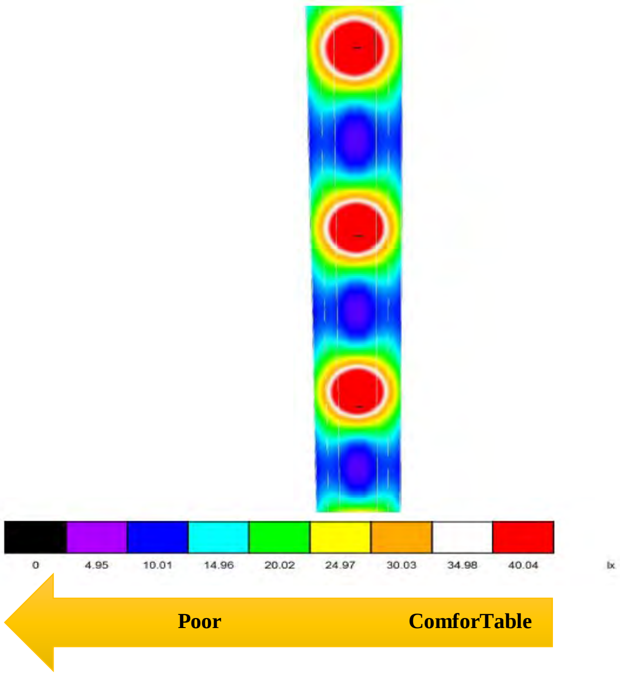


Figure 5.11: LED fourth scenario of false color rendering with 240 W
(Source : Author through DIALux ,2018)

In addition, all four LED scenarios were compared to BS individually. Chart 5.6 illustrates the outputs of each scenario compared to BS.

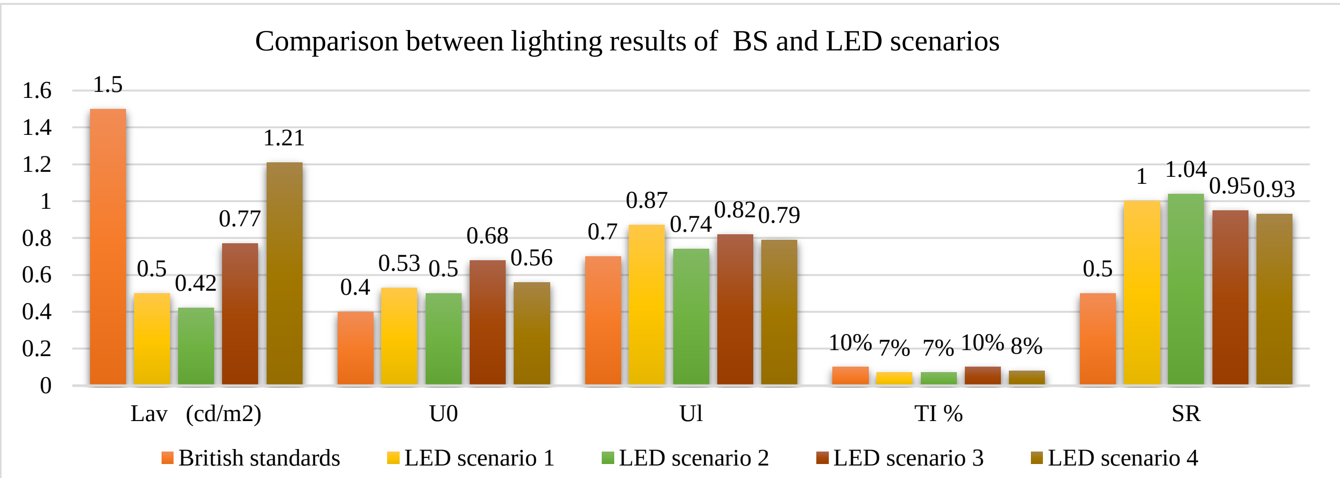


Chart 5.6: Comparison between lighting results of BS and LED scenarios
(Source : Author through DIALux ,2018)

It was concluded from the four LED scenarios that the Schréder Ampera Maxi 5138 - 128 Cree XP-G2 700 mA NW 230 V Flat Glass, Extra Clear, Smooth 357172 with 240 W LED is the optimum system because it yielded the best outputs and featured in the scenario that yielded outputs closest to BS. Moreover, although the current HPS roadway lighting system meets BS, if the system were to be upgraded to keep up with technological advancements and to meet sustainability goals, scenario 4—with further enhancements—would be the most suitable.

5.5.Phase 4: Results and Discussion of the Technical Parameters of the LED Lighting System

The fourth phase was analysing the parameters identified that could assist in the design of an optimum LED lighting model, namely boom angle, pole height, pole spacing, number of luminaires, and pole arrangement. Each parameter was examined through several trials, all of which involved fixing all variables except those under study, as shown in Table 5.27.

Table 5.27: Fixed and changed variables of simulations
(Source: Author through DIALux,2018)

Fixed variables				Changed variables		
LED Specifications	Luminaire Wattage	Number of luminaires	Pole arrangement	Boom angle	Pole height (m)	Pole Distance (m)
CHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172	240 W	2	Median	0º	12	50
				2º	14	60
				5º	16	70

In this phase, 27 parameter scenarios (PS) were divided into three parameter groups (PG) identified by boom angles of 0°, 2°, and 5°, with the same simulation techniques used for each scenario. The results of the first parameter group (PG_1), which used a 0° boom angle, are summarized in Table 5.28, with details of the simulation shown in Appendix (E).

Table 5.28 : Lighting measurements for first parameter group
(Source: Author through DIALux,2018)

LED Specifications of lighting system : SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172										**Parameter Group 1**
Luminous flux (Luminaire): 27927 lm										
Luminous flux (Lamps): 33147 lm										
Luminaire Wattage : 240 W										
Number of luminaires : 2										
Pole arrangement : Median										
0^{o}			0^{o}			0^{o}			Boom angle	
16			14			12			Pole Height (m)	
70	60	50	70	60	50	70	60	50	Pole Spacing (m)	
1.17	1.38	**1.66**	1.17	1.38	**1.67**	1.12	1.33	**1.61**	L_{avg} (cd/m2)	
0.53	0.59	0.63	0.46	0.5	0.53	0.37	0.4	0.41	U_o	
0.71	0.9	0.92	0.6	0.74	0.9	0.51	0.61	0.73	U_l	
8	7	9	9	8	7	9	8	7	TI(%)	
0.92	0.92	0.92	0.89	0.89	0.89	0.9	0.9	0.9	SR	
PS_9	PS_8	**PS_7**	PS_6	PS_5	**PS_4**	PS_3	PS_2	**PS_1**	Parameters scenarios (PS)	

The three most effective L_{av}, U_o, and U_l lighting outputs derived were compared to BS, as shown in, as shown in Chart 5.7 .

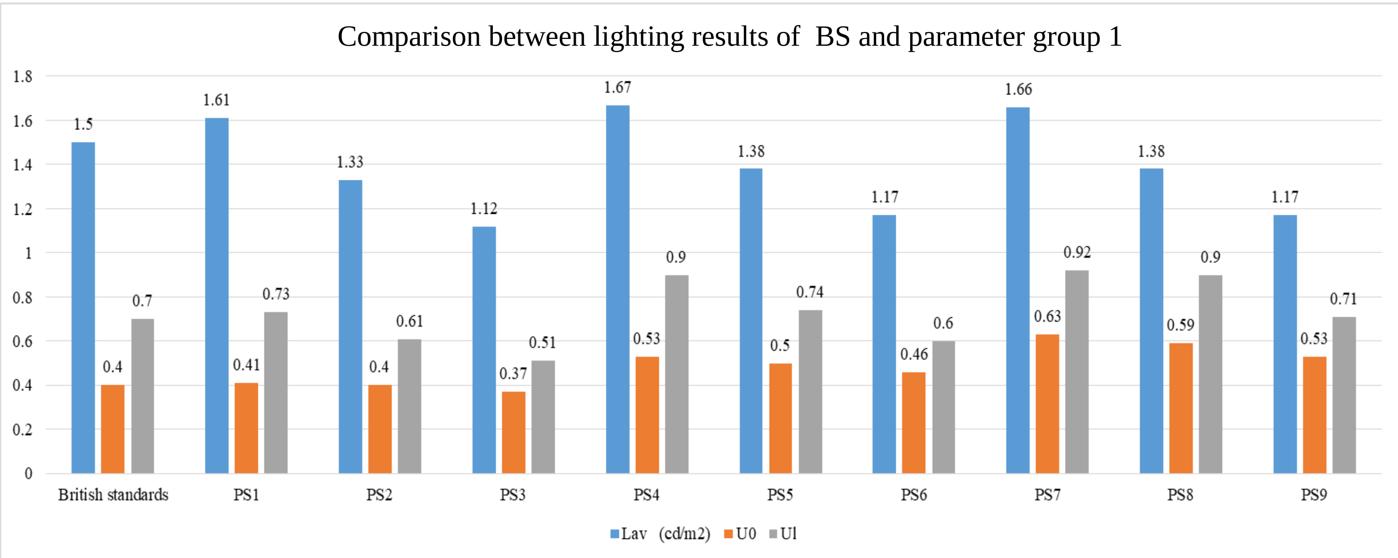


Chart 5.7: Comparison between lighting results of BS and parameter group 1.
(Source : Author through DIALux ,2018)

It was concluded that PS_7 was the optimum scenario due to the outputs yielded and compliance with BS.The results of the parameter scenarions presented earlier in Table and Chart , the selected optimum parameter scenarios were PS1,PS4 and PS7, due to the lighting measurements and complies with British Standards.

On the other hand , the second parameter group (PG_2), with a 2° as boom angle, is shown in Table 5.29, with further technical details shown in Appendix (F).

Table 5.29 :Lighting measurements for second parameter group
(Source: Author through DIALux,2018)

LED Specifications of lighting system : SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172										**Parameter Group 2**
Luminous flux (Luminaire): 27927 lm										
Luminous flux (Lamps): 33147 lm										
Luminaire Wattage : 240 W										
Number of luminaires : 2										
Pole arrangement : Median										
2°			2°			2°			Boom angle	
16			14			12			Pole Height (m)	
70	60	50	70	60	50	70	60	50	Pole Spacing (m)	
1.04	1.22	**1.47**	1.05	1.23	**1.49**	1.02	1.2	**1.46**	$L_{avg\,(cd/m2)}$	
0.55	0.61	0.65	0.49	0.53	0.56	0.41	0.44	0.46	U_o	
0.73	0.9	0.91	0.61	0.76	0.89	0.52	0.62	0.74	U_l	
8	7	6	9	8	7	10	9	7	TI(%)	
0.93	0.93	0.93	0.91	0.91	0.91	0.9	0.9	0.9	SR	
PS_{18}	PS_{17}	$\mathbf{PS_{16}}$	PS_{15}	PS_{14}	$\mathbf{PS_{13}}$	PS_{12}	PS_{11}	$\mathbf{PS_{10}}$	Parameters scenarios (PS)	

The lighting measurement output of all the parameter scenarios in (PG2) ,were compared with the british standards , as shown in Chart 5.8.

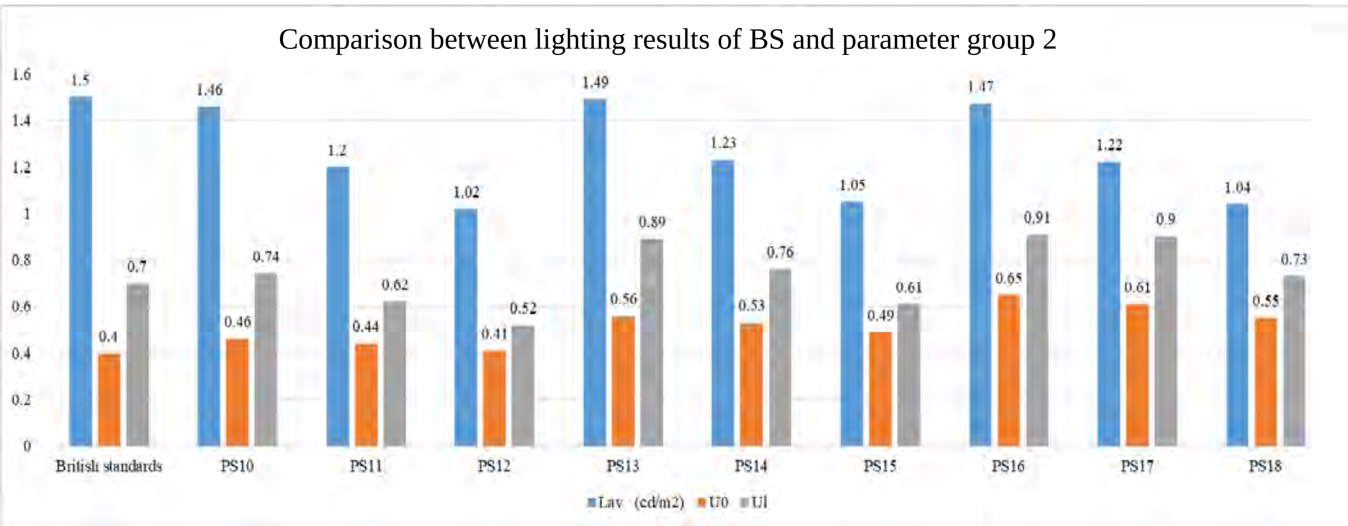


Chart 5.8: Comparison between lighting results of BS and parameter group 2.
(Source : Author through DIALux ,2018)

The Chart shows only three lighting measurement outputs of (L_{avg}) , (U_0) and (U_l) , due to the the selected optimum parameter scenarios were PS10 , PS13 and PS16 due to the lighting measurements and the close to accomplish measurements of British Standards.

In addition , for the third parameter group (PG3), with a 5° as boom angle, the results are shown in Table 5.30, with further technical details available in Appendix (G).

Table5.30 : Lighting measurements for third parameter group

(Source: Author through DIALux,2018)

LED Specifications of lighting system : SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172										Parameter Group 3
Luminous flux (Luminaire): 27927 lm										
Luminous flux (Lamps): 33147 lm										
Luminaire Wattage : 240 W										
Number of luminaires : 2										
Pole arrangement : Median										
5°			5°			5°			Boom angle	
16 m			14 m			12 m			Height	
70	60	50	70	60	50	70	60	50	Pole Distance	
1.11	1.18	**1.41**	1.02	1.34	**1.45**	1.12	1.2	**1.45**	$L_{avg\ (cd/m2)}$	
0.57	0.63	0.67	0.52	0.56	0.59	0.46	0.49	0.51	U_o	
0.74	0.91	0.92	0.62	0.79	0.9	0.54	0.63	0.76	U_l	
9	7	6	10	9	7	11	9	8	TI(%)	
0.94	0.94	0.94	0.93	0.93	0.93	0.92	0.92	0.92	SR	
PS_{27}	PS_{26}	$\mathbf{PS_{25}}$	PS_{24}	PS_{23}	$\mathbf{PS_{22}}$	PS_{21}	PS_{20}	$\mathbf{PS_{19}}$	Parameters scenarios (PS)	

The lighting measurement output of all the parameter scenarios in (PG3) were compared with the british standards , as shown in Chart 5.9.

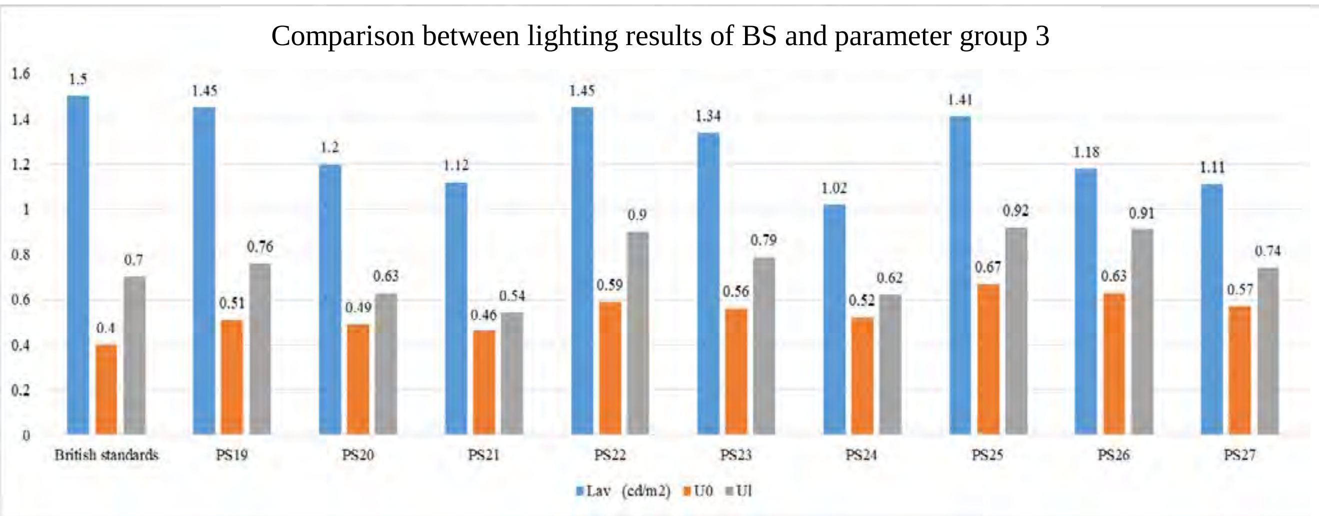


Chart 5.9: Comparison between lighting results of BS and parameter group 3

(Source : Author through DIALux ,2018)

It was subsequently concluded that the optimum scenarios were PS16 and PS22 due to the lighting measurements which yielded superior results that align with BS.

5.6. Final Results and Discussion

The optimum parameter scenarios were collected and presented in Table below as shown the pole height preferred is 12m, 14m, 16m however the 14m is the current pole height that is usd in the federal roadways therefore it is preferable to maintain same height over all other areas. On the other hand the optimum pole spacing was find to be 50m while the current case in the federal roadways shows that the pole spacing start from 50m in some roads while goes for 55m in other roadways and the maximum pole spacing could reach 60m in some roadways.

The results of the three scenarios starting with boom angle 0^{o}, then 2^{o} and ending by 5^{o} were compared to the british standards are shown below in Table 5.31.

Table 5.31: Optimum scenarios summary

(Source : Author through DIALux ,2018)

									Optimum Parameter Scenarios
LED Specifications of lighting system : SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172									
Luminous flux (Luminaire): 27927 lm									
Luminous flux (Lamps): 33147 lm									
Luminaire Wattage : 240 W									
Number of luminaires : 2									
Pole arrangement : Median									
5°	**5°**	**2°**	**2°**	**2°**	**0°**	**0°**	**0°**	**Boom angle**	
14	**12**	**16**	**14**	**12**	**16**	**14**	**12**	**Pole Height (m)**	
50	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**Pole Spacing (m)**	
1.45	1.45	1.47	1.49	1.46	1.66	1.67	1.61	$L_{avg\ (cd/m2)}$	
0.59	0.51	0.65	0.56	0.46	0.63	0.53	0.41	U_o	
0.9	0.76	0.91	0.89	0.74	0.92	0.9	0.73	U_l	
7	8	6	7	7	9	7	7	**TI(%)**	
0.93	0.92	0.93	0.91	0.9	0.92	0.89	0.9	**SR**	
PS_{22}	PS_{19}	PS_{16}	PS_{13}	PS_{10}	PS_{7}	PS_{4}	PS_{1}	**Parameters scenarios (PS)**	

Chapter 6: Conclusion of the Research

6.1.Conclusion

Roadway lighting plays a key role in the improvement of infrastructure quality and driver safety through the reduction of night-time traffic accidents. The scope of this research was federal roadways that fall within the purview of the Ministry of Infrastructure Development (MoID). Currently, HPS lighting is used on UAE federal highways. Therefore, the aim of this study was to clarify the potential savings related to replacing the current lighting system with an LED system and the impact of this shift on the sustainability indicators highlighted by Governmental Vision 2021, which sets out the goal of building an ‘integrated, sustainable infrastructure system by forming a joint vision between the local and federal sectors.

This research involved various phases to define an optimum lighting scenario in terms of power consumption and cost by comparing the outputs of HPS and LED systems, and by comparing these results with British standards (BS). Reviewing similar previous research and studies was a key aspect of the research, as this yielded an improved understanding of the results and procedures that influenced the progress of the research in defining the best solutions. Suggested methodologies, such as case study, field measurement, and computer simulation methods, were identified and evaluated by comparing their characteristics. Computer simulation was found to be the most suitable methodology, as it would yield data and graphs useful for comparison.

The first phase was evaluating various quantitative factors such as number of traffic accidents at night, traffic volume, roadway speed limits, topography, and number of urban settlements served. This allowed the researcher to identify a suitable section of roadway for study, namely 1 km of federal roadway E18 Manama–Karan–Shaam, and to prioritize the implementation of lighting upgrades along the remaining federal roadways considered.

DIALux software was used to run the simulations, as it allowed the researcher to adjust the input data during the four simulation phases. The second phase involved evaluating the existing 400 W HPS lighting system. This evaluation was used as the baseline case during the remaining phases.

The third phase of the study focused on evaluating four LED lighting scenarios: 109 W, 123 W, 198 W, and 240 W LED lighting. Therefore, the outputs of four types of lighting systems were compared with BS, with an emphasis on cost and efficiency. The 240 W system was found to be the optimum system in terms of output, efficiency, and cost, which includes installation, maintenance, and operation. In the fourth phase, the 240 W LED system was used as a baseline case to examine the effects of changing parameters such as pole height and boom angle to identify the optimum installation parameters.

It can be concluded that simulation software is a vital tool for examining and understanding lighting properties and for evaluating the scenarios proposed to enhance efficiency. DIALux was found to be compatible with the analysis of outdoor lighting, and to be user friendly and efficient in terms of time. However, because energy consumption calculations were not supported by the software, other formulas had to be used to obtain this information.

The analysis revealed that the optimum LED lighting system should have a 2° boom angle, with a pole height of 16 m, two luminaires per pole, 50 m spacing between poles, and poles that are arranged on the same side of the roadway. Furthermore, the research indicates that lighting affects the rate of night-time traffic accidents; thus, improving visibility on the case study roadway is crucial. Improved lighting reduces the number of traffic accidents that occur at night. Nevertheless, it is important to consider and address other factors that affect traffic accident rates, such as roadway fixtures, paving quality, traffic volume, and number of lanes.

6.2.Future Recommendations

This research creates a foundation for future studies on the same topic in different areas within the United Arab Emirates, or for research focused on the same case study area, but from a different perspective.

Suggestions for future studies include

1. Conducting similar research on other federal roadways where similar problems have been identified, as listed in the federal roadway priority index created in this study
2. Using the same study method for a similar simulation analysis, but focusing on a different roadway segment where the traffic volume is high
3. Exploring the possibility of establishing a unified road design code that includes all previously examined parameters and setting safety factors and other benchmarks for use as a national standard instead of the British standards currently used
4. Investigating alternative lighting systems that offer superior sustainability features in terms of using renewable energy resources
5. Identifying how the lighting colour of the luminaries influences visibility while driving at night, which lead to a simple solution for enhancing roadway lighting in future
6. Identify either the lighting color of the luminaires may influence on the human eye visibility while driving at night time which may be simple solution of enhancements the lighting in roadways in future aspects.

List of References

Agi32.com. (2014). *Lighting Design Software by Lighting Analysts*. [online] Available at: https://www.agi32.com/ [Accessed 15 Feb. 2018].

Aksamija, A. (2013). Building Simulations and High-Performance Buildings Research. *research journal*, 5(01), pp.19-32.

A. Avrenli, K., Benekohal, R. and Medina, J. (2012). *LED ROADWAY LIGHTING VOLUME 1: BACKGROUND INFORMATION*. [online] avrenli.me. Available at: http://avrenli.me/LED1.pdf [Accessed 29 Jan. 2017].

Al-Haji, G. (2014). *The Impact of New Roadways Lighting Technologies on Traffic Safety*. [online] jtle.net. Available at: http://www.jtle.net/uploadfile/2014/0604/20140604035012103.pdf [Accessed 13 Apr. 2017].

Asnt.org. (2017). *Codes and Standards Overview*. [online] Available at: https://www.asnt.org/MajorSiteSections/NDT-Resource-Center/Codes_and_Standards.aspx [Accessed 25 Jul. 2017].

Al-Dulaimi, M. (2015). *A METHOD TO CALIBRATE ROADWAY LIGHTING WARRANTS AND LEVELS WITH CRASH-HISTORY*. [online] Spectrum.library.concordia.ca. Available at: https://spectrum.library.concordia.ca/980642/1/Al-Dulaimi_PhD_S2016.pdf [Accessed 29 Sep. 2017].

Al Mojil, A., Farhan, M., Osman, S., Faruque, S. and Aftab, A. (2017). Overview of traffic safety issues in two main areas of Dammam. In: *Engineering and safety of transport and traffic*. Al Kobar - KSA: Imam Abdul Rehman Bin Faisal University, pp.1-14.

Box, P.C. 1970. Relationship between illumination and freeway accident. Transportation Research Record, Transportation Research Board of the National Academies. No. 416. pp. 10-20

Bullough, J., Rea, M. and Zhang, X. (2012). EVALUATION OF VISUAL PERFORMANCE FROM PEDESTRIAN CROSSWALK LIGHTING. *Transportation Research Board 91st Annual Meeting*, 12(3348), pp.1-8

Bitar, K. (2017). *MoID information federal roadways*

Choueiri, B., Choueiri, G. and Choueiri, E. (2010). *Cite a Website - Cite This For Me*. [online] Pdfs.semanticscholar.org. Available at: https://pdfs.semanticscholar.org/1e29/56e4c5b049ff2421d9ac4981a529ac1df932.pdf [Accessed 1 Jan. 2018].

Cltc.ucdavis.edu. (2015). *LIGHTING TECHNOLOGY OVERVIEW*. [online] Available at: http://cltc.ucdavis.edu/sites/default/files/files/publication/2015-lighting-technology-overview-apr-2016.pdf [Accessed 23 Jan. 2017].

Cripps, M. (2016). *The Corporation of TOWN OF MILTON*. [online] Milton.ca. Available at: https://www.milton.ca/MeetingDocuments/Council/agendas2016/rpts2016/ENG-029-16%20Appleby%20Line%20In%20Service%20Road%20Safety%20final.pdf [Accessed 22 Nov. 2017].

Comt.ca. (2017). *Canada's National Highway System Annual Report 2012*. [online] Available at: http://www.comt.ca/english/NHS%20Annual%202012.pdf [Accessed 22 Nov. 2017].

Department of Municipal Affairs and Transport in Abu Dhabi ,UAE (2016). LIGHTING MANUAL. Abu Dhabi: Department of Municipal Affairs and Transport in Abu Dhabi ,UAE, pp.39-200.

etcc-ca.com. (2009). *LED Roadways Lighting Assessment*. [online] Available at: http://www.etcc-ca.com/sites/default/files/OLD/images/stories/et_09.01_led_roadways_lighting_final.pdf [Accessed 12 Apr. 2017].

Energy Efficient Roadways Lighting Guidelines. (2010). [online] environment.nsw.gov.au. Available at: http://www.environment.nsw.gov.au/resources/business/140016-energy-efficient-lighting-tech-detail.pdf [Accessed 21 Jan. 2017].

51ballast.cn. (2000). *CIE road lighting calculations*. [online] Available at: http://www.51ballast.cn/tec/gf/8.pdf [Accessed 2 Aug. 2017].

Fodah, M. (2017). [online] Available at: http://www.emaratalyoum.com/local-section/other/2017-09-14-1.1027032 [Accessed 29 Nov. 2017].

Global Competitiveness Index 2017-2018. (2018). *Competitiveness Rankings*. [online] Available at: http://reports.weforum.org/global-competitiveness-index-2017-2018/competitiveness-rankings/?doing_wp_cron=1514804655.4938240051269531250000#series=GCI.A.02 [Accessed 1 Jan. 2018].

Government.ae. (2017). *Topography and ecosystems*. [online] Available at: https://government.ae/en/information-and-services/environment-and-energy/topography-and-ecosystems [Accessed 19 Nov. 2017].

Graham, J. (1998). Target Risk: Dealing with the Danger of Death, Disease and Damage in Everyday Decisions.: By Gerald J S Wilde. (Pp 234.) Toronto: PDE Publications, 1994. ISBN 0-9699-12404. *Injury Prevention*, 4(2), pp.162-163.

ga.gov.au. (2017). *What is a Topographic Map?*. [online] Available at: http://www.ga.gov.au [Accessed 27 Dec. 2017].

Harris, B., Montes, J. and Forbes, N. (2015). *A Novel Approach to Sensor-less Daylight Harvesting in Commercial Office Buildings*. [online] http://fredon.com.au. Available at: http://fredon.com.au/wp-content/uploads/2017/11/A-Novel-Approach-to-Sensor-less-Daylight-Harvesting-in-Commercial-Office-Buildings-27-4-2017.pdf [Accessed 15 Feb. 2018].

Hye Oh, J., Rag Do, Y. and Yang, S. (2014). Healthy, natural, efficient and tunable lighting: four-package white LEDs for optimizing the circadian effect, color quality and vision performance. *Light: Science & Applications*, [online] 3(141), pp.1-9. Available at: http://www.nature.com/lsa/journal/v3/n2/pdf/lsa201422a.pdf [Accessed 31 Mar. 2017].

Hooker, J. (2011). *The Low Pressure Sodium Lamp*. [online] Lamptech.co.uk. Available at: http://www.lamptech.co.uk/Documents/SO%20Introduction.htm [Accessed 12 Apr. 2017].

Hamrle, D. (2014). *Cite a Website - Cite This For Me*. [online] Dspace.cvut.cz. Available at: https://dspace.cvut.cz/bitstream/handle/10467/63751/F6-DP-2014-Hamrle-Daniel-Transport%20safety%20assessment%20of%20road%20adaptive%20lighting%20implementation.pdf?sequence=-1 [Accessed 14 Apr. 2017].

Humanities.manchester.ac.uk. (2017). *Research Methodology | Study Skills | University of Manchester*. [online] Available at: http://www.humanities.manchester.ac.uk/studyskills/assessment_evaluation/dissertations/methodology.html [Accessed 2 May 2017].

Integrated Publishing, I. (2017). *Boom Angle Indicators*. [online] Tpub.com. Available at: http://www.tpub.com/eqopbas/142.htm [Accessed 21 Dec. 2017].

Isebrands, H., Hallmark, S., Li, W., McDonald, T., Storm, R. and Preston, H. (2010). Roadway Lighting Shows Safety Benefits at Rural Intersections. *Journal of Transportation Engineering*, 136(11), pp.949-955.

Jackett, M. and Frith, W. (2013). Quantifying the impact of road lighting on road safety — A New Zealand Study. *IATSS Research*, 36(2), pp.139-145.

Jackett, W. and Jackett, M. (2015). *The relationship between road lighting and night-time crashes in areas with speed limits between 80 and100km/h*. [online] nzta.govt.nz. Available at: https://www.nzta.govt.nz/assets/resources/research/reports/573/573-the-relationship-between-road-lighting-and-night-time-crashes.pdf [Accessed 18 Apr. 2017].

khaleejtimes (2015). Residents cry foul over difference in Fewa power tariff. [online] p.1. Available at: https://www.khaleejtimes.com/nation/general/residents-cry-foul-over-difference-in-fewa-power-tariff [Accessed 8 Feb. 2018].

Kytömaa, L. (2014). *Road lighting user experiments - a review and a new assessment method*. [online] Aaltodoc.aalto.fi. Available at: https://aaltodoc.aalto.fi/bitstream/handle/123456789/14837/master_Kyt%C3%B6maa_Lauri_2014.pdf?sequence=1 [Accessed 23 Mar. 2017].

Kemeh, J. (2010). *ROAD TRAFFIC CRASHES ON THE KONONGO-KUMASI HIGHWAY - TWO YEARS AFTER RECONSTRUCTION*. [online] Ir.knust.edu.gh. Available at: http://ir.knust.edu.gh/bitstream/123456789/1419/1/Kemeh%20THESIS%20Main%20Report.pdf [Accessed 18 Apr. 2017].

Light distribution in dynamic roadways lighting: two experimental studies on its effects on perceived safety, prospect, concealment and escape. (2012). *Journal of Environmental Psychology*, 32(4), pp.342-352.

Lumileds.com. (2016). *Roadways Lighting ,LEDs: coming soon to a roadways light near you*. [online] Available at: http://www.lumileds.com/uploads/166/WP14-pdf [Accessed 30 Jan. 2017].

Lee, X., Moreno, I. and Sun, C. (2013). High-performance LED roadways lighting using microlens arrays. *Optics Express*, [online] 21(9), p.10612. Available at: https://doi.org/10.1364/OE.21.010612 [Accessed 29 Dec. 2017].

Malliga, A., Preetha, M. and Merlin, S. (2017). ANALYSIS OF INSUFFICIENT LIGHTING IN SUBSTATION BY BY DIALUX SOFTWARE. *International Journal of Advanced in Management, Technology and Engineering Sciences*, 7(12, 2017), pp.131-136.

Muvuringi, M. (2012). *ROAD TRAFFIC ACCIDENTS IN ZIMBABWE, INFLUENCING FACTORS IMPACT AND STRATEGIES*. [online] bibalex.org. Available at: http://www.bibalex.org/Search4Dev/files/428824/455667.pdf [Accessed 14 Apr. 2017].

Marzoug, R., Ez-Zahraouy, H. and Benyoussef, A. (2015). Simulation study of car accidents at the intersection of two roadways in the mixed traffic flow. *International Journal of Modern Physics C*, [online] 26(01), p.1550007. Available at: https://www.academia.edu/7386160/Simulation_study_of_car_accidents_at_the_intersection_of_two_roadways_in_the_mixed_tra_c_ow [Accessed 27 May 2017].

Mohan, D., Tiwari, G. and Mukherjee, S. (2016). *Urban traffic safety assessment: A case study of six Indian cities*. [online] Ac.els-cdn.com. Available at: http://ac.els-cdn.com/S0386111216000054/1-s2.0-S0386111216000054-main.pdf?_tid=2b36fd06-4a8a-11e7-80b0-00000aacb35f&acdnat=1496734475_4f520fbbf680df0963d05ed7bb338336 [Accessed 6 Jun. 2017].

Manner, H. and Wünsch-Ziegler, L. (2013). *Analyzing the severity of accidents on the German Autobahn - ScienceDirect*. [online] Sciencedirect.com. Available at: http://www.sciencedirect.com/science/article/pii/S0001457513001206 [Accessed 11 Jun. 2017].

Pliszczak, R. (2012). *Roadways Lighting Management System*. [online] WROCLAW UNIVERSITY OF TECHNOLOGY. Available at: http://file:///C:/Users/Dr%20Al%20shehhi/Desktop/Thesis_14_3_2017/Refernces/Roadways%20Lighting%20Management%20System.pdf [Accessed 23 Mar. 2017].

Patentinsightpro.com. (2010). *Technology Insight Report LED Technology In Lighting*. [online] Available at:

http://www.patentinsightpro.com/techreports/0410/Gridlogics%20Technology%20Insight%20Report-LEDs%20in%20Lighting.pdf [Accessed 25 Mar. 2017].

Radetsky, L. (2010). *Choosing between LED and HPS roadways lights*. [online] Ledsmagazine.com. Available at: http://www.ledsmagazine.com/articles/print/volume-7/issue-12/features/choosing-between-led-and-hps-roadways-lights.html [Accessed 21 Feb. 2017].

Reinhart, C. and Wienold, J. (2011). The daylighting dashboard e A simulation-based design analysis for daylit spaces. *Building and Environment*, 45(22), pp.386-396.

Saraiji, R., Hamadan, M. and Harb, A. (2014). Illuminance Degradation of LED Streetlighting. *LEUKOS: The Journal of the Illuminating Engineering*, 9(3), pp.201-2016.

Sanderson, S. and Simons, K. (2012). *Light Emitting Diodes and the Lighting Revolution:The Emergence of a Solid-State Lighting Industry*. [online] homepages.rpi.edu. Available at: http://homepages.rpi.edu/~simonk/pdf/industryEmergenceSSL.pdf [Accessed 31 Mar. 2017].

Shop.bsigroup.com. (2012). *BS 5489-1:2013 Code of practice for the design of road lighting. Lighting of roadways and public amenity areas*. [online] Available at: https://shop.bsigroup.com/ProductDetail/?pid=000000000030217237 [Accessed 13 Aug. 2017].

Scribd. (2010). *CIE 115-2010_Road Lighting | Lighting | Traffic*. [online] Available at: https://www.scribd.com/doc/249739724/CIE-115-2010-Road-Lighting [Accessed 13 Aug. 2017].

Thomas, R. (2014). *https://www.slideshare.net/renususanthomas/case-studyresearchmethod*

Usabilitybok.org. (2012). *Field Study | Usability Body of Knowledge*. [online] Available at: http://www.usabilitybok.org/field-study [Accessed 2 May 2017].

www.dfintl.com. (2014). *LED Road Lighting Design Manual*. [online] Available at: http://www.dfintl.com/wp-content/uploads/2016/04/LED-Road-Lighting-Design-Manual1.pdf [Accessed 23 Jan. 2017].

Appendix (A)

Appendix (A): Traffic accidents at night time in federal roadways 2016-August 2017.

Table A.1: Traffic accidents at night time in E11 ITHIHAD roadway.

(Source: MoID, 2016-2017)

E11			
NO	**Date**	**Chainage**	**Code**
1	17/08/2017	4+0870	Inc_1773
2	12/08/2017	12+0040	Inc_2344
3	17/06/2017	30+0210	Inc_1075
4	15/06/2017	30+0740	Inc_1015
5	14/05/2017	28+0840	Inc_1099
6	14/05/2017	21+0150	Inc_809
7	14/05/2017	28+0840	Inc_811
8	12/05/2016	47+0650	E11B001/16
9	17/08/2015	47+0650	E11B001/15
10	12/09/2017	47+0560	Inc_2360
11	30/08/2017	17+0960	ACCSAE306170830
12	23/07/2017	0+0000	ACCSAE204717072
13	13/06/2017	5+0580	Inc_1009
14	13/06/2017	7+0670	Inc_1010
15	14/05/2017	26+0580	Inc_810
16	27/01/2017	0+0000	ACCSAE306170127
17	25/01/2017	0+0000	ACC2068
18	27/12/2016	0+0000	ACC1976
19	01/03/2016	21+0030	E11F005/16
20	31/01/2016	5+0590	E11F002/16
21	28/01/2016	20+0460	E11F003/16
22	27/01/2016	24+0620	E11F004/16
23	19/01/2016	12+0250	E11F001/16

Table A.2: Traffic accidents at night time in E18 MANAMA-KARAN-SHAAM roadway.

(Source: MoID, 2016-2017)

E18			
NO	**Date**	**Chainage**	**Code**
1	13/09/2017	14+0750	Inc_2409
2	13/09/2017	14+0770	Inc_2413
3	13/09/2017	24+0790	Inc_2443
4	13/09/2017	26+0560	Inc_2446
5	13/08/2017	3+0590	Inc_1633
6	13/08/2017	26+0670	Inc_1645
7	13/08/2017	41+0510	Inc_1649
8	09/08/2017	25+0680	Inc_1476
9	03/08/2017	3+0380	Inc_1344
10	03/08/2017	3+0380	Inc_1344
11	04/08/2017	3+0381	Inc_1345
12	05/08/2017	3+0382	Inc_1346
13	06/08/2017	3+0383	Inc_1347
14	31/07/2017	1+0080	Inc_1277
15	31/07/2017	1+0080	Inc_1277
16	16/07/2017	4+0010	Inc_1191
17	10/07/2017	5+0430	Inc_1095
18	10/07/2017	5+0570	Inc_1096
19	01/07/2017	23+0369	Inc_1047
20	02/07/2017	23+0370	Inc_1048
21	16/06/2017	32+0650	Inc_1021
22	07/05/2017	0+0190	Inc_776
23	07/05/2017	0+0190	Inc_776
24	02/05/2017	19+0370	Inc_693
25	02/05/2017	20+0630	Inc_694
26	02/05/2017	22+0310	Inc_695
27	18/04/2017	16+0720	Inc_503
28	08/04/2017	12+0190	Inc_511
29	08/04/2017	14+0900	Inc_512
30	08/04/2017	15+0650	Inc_513
31	06/04/2017	1+0790	Inc_508
32	06/04/2017	12+0400	Inc_509
33	05/04/2017	12+0400	Inc_499
34	05/04/2017	18+0530	Inc_501
35	29/03/2017	18+0390	Inc_711
36	19/01/2017	0+0000	ACC2049
37	30/09/2017	0+30590	Inc_2763
38	24/09/2017	0+40380	Inc_2663

E18			
NO	**Date**	**Chainage**	**Code**
39	13/08/2017	0+4220	Inc_1663
40	09/08/2017	0+21220	Inc_1484
41	16/07/2017	0+5140	Inc_1186
42	19/06/2017	0+29540	Inc_1280
43	24/05/2017	0+21490	Inc_864
44	24/05/2017	0+21220	Inc_866
45	24/05/2017	0+21210	Inc_867
46	24/05/2017	0+21180	Inc_868
47	24/05/2017	0+21020	Inc_870
48	24/05/2017	0+15310	Inc_871
49	24/05/2017	0+14640	Inc_872
50	24/05/2017	0+14550	Inc_873
51	06/04/2017	0+13220	Inc_510
52	24/09/2017	2+0310	Inc_2644
53	11/09/2017	18+0330	Inc_2351
54	11/09/2017	31+0460	Inc_2352
55	11/09/2017	34+0410	Inc_2353
56	13/08/2017	35+0030	Inc_1659
57	13/08/2017	35+0020	Inc_1660
58	09/08/2017	32+0560	Inc_1483
59	03/08/2017	4+0080	Inc_1365
60	03/08/2017	4+0080	Inc_1365
61	02/08/2017	19+0530	Inc_1322
62	31/07/2017	49+0990	Inc_1879
63	01/08/2017	49+0991	Inc_1880
64	05/06/2017	0+0980	Inc_1360
65	05/06/2017	4+0480	Inc_948
66	07/05/2017	20+0090	Inc_2120
67	02/05/2017	11+0080	Inc_743
68	27/04/2017	10+0960	Inc_688
69	18/04/2017	3+0150	Inc_497
70	19/04/2016	9+0660	E18_2F001/16
71	20/04/2016	9+0661	E18_2F001/17
72	25/09/2017	16+0499	Inc_2708
73	26/09/2017	16+0500	Inc_2709
74	05/08/2017	40+0080	Inc_1378
75	26/07/2017	47+0130	Inc_2132
76	27/07/2017	47+0131	Inc_2133
77	27/07/2017	47+0131	Inc_2133
78	08/05/2017	38+0860	Inc_1340
79	09/05/2017	38+0861	Inc_1341

E18			
NO	**Date**	**Chainage**	**Code**
80	04/05/2017	38+0840	Inc_1295
81	06/01/2017	53+0480	ACC2022

Table A.3: Traffic accidents at night time in E 84 SHAIEK KHALIFA BIN ZAYED roadway.

(Source: MoID, 2016-2017)

E84			
NO	**Date**	**Chainage**	**Code**
1	28/08/2017	39+0400	Inc_2141
2	29/01/2017	0+0000	ACC2069
3	28/01/2017	0+0000	ACC2070
4	21/01/2017	0+0000	ACC2051
5	17/01/2017	0+0000	ACC2038
6	16/01/2017	0+0000	ACC2053
7	15/01/2017	0+0000	ACC2040
8	09/01/2017	0+0000	ACC2045
9	01/01/2017	0+0000	ACC2074

Table A.4: Traffic accidents at night time in E87 DIBBA-TAWAIN roadway.

(Source: MoID, 2016-2017)

E87			
No	**Date**	**Chainage**	**Code**
1	16/03/2017	0+0000	Inc_455
2	25/01/2017	0+0000	ACC2077
3	22/01/2017	0+0000	ACC2065
4	21/01/2017	0+0000	ACC2076
5	17/02/2016	0+0090	E87F003/16
6	09/07/2017	0+14260	Inc_1089
7	08/02/2016	0+14590	E87B003/16
8	29/06/2017	0+15190	Inc_1043
9	08/08/2017	0+16800	Inc_1593
10	24/02/2016	0+17160	E87B005/16
11	04/05/2016	0+17400	E87B009/16

E87			
No	**Date**	**Chainage**	**Code**
12	02/06/2017	0+19720	Inc_1358
13	05/02/2016	0+20600	E87B002/16
14	18/02/2016	0+21120	E87B004/16
15	02/02/2016	0+23060	E87B001/16
16	30/09/2017	0+26070	Inc_2777
17	09/07/2017	0+27260	Inc_1086
18	09/07/2017	0+28550	Inc_1079
19	30/09/2017	0+29220	Inc_2776
20	09/05/2017	0+29980	Inc_911
21	07/05/2017	0+30090	Inc_779
22	20/08/2016	0+30090	E87B008/16
23	06/04/2016	0+30090	E87B006/16
24	06/04/2016	0+30090	E87B007/16
25	04/06/2017	0+7370	Inc_937
26	04/05/2017	2+0990	Inc_734
27	04/01/2017	4+0950	ACCSAE206917010
28	04/05/2017	4+0980	Inc_735
29	04/05/2017	7+0540	Inc_737
30	04/05/2017	7+0660	Inc_738
31	03/06/2016	8+0390	E87F001/16
32	23/03/2017	10+0870	Inc_710
33	02/06/2017	16+0030	Inc_919
34	02/06/2017	16+0080	Inc_916
35	02/06/2017	16+0080	Inc_917
36	08/02/2016	17+0170	E87F002/16
37	28/01/2016	19+0270	E87F001/16
38	11/05/2017	20+0810	Inc_805
39	18/05/2017	21+0050	Inc_834
40	11/05/2017	23+0380	Inc_806
41	05/05/2016	24+0819	E87F004/16
42	06/05/2016	24+0820	E87F004/16
43	09/07/2017	25+0530	Inc_1088
44	14/07/2015	27+0770	E87F002/15
45	16/05/2016	27+0830	E87F005/16

Table A.5: Traffic accidents at night time in E88 SHARJAH _AL DHAID_MASAFI roadway.

(Source: MoID, 2016-2017)

E88			
NO	**Date**	**Chainage**	**Code**
1	14/04/2016	0+0000	E88_2F005/16
2	18/09/2017	0+0120	Inc_2722
3	14/08/2017	0+11110	Inc_1690
4	24/07/2017	0+1170	Inc_1244
5	14/08/2017	0+11880	Inc_1689
6	01/06/2017	0+13220	Inc_896
7	31/05/2017	0+13240	Inc_903
8	27/08/2017	0+14250	Inc_2137
9	09/05/2017	0+19320	Inc_1736
10	06/07/2017	0+19870	Inc_1063
11	29/05/2017	0+20280	Inc_880
12	29/05/2017	0+20290	Inc_879
13	17/04/2016	0+23450	E88_1F001/16
14	14/08/2017	0+24900	Inc_1728
15	28/09/2017	0+25000	Inc_2739
16	13/08/2017	0+27200	Inc_1665
17	01/07/2017	0+28520	Inc_1074
18	16/07/2017	0+28660	Inc_1190
19	30/04/2017	0+29090	Inc_648
20	12/06/2017	0+33440	Inc_1076
21	07/02/2016	0+35390	E88_1B001/16
22	03/06/2017	0+5370	Inc_928
23	14/08/2017	2+0150	Inc_1697
24	20/04/2017	2+0660	Inc_2771
25	13/07/2017	2+0850	Inc_1172
26	08/02/2016	3+0670	E88_2F002/16
27	16/02/2016	5+0090	E88_2F001/16
28	06/04/2016	7+0880	E88_2F004/16
29	30/05/2016	9+0730	E88_2F006/16
30	04/06/2017	9+0990	Inc_932
31	04/06/2017	10+0080	Inc_936
32	15/07/2017	10+0870	Inc_1183
33	03/03/2016	12+0730	E88_2F003/16
34	14/09/2017	13+0350	Inc_2469
35	07/09/2017	13+0910	Inc_2280

E88			
NO	**Date**	**Chainage**	**Code**
36	11/06/2017	14+0100	Inc_1182
37	19/03/2017	15+0880	Inc_1581
38	14/08/2017	20+0490	Inc_1707
39	12/07/2017	21+0750	Inc_1155
40	12/07/2017	23+0480	Inc_1318
41	14/06/2017	24+0240	Inc_1004
42	14/06/2017	24+0320	Inc_1005
43	12/07/2017	24+0910	Inc_1153
44	12/07/2017	24+0930	Inc_1350
45	14/08/2017	26+0990	Inc_1716
46	11/07/2017	27+0540	Inc_1117
47	01/06/2017	27+0760	Inc_895
48	30/05/2017	27+0790	Inc_904
49	16/07/2017	28+0610	Inc_1189
50	14/06/2017	29+0250	Inc_1006

Table A.6: Traffic accidents at night time in E89 MASSAFI-FUJERAH roadway.

(Source: MoID, 2016-2017)

E89			
NO	**Date**	**Chainage**	**Code**
1	11/05/2017	0+2100	Inc_808
2	12/08/2017	0+1930	Inc_1591
3	22/04/2017	0+9240	Inc_1921
4	11/07/2017	0+14340	Inc_1118
5	14/06/2017	0+14340	Inc_1007
6	30/04/2017	0+7620	Inc_649
7	19/03/2017	0+0000	Inc_479
8	09/07/2017	0+14670	Inc_1091
9	09/07/2017	0+14880	Inc_1092
10	05/06/2017	0+14230	Inc_940
11	29/05/2017	0+2790	Inc_907
12	04/04/2017	0+2570	Inc_507

Table A.7: Traffic accidents at night time in E99 DIBBA-KHORFFAKAN- FUJIRAH-KALBA- roadway.

(Source: MoID, 2016-2017)

E99			
NO	**Date**	**Chainage**	**Code**
1	17/08/2017	0+32630	Inc_1791
2	25/07/2017	0+34380	Inc_1247
3	11/07/2017	0+34380	Inc_1125
4	05/06/2017	0+27040	Inc_943
5	21/05/2017	0+27880	Inc_908
6	09/08/2017	0+18180	Inc_1463
7	11/07/2017	0+10810	Inc_1129
8	05/06/2017	0+14280	Inc_946
9	25/05/2017	0+9360	Inc_877
10	23/05/2016	0+18760	E99_1B002/16
11	20/03/2016	0+0870	E99_1B001/16
12	22/12/2016	0+10570	E99_1B001/17
13	15/06/2017	0+34500	Inc_1003
14	05/06/2017	0+15980	Inc_949
15	04/05/2017	0+4100	Inc_1001
16	21/05/2017	0+28960	Inc_909
17	04/05/2017	0+1160	Inc_744
18	26/04/2017	0+27620	Inc_723
19	31/05/2016	0+2340	E99_1F009/16
20	22/05/2016	0+0000	E99_1F008/16
21	10/05/2016	0+0000	E99_1F007/16
22	04/05/2016	0+0000	E99_1F006/16
23	30/04/2016	0+14210	E99_1F005/16
24	25/04/2016	0+14210	E99_1F004/16
25	20/03/2016	0+20310	E99_1F003/16
26	10/03/2016	0+5950	E99_1F002/16
27	14/02/2016	0+4320	E99_1F001/16
28	30/08/2017	0+11810	ACCSAE819170830
29	13/09/2017	13+0860	Inc_2433
30	30/08/2017	0+15590	ACCSAE213817083

Table A.8: Traffic accidents at night time in E311 SHAIEK MOHAMMED BIN ZAYED roadway.

(Source: MoID, 2016-2017)

E311			
NO	**Date**	**Chainage**	**Code**
1	29/01/2017	0+0000	ACC2072
2	28/01/2017	0+0000	ACC2079
3	26/01/2017	0+0000	ACC2078
4	19/01/2017	0+0000	ACC2060
5	17/01/2017	0+0000	ACC2035
6	11/01/2017	0+0000	ACC2017
7	10/01/2017	0+0000	ACC2020
8	10/01/2017	0+0000	ACC2029
9	24/12/2016	0+0000	ACC2014
10	11/12/2016	0+0000	ACC2013
11	30/04/2016	0+0000	ACC2016
12	13/02/2016	0+0000	E311F006/16
13	02/08/2017	0+0710	Inc_1486
14	19/07/2017	1+0050	Inc_1209
15	06/05/2017	1+0690	Inc_984
16	06/05/2017	1+0780	Inc_986
17	06/05/2017	1+0920	Inc_1319
18	20/05/2017	2+0090	Inc_981
19	02/08/2017	2+0620	Inc_1321
20	09/08/2017	5+0890	Inc_2510
21	04/05/2017	8+0160	Inc_974
22	25/07/2017	8+0300	Inc_1245
23	30/05/2017	8+0300	Inc_884
24	10/08/2017	8+0330	Inc_1552
25	04/05/2017	8+0350	Inc_1550
26	05/06/2016	8+0530	E311F011/16
27	12/12/2016	8+0530	E311F001/15
28	13/03/2017	9+0150	Inc_1203
29	19/07/2017	9+0350	Inc_1205
30	02/05/2017	9+0630	Inc_691
31	02/05/2017	9+0820	Inc_692
32	27/08/2017	10+0850	Inc_2136
33	22/08/2017	11+0040	Inc_1963

E311			
NO	Date	Chainage	Code
34	22/06/2016	13+0590	E311B001/15
35	26/09/2017	14+0560	Inc_2738
36	17/09/2017	14+0930	Inc_2502
37	01/09/2017	17+0800	ACCSAE210017090
38	26/09/2017	18+0110	Inc_2691
39	12/08/2017	19+0180	Inc_1614
40	08/05/2016	20+0950	E311F010/16
41	19/01/2016	20+0950	E311F001/16
42	06/12/2016	20+0950	E311F003/15
43	25/08/2014	20+0950	E311F001/14
44	12/08/2017	21+0050	Inc_1606
45	17/05/2016	26+0920	ACCSAE208115051
46	11/07/2017	27+0600	Inc_1122
47	11/07/2017	27+0760	Inc_1123
48	08/01/2016	29+0230	E311F005/16
49	25/03/2016	31+0060	E311B001/16
50	16/03/2017	34+0520	Inc_1303
51	09/05/2016	34+0870	E311B004/16
52	05/02/2016	35+0610	E311F002/16
53	14/02/2016	39+0650	E311F004/16
54	01/10/2017	41+0940	Inc_2796
55	15/12/2016	42+0350	E311B002/15
56	10/05/2016	43+0580	E311B005/16
57	03/05/2016	44+0440	E311F008/16
58	07/04/2016	50+0440	E311B002/16
59	29/06/2017	51+0520	Inc_1044
60	11/05/2016	54+0370	E311F009/16
61	18/05/2017	56+0530	Inc_833
62	09/08/2017	58+0360	Inc_1465
63	17/02/2016	60+0000	E311F003/16
64	12/04/2016	66+0770	E311F007/16
65	06/07/2016	66+0770	E311F002/15
66	08/08/2017	70+0720	Inc_1446
67	08/08/2017	70+0740	Inc_1447
68	27/04/2016	70+0950	E311B003/16

Table A.9: Traffic accidents at night time in E611 EMIRATES roadway.

(Source: MoID, 2016-2017)

E611			
NO	**Date**	**Chainage**	**Code**
1	04/09/2017	0+0000	ACCSAE306170904
2	20/08/2017	0+0150	Inc_1945
3	30/05/2017	0+12440	Inc_885
4	01/03/2016	0+12640	E611_2F001/16
5	07/08/2017	0+12900	Inc_1438
6	08/08/2017	0+12910	Inc_1440
7	07/08/2017	0+12920	Inc_1437
8	18/04/2016	0+13400	E611_2F004/16
9	29/05/2016	0+15190	E611_2F005/16
10	24/08/2017	0+15630	ACCSAE808170824
11	26/01/2017	0+15630	ACC2067
12	02/01/2017	0+15630	ACC2047
13	11/07/2017	0+16730	Inc_1414
14	02/04/2016	0+19770	E611_1B001/16
15	03/05/2016	0+20430	E611_1B003/16
16	28/04/2016	0+20430	E611_1B002/16
17	24/08/2017	0+24580	Inc_2066
18	15/03/2015	0+24580	E611_1B001/15
19	09/03/2016	0+3340	E611_2F002/16
20	11/07/2017	0+4040	Inc_1111
21	09/03/2016	0+4600	E611_2F003/16
22	01/05/2017	0+4620	Inc_681
23	01/05/2017	0+4930	Inc_682
24	17/05/2017	0+6450	Inc_830
25	06/08/2017	0+6680	Inc_1401
26	14/08/2017	0+7290	Inc_1688
27	12/08/2017	0+7340	Inc_1626
28	17/05/2017	0+7590	Inc_829
29	18/07/2017	0+7920	Inc_1198
30	29/05/2017	0+9280	Inc_883
31	20/04/2017	0+9440	Inc_827
32	20/04/2017	0+9480	Inc_826
33	17/08/2017	1+0970	Inc_1776
34	06/08/2017	6+0380	Inc_1406
35	07/09/2017	7+0740	Inc_2276
36	03/06/2017	8+0760	Inc_926
37	07/08/2017	12+0910	Inc_1439
38	14/03/2016	15+0120	E611_1F001/16

E611			
NO	**Date**	**Chainage**	**Code**
39	03/06/2017	19+0340	Inc_927
40	01/05/2017	20+0620	Inc_677
41	15/07/2017	21+0160	Inc_1184
42	20/08/2017	24+0610	Inc_1889
43	10/07/2017	24+0610	Inc_1101
44	17/05/2017	24+0610	Inc_828

Appendix (B)

Appendix (B): Average daily traffic by number of vehicles from 2014-2016.

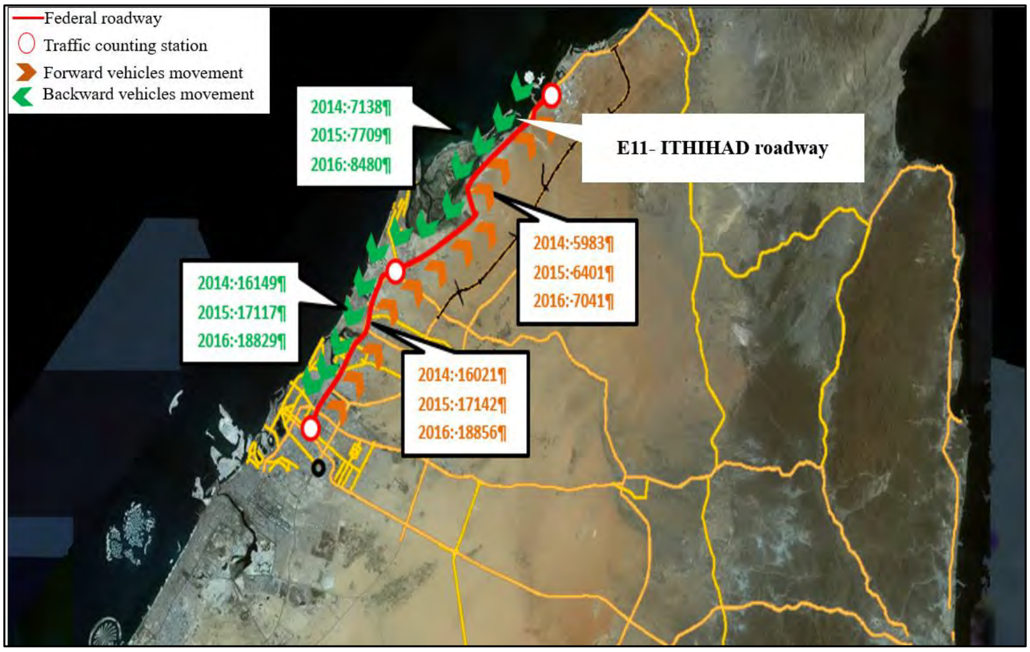


Figure B.1: E11 ITHIHAD road traffic volume.
(Source: Author, image from Google Earth, 2017)

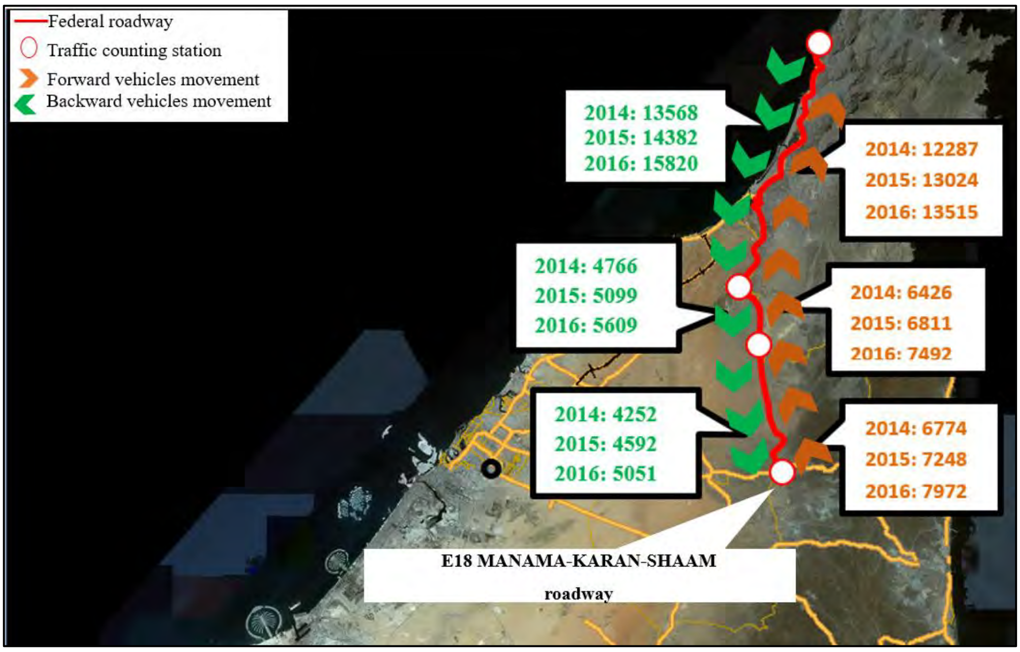


Figure B.2: E18 MANAMA-KARAN-SHAAM road traffic volume.
(Source: Author, image from Google Earth, 2017)

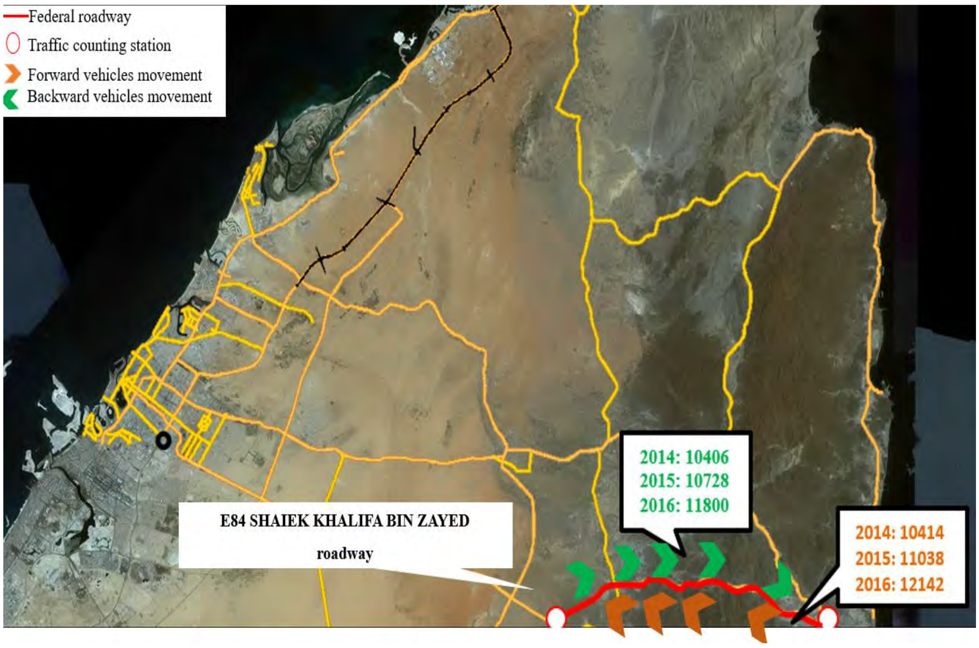


Figure B.3: E84 SHAIEK KHALIFA BIN ZAYED road traffic volume.
(Source: Author, image from Google Earth, 2017)

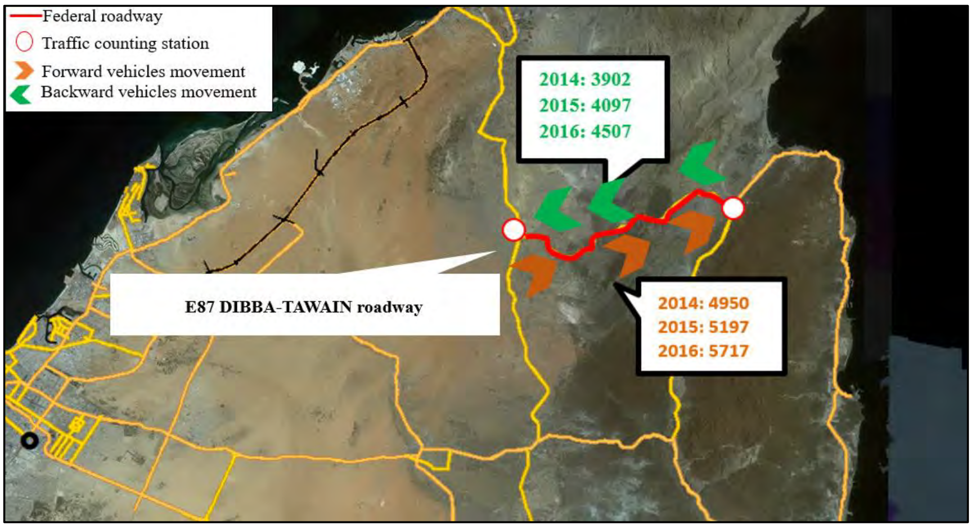


Figure B.4: E87 DIBBA-TAWAIN road traffic volume.
(Source: Author, image from Google Earth, 2017)

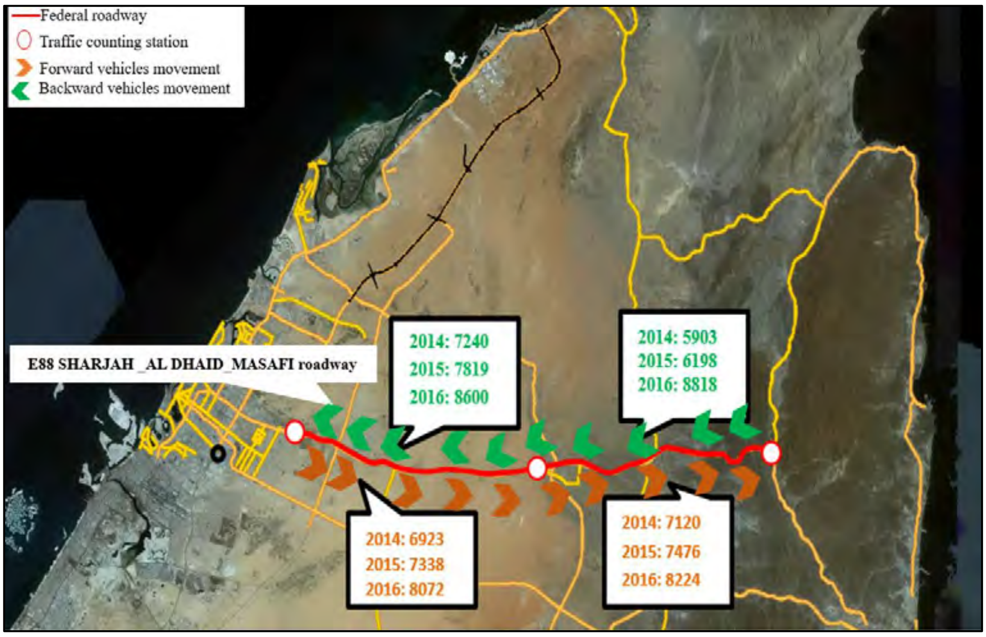


Figure B.5: E88 SHARJAH _AL DHAID_MASAFI road traffic volume.
(Source: Author, image from Google Earth, 2017)

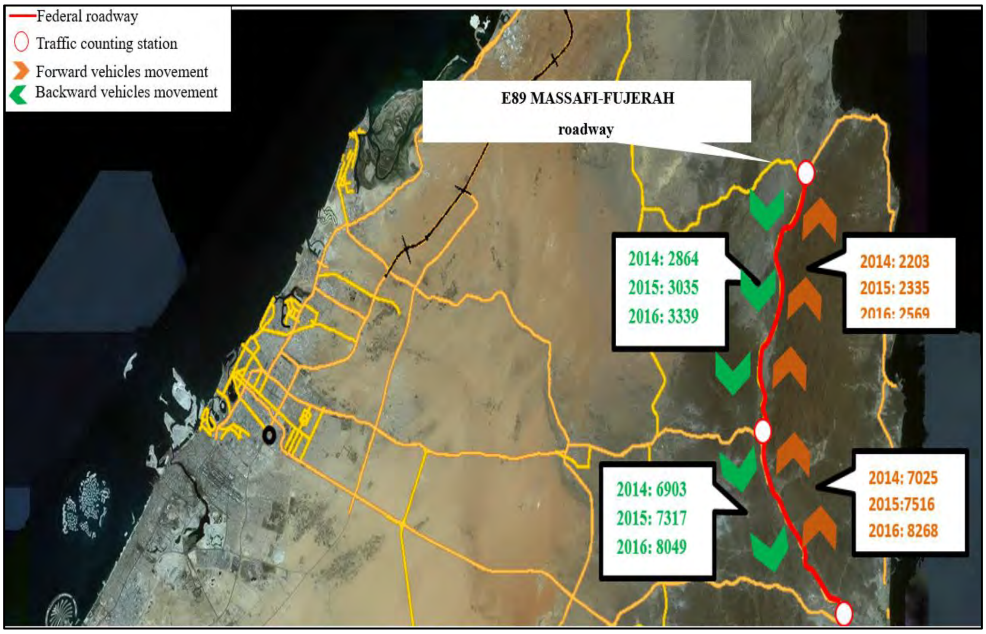


Figure B.6:E89 MASSAFI-FUJERAH road traffic volume
(Source: Author, image from Google Earth, 2017)

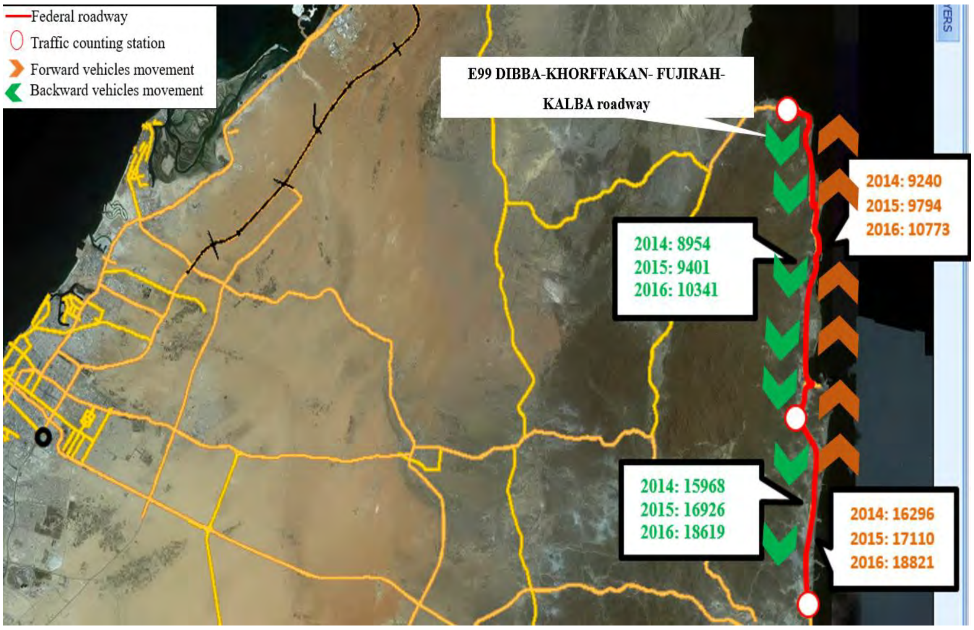


Figure B.7: E99 DIBBA-KHORFFAKAN- FUJIRAH-KALBA road traffic volume
(Source: Author, image from Google Earth, 2017)

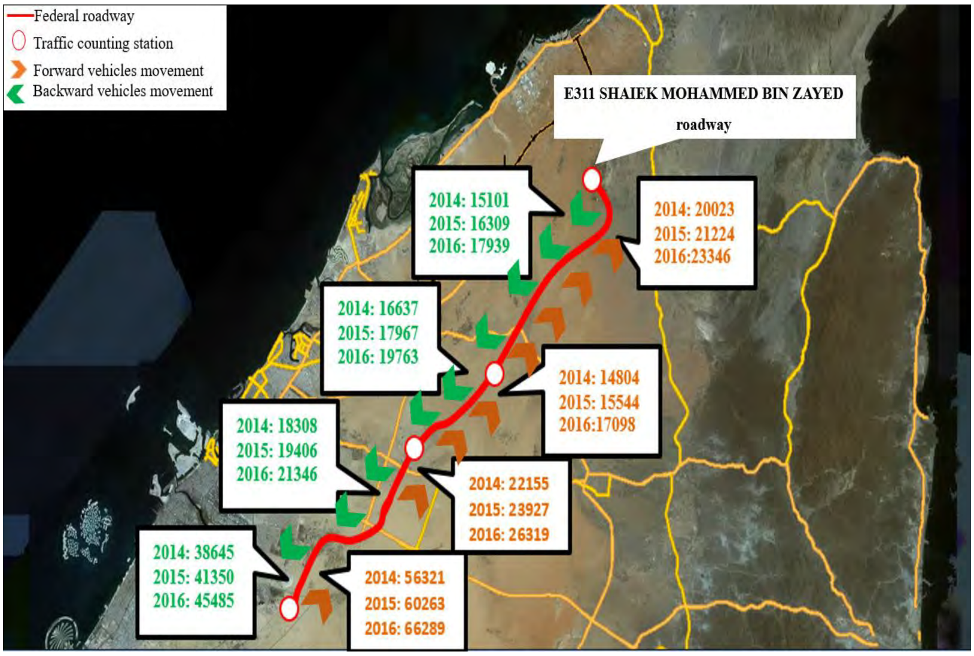


Figure B.8: E311 SHAIEK MOHAMMED BIN ZAYED road traffic volume
(Source: Author, image from Google Earth, 2017)

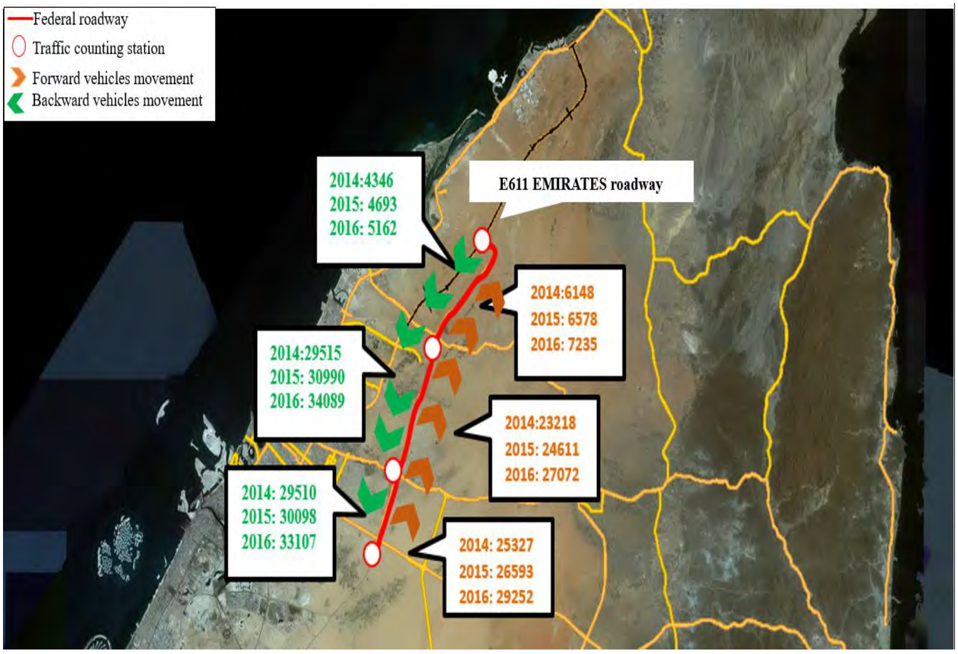


Figure B.9: E611 EMIRATES road traffic volume
(Source: Author, image from Google Earth, 2017)

Appendix (C)

HPS

Date: 17.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

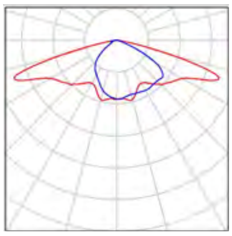
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

HPS / Luminaire parts list

20 Pieces SCHREDER DZ25: (223837) Bended Smooth Glass Standard 1787 SON-T 400 W
Article No.:
Luminous flux (Luminaire): 44622 lm
Luminous flux (Lamps): 56500 lm
Luminaire Wattage: 400.0 W
Luminaire classification according to CIE: 100
CIE flux code: 33 67 95 100 79
Fitting: 1 x SON-T 400 W (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

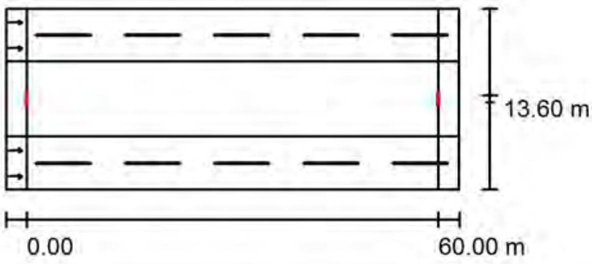
E18-KARAN-SHAAM ROAD / Planning data

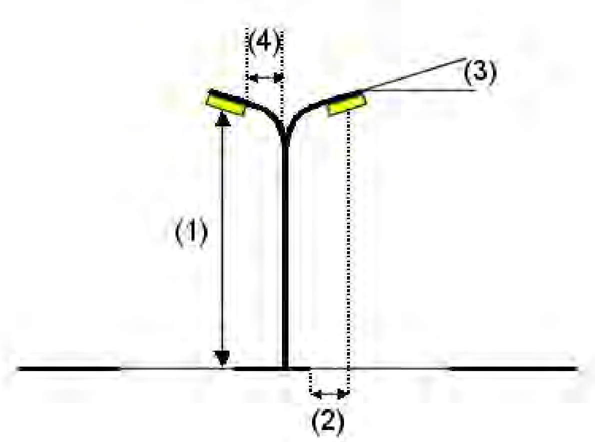
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.70

Luminaire Arrangements



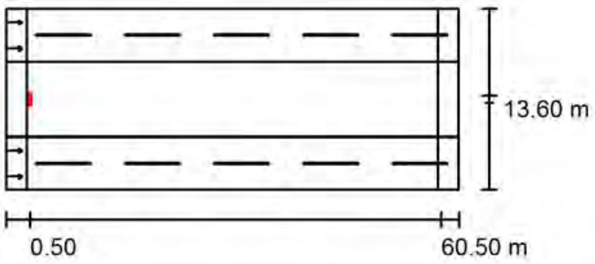


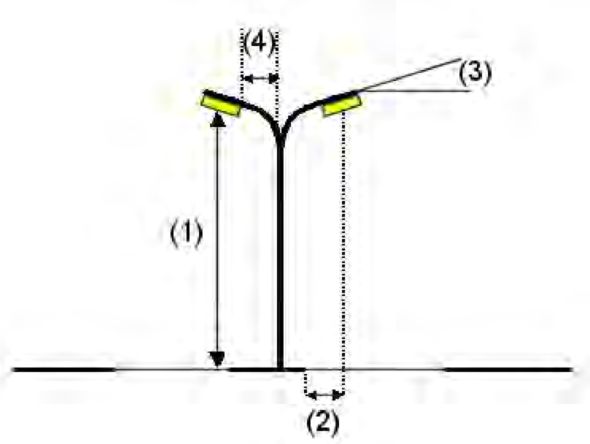
Luminaire:	SCHREDER DZ25: (223837) Bended Smooth Glass Standard 1787 SON-T 400 W		
Luminous flux (Luminaire):	44622 lm	Maximum luminous intensities	
Luminous flux (Lamps):	56500 lm	at 70°:	564 cd/klm
Luminaire Wattage:	400.0 W	at 80°:	117 cd/klm
Arrangement:	on Median	at 90°:	12 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.732 m	Arrangement complies with luminous intensity class G2.	
Overhang (2):	-4.988 m	Arrangement complies with glare index class D.0.	
Boom Angle (3):	5.0 °		
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Planning data

Luminaire Arrangements

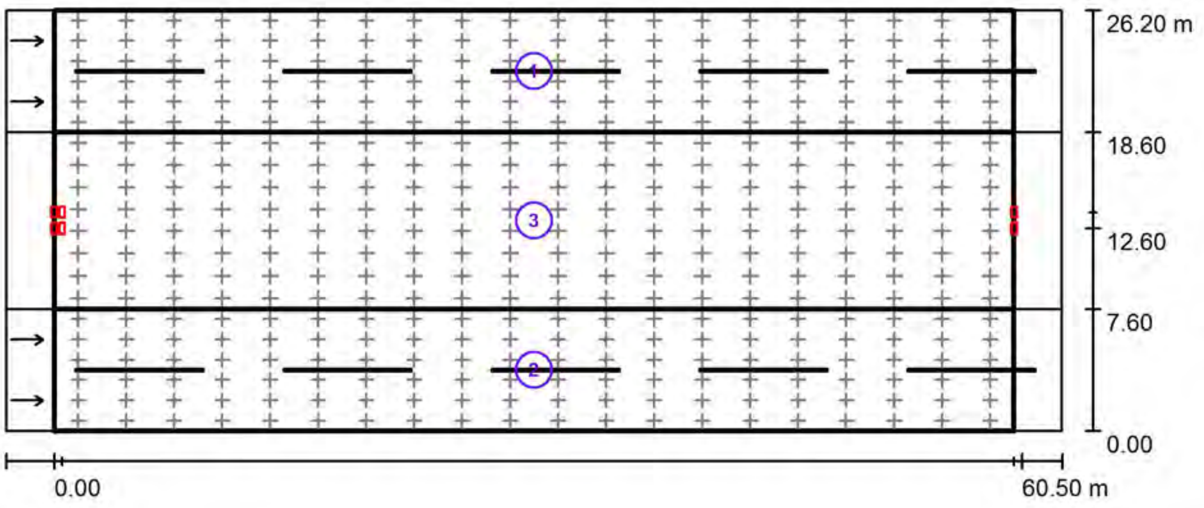




Luminaire:	SCHREDER DZ25: (223837) Bended Smooth Glass Standard 1787 SON-T 400 W		
Luminous flux (Luminaire):	44622 lm	Maximum luminous intensities	
Luminous flux (Lamps):	56500 lm	at 70°:	564 cd/klm
Luminaire Wattage:	400.0 W	at 80°:	117 cd/klm
Arrangement:	on Median	at 90°:	12 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.732 m	Arrangement complies with luminous intensity class G2.	
Overhang (2):	-4.988 m	Arrangement complies with glare index class D.0.	
Boom Angle (3):	5.0 °		
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Photometric Results



Light loss factor: 0.70

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
2.69	0.42	0.63	19	0.96

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
2.69	0.42	0.63	19	0.96

3 Valuation Field Median
Length: 60.000 m, Width: 11.000 m
Grid: 20 x 8 Points
Accompanying Street Elements: Median .
Selected Lighting Class: CE5

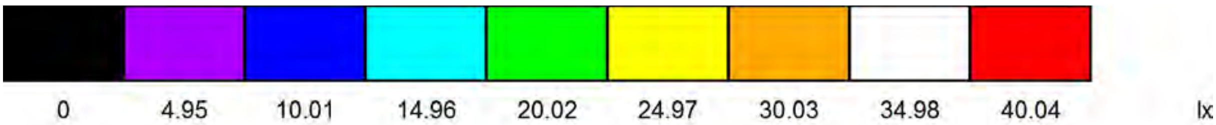
E_{av} [lx]	U0
62.23	0.48

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / 3D Rendering

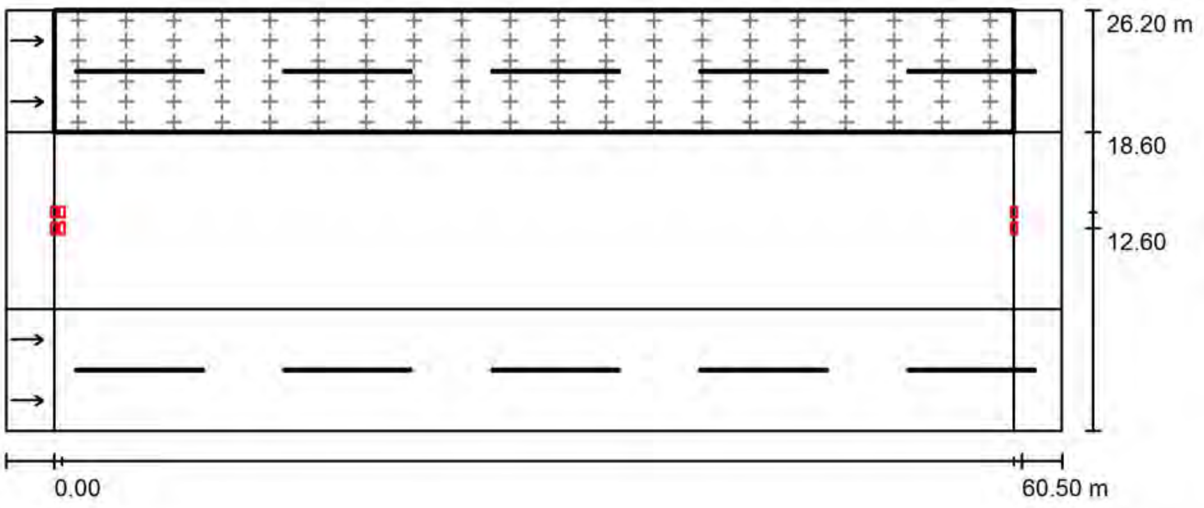
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

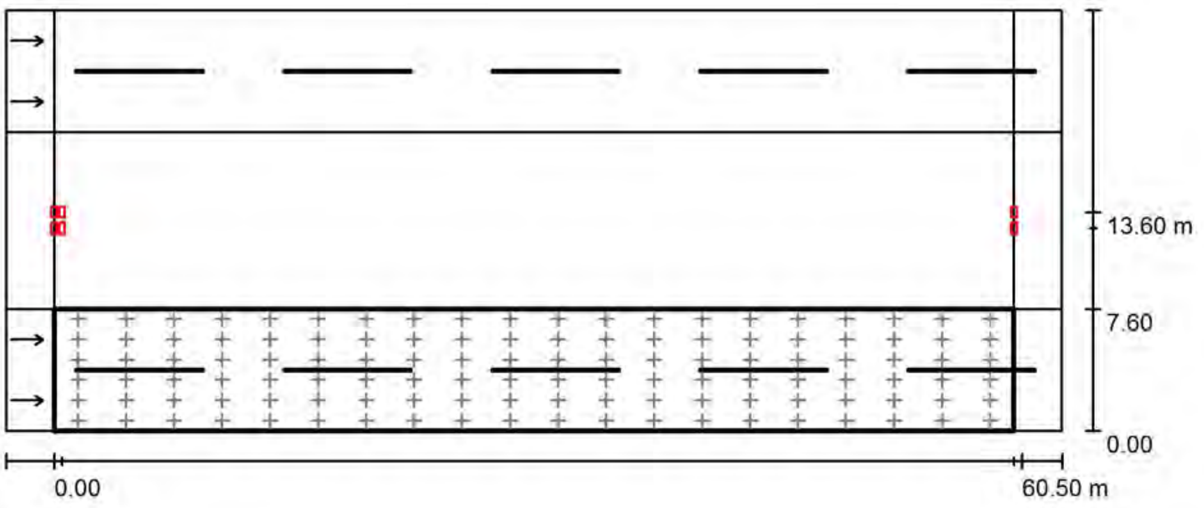
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
2.69	0.42	0.63	19	0.96

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	2.69	0.47	0.68	19
2	Observer 4	(-60.000, 24.300, 1.500)	3.18	0.42	0.63	12

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
2.69	0.42	0.63	19	0.96

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	3.18	0.42	0.63	12
2	Observer 2	(-60.000, 5.700, 1.500)	2.69	0.47	0.68	19

Appendix (D)

110 Watt

Date: 27.02.2018
Operator: Aisha Al Shehhi

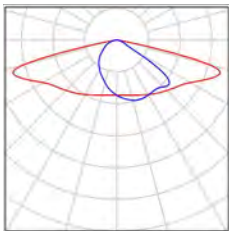
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

110 Watt / Luminaire parts list

10 Pieces SCHREDER AMPERA MAXI / 5118 / 96 LEDS 350mA CW / 356862
Article No.:
Luminous flux (Luminaire): 13249 lm
Luminous flux (Lamps): 15936 lm
Luminaire Wattage: 109.0 W
Luminaire classification according to CIE: 100
CIE flux code: 33 68 96 100 83
Fitting: 1 x 96 LEDS 350mA CW (Correction Factor 1.000).

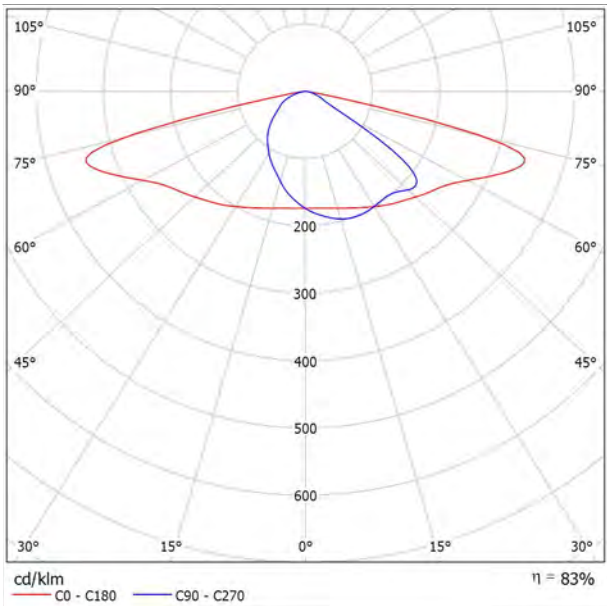


27.02.2018

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI / 5118 / 96 LEDS 350mA CW / 356862 / Luminaire Data Sheet

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 33 68 96 100 83

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

CONCEPT
Family of 3 road LED luminaires: Mini, Midi, Maxi
Applications: Urban roads and streets, Squares and pedestrian areas, Roads and highways, Residential streets, Car parks, Bike paths
Dimensions (mm):
• Width: 438
• Height: 135
• Length: 900
Weight (kg): 18.15
Recommended height installation: between 3.5m and 5mm
For optimal heat dissipation, the driver and LED engine are in separate compartments and juxtaposed in a horizontal section
Independent optical compartment on spigot ensures easy installation

HOUSING & FINISH
• Housing in high-pressure, die-cast aluminium, polyester powder coated
• Direct and tool free access to housing with driver compartment and optical unit by releasing the lateral latches and pivoting downwards. Quick connectors (knife switch) allow easy removal of the housing.
• Colour: AKZO grey 900 sanded
• Luminaire Cd.S (drag): 0.097m²; Cs.S (side): 0.042m²; Cl.S (lift): 0.176m²
• Tightness - driver & optical: IP 66
• Impact resistance: IK 09

INSTALLATION
• Reversible fixation in high-pressure, die-cast aluminium
• Diameter 32-48, 48-60mm or 76mm, tightened with 2 stainless steel screws
• Allows tilt on a vertical pole from 0 to +15°; on a horizontal spigot from 0 to -15° by 5° steps
• Tool free access for maintenance

OPTICAL UNIT
• “FutureProof” optical unit, replaceable on-site, enclosed in the housing with a removable gasket – Shore50
• Protected against lens degradation with a 5mm thick extra clear hardened glass
• Flatbed PCB with acrylic lens overlay principle
• Various photometric distributions: from narrow road to motorway, medium and large area
• CRI > 70
• ULR: 0%
LED lumen depreciation
• Lifetime residual flux @ Tq=25°C @ 100.000 hrs: 350mA & 500mA: 90%; 700mA: 80%

ELECTRICAL

• Class I or Class II
• Input voltage: 120-277V - 50-60Hz
• Power factor > 90% at full load
• 10kV, 10kA surge protection
• Power automatically switches off when opened
• Thermal protection on LED PCBA

STANDARDS & CERTIFICATIONS
• CE
• ENEC
• LM79-80
• ETL
• ROHS
• All measurements in ISO17025 accredited laboratory

OPTIONS
• Other RAL or AKZO colours
• Other light distributions
• Back light control
• CW or WW LEDs
• OWLET remote management
• Custom dimming profile; Constant Lumen Output (CLO); Bi-Power
• Photocell
• Motion detection

AMPERA MAXI – YOUR OPTICAL UNIT CONFIGURATION:
• Optic: 5118 - Matrix: 356862
• Protector: [Extraciré sklo, Rovný, Hladký]
• Source: 96 LEDS 350mA CW
• Power (W): 109
• Tightness optical unit: IP 66
• Specifications may differ per country and be changed without notice due to continuous R&D on our products. (*) Tolerance of 7% on flux data.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

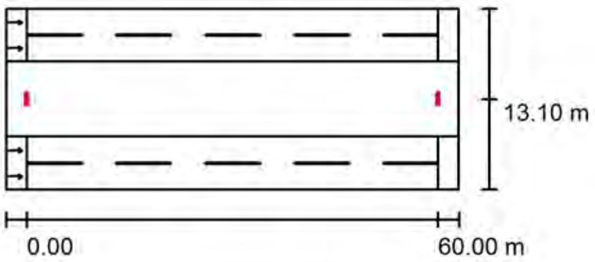
E18-KARAN-SHAAM ROAD / Planning data

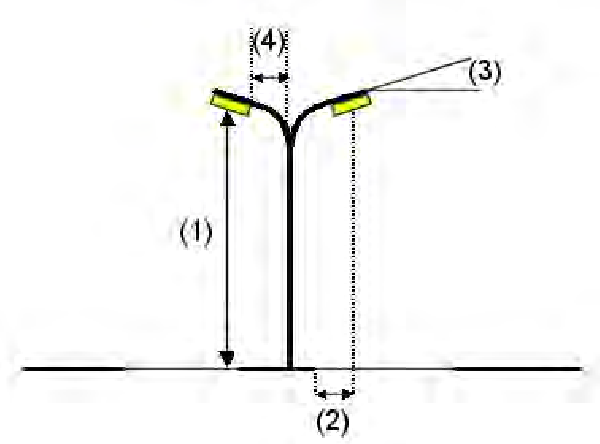
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.70

Luminaire Arrangements

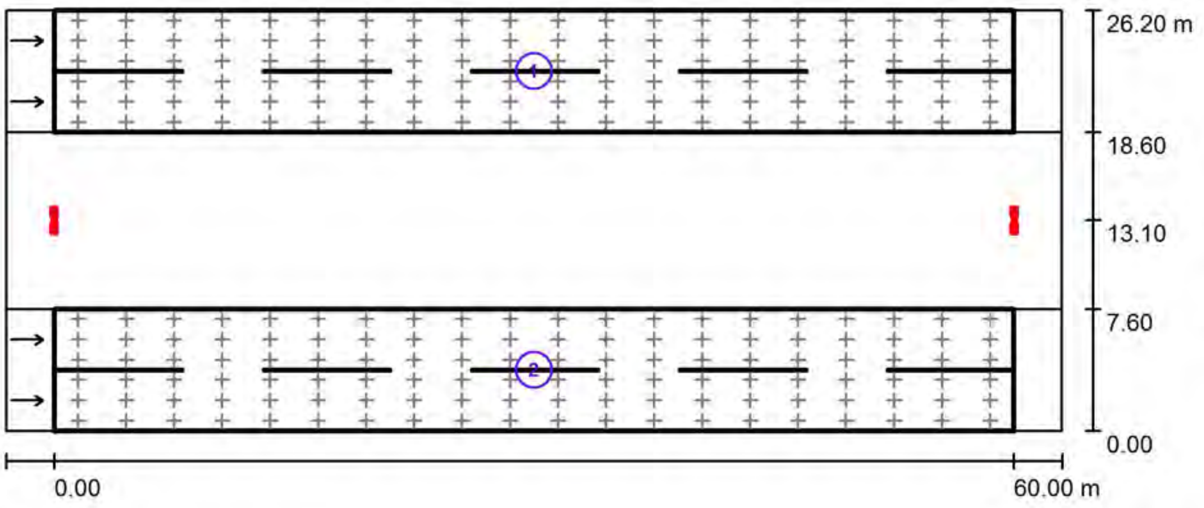




Luminaire:	SCHREDER AMPERA MAXI / 5118 / 96 LEDS 350mA CW / 356862		
Luminous flux (Luminaire):	13249 lm	Maximum luminous intensities	
Luminous flux (Lamps):	15936 lm	at 70°:	503 cd/klm
Luminaire Wattage:	109.0 W	at 80°:	207 cd/klm
Arrangement:	on Median	at 90°:	2.01 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	14.045 m	No luminous intensities above 95°.	
Overhang (2):	-4.870 m	Arrangement complies with glare index class D.3.	
Boom Angle (3):	5.0 °		
Boom Length (4):	0.002 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Photometric Results



Light loss factor: 0.70 Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.41	0.47	0.76	11	1.00

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

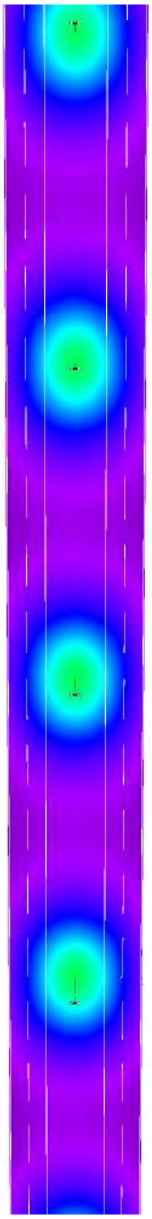
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.41	0.47	0.76	11	1.00

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

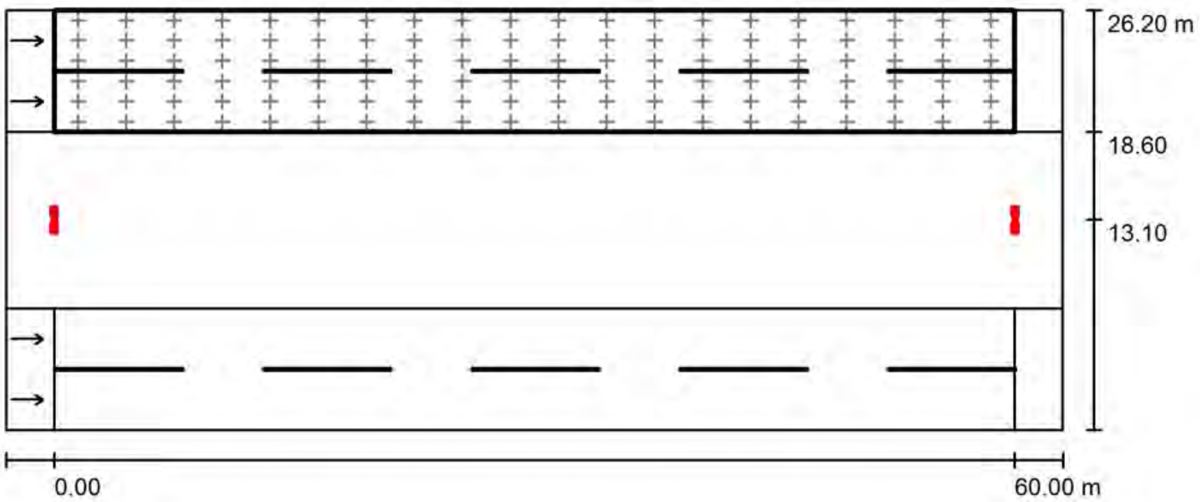
E18-KARAN-SHAAM ROAD / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

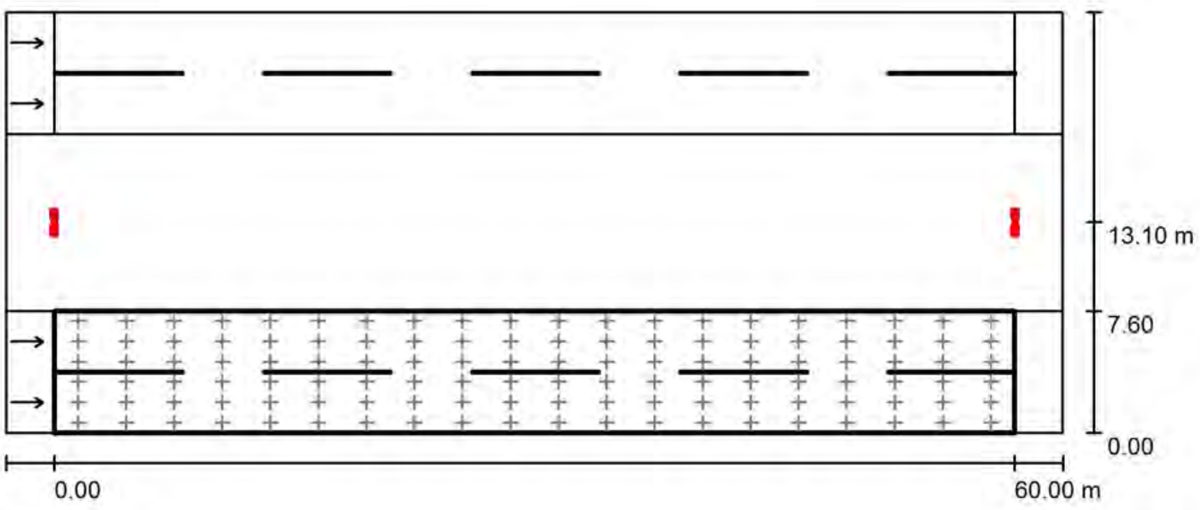
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.41	0.47	0.76	11	1.00

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.41	0.53	0.87	11
2	Observer 4	(-60.000, 24.300, 1.500)	0.50	0.47	0.76	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.41	0.47	0.76	11	1.00

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	0.50	0.47	0.76	7
2	Observer 2	(-60.000, 5.700, 1.500)	0.41	0.53	0.87	11

198 watt

Date: 02.03.2018
Operator: Aisha Al Shehhi

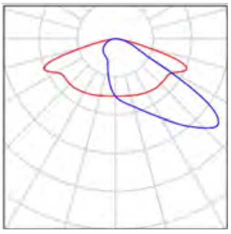
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

198 watt / Luminaire parts list

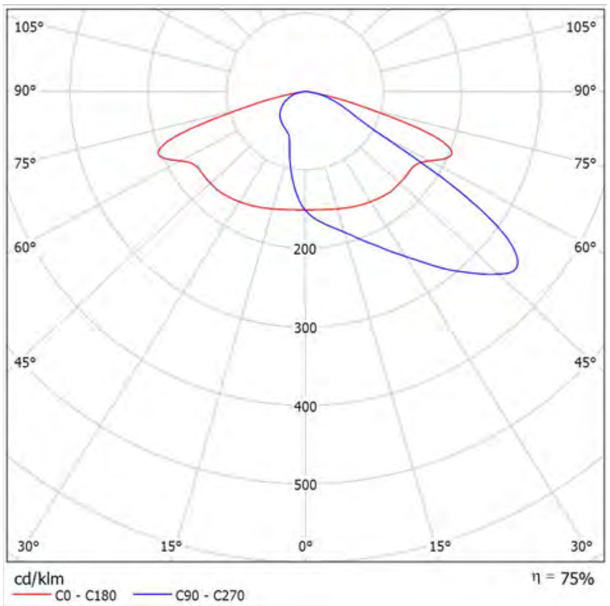
10 Pieces SCHREDER AMPERA MAXI / 5117 / 128 LEDS 500mA NW / 356852
Article No.:
Luminous flux (Luminaire): 21428 lm
Luminous flux (Lamps): 28685 lm
Luminaire Wattage: 198.0 W
Luminaire classification according to CIE: 100
CIE flux code: 31 69 96 100 74
Fitting: 1 x 128 LEDS 500mA NW (Correction Factor 1.000).



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI / 5117 / 128 LEDS 500mA NW / 356852 / Luminaire Data Sheet

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 31 69 96 100 74

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

CONCEPT
Family of 3 road LED luminaires: Mini, Midi, Maxi
Applications: Urban roads and streets, Squares and pedestrian areas, Roads and highways, Residential streets, Car parks, Bike paths
Dimensions (mm):
• Width: 438
• Height: 135
• Length: 900
Weight (kg): 18.15
Recommended height installation: between 3.5m and 5mm
For optimal heat dissipation, the driver and LED engine are in separate compartments and juxtaposed in a horizontal section
Independent optical compartment on spigot ensures easy installation

HOUSING & FINISH
• Housing in high-pressure, die-cast aluminium, polyester powder coated
• Direct and tool free access to housing with driver compartment and optical unit by releasing the lateral latches and pivoting downwards. Quick connectors (knife switch) allow easy removal of the housing.
• Colour: AKZO grey 900 sanded
• Luminaire Cd.S (drag): 0.097m²; Cs.S (side): 0.042m²; Cl.S (lift): 0.176m²
• Tightness - driver & optical: IP 66
• Impact resistance: IK 09

INSTALLATION
• Reversible fixation in high-pressure, die-cast aluminium
• Diameter 32-48, 48-60mm or 76mm, tightened with 2 stainless steel screws
• Allows tilt on a vertical pole from 0 to +15°; on a horizontal spigot from 0 to -15° by 5° steps
• Tool free access for maintenance

OPTICAL UNIT
• “FutureProof” optical unit, replaceable on-site, enclosed in the housing with a removable gasket – Shore50
• Protected against lens degradation with a 5mm thick extra clear hardened glass
• Flatbed PCB with acrylic lens overlay principle
• Various photometric distributions: from narrow road to motorway, medium and large area
• CRI > 70
• ULR: 0%
LED lumen depreciation
• Lifetime residual flux @ Tq=25°C @ 100.000 hrs: 350mA & 500mA: 90%; 700mA: 80%

ELECTRICAL

• Class I or Class II
• Input voltage: 120-277V - 50-60Hz
• Power factor > 90% at full load
• 10kV, 10kA surge protection
• Power automatically switches off when opened
• Thermal protection on LED PCBA

STANDARDS & CERTIFICATIONS
• CE
• ENEC
• LM79-80
• ETL
• ROHS
• All measurements in ISO17025 accredited laboratory

OPTIONS
• Other RAL or AKZO colours
• Other light distributions
• Back light control
• CW or WW LEDs
• OWLET remote management
• Custom dimming profile; Constant Lumen Output (CLO); Bi-Power
• Photocell
• Motion detection

AMPERA MAXI – YOUR OPTICAL UNIT CONFIGURATION:
• Optic: 5117 Back light - - Back light Matrix: 356852
• Protector: [Extraciré sklo, Rovný, Hladký]
• Source: 128 LEDS 500mA NW
• Power (W): 198
• Tightness optical unit: IP 66
• Specifications may differ per country and be changed without notice due to continuous R&D on our products. (*) Tolerance of 7% on flux data.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

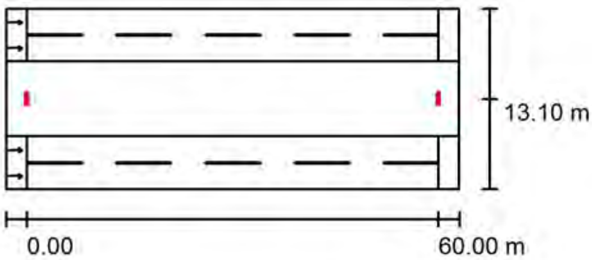
LED 1 / Planning data

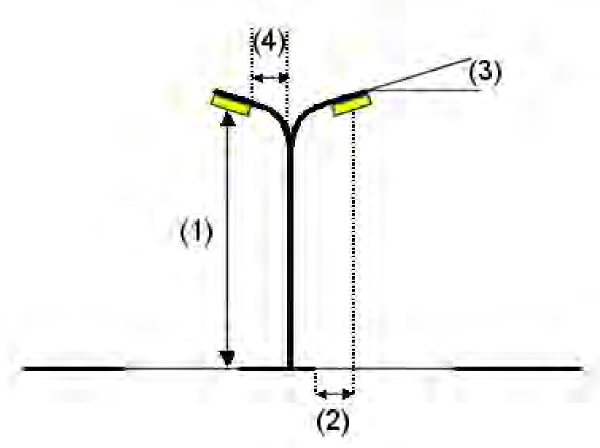
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements



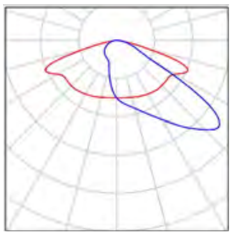


Luminaire:	SCHREDER AMPERA MAXI / 5117 / 128 LEDS 500mA NW / 356852		
Luminous flux (Luminaire):	21428 lm	Maximum luminous intensities	
Luminous flux (Lamps):	28685 lm	at 70°:	502 cd/klm
Luminaire Wattage:	198.0 W	at 80°:	192 cd/klm
Arrangement:	on Median	at 90°:	5.37 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	14.045 m	No luminous intensities above 95°.	
Overhang (2):	-4.872 m	Arrangement complies with luminous intensity class G1.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.1.	
Boom Length (4):	0.000 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

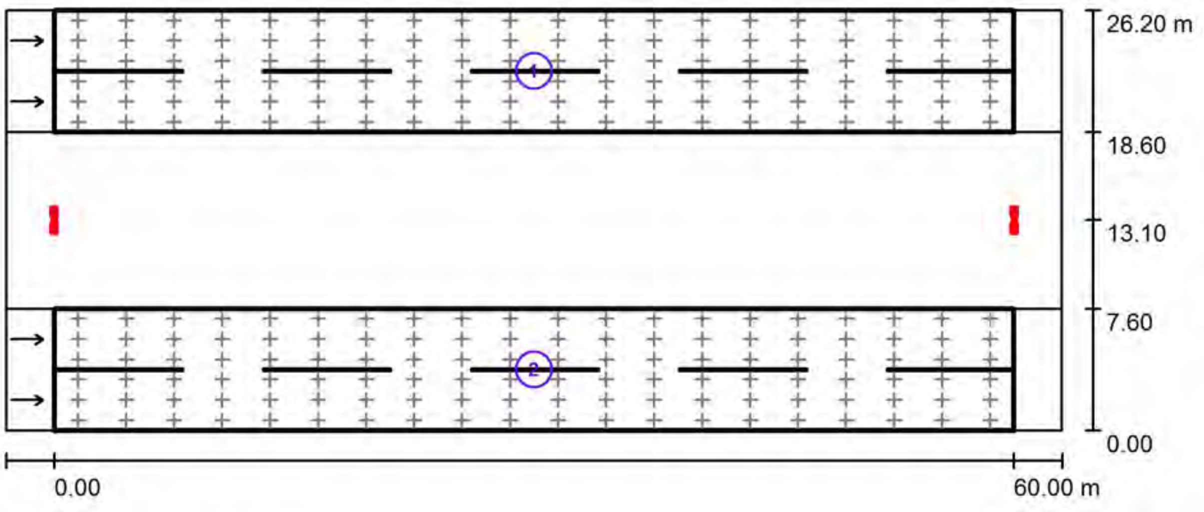
LED 1 / Luminaire parts list

SCHREDER AMPERA MAXI / 5117 / 128 LEDS 500mA NW / 356852
Article No.:
Luminous flux (Luminaire): 21428 lm
Luminous flux (Lamps): 28685 lm
Luminaire Wattage: 198.0 W
Luminaire classification according to CIE: 100
CIE flux code: 31 69 96 100 74
Fitting: 1 x 128 LEDS 500mA NW (Correction Factor 1.000).



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.65	0.63	0.80	12	0.95

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

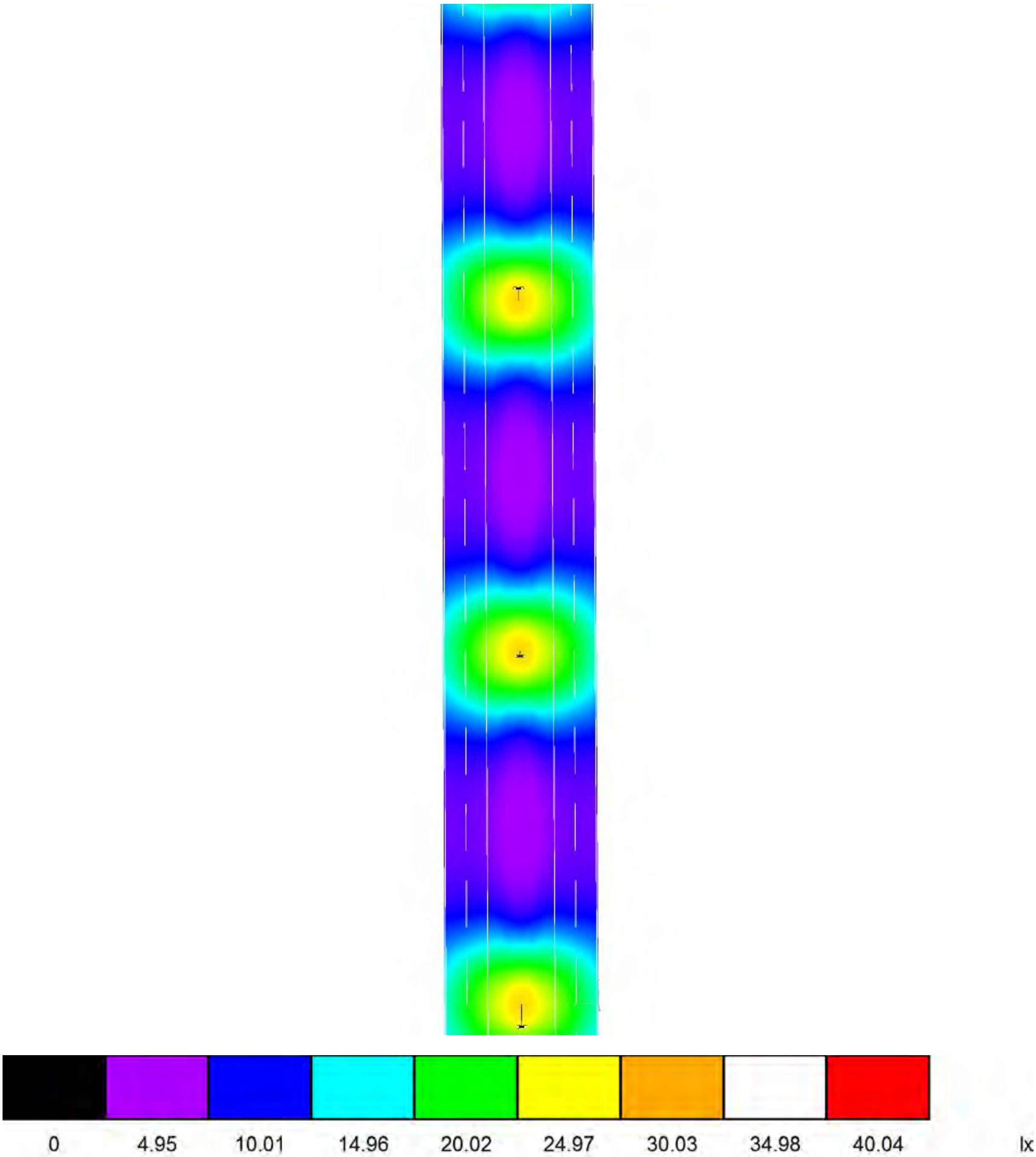
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.65	0.63	0.80	12	0.95

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

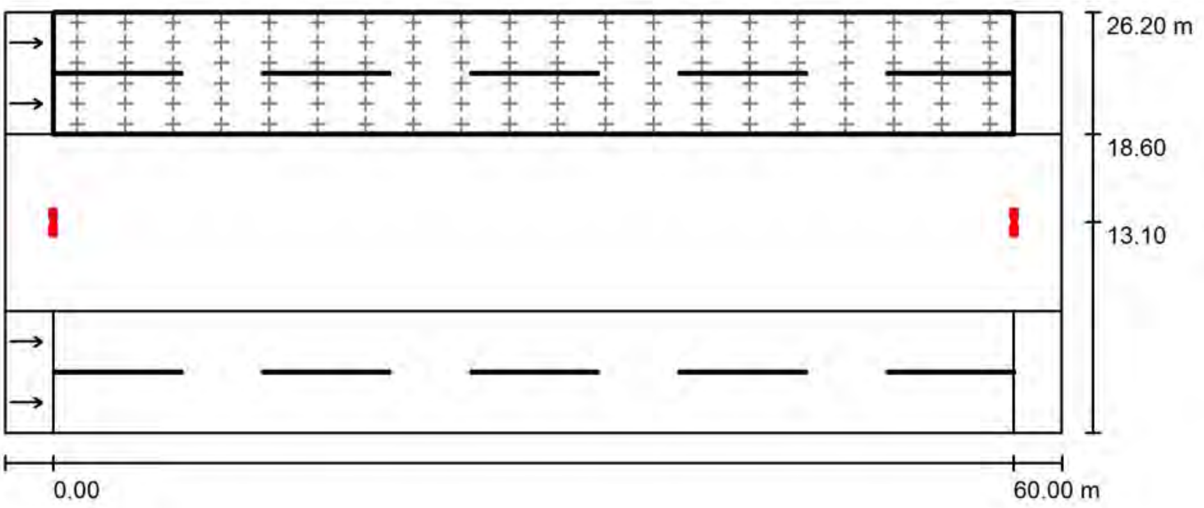
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

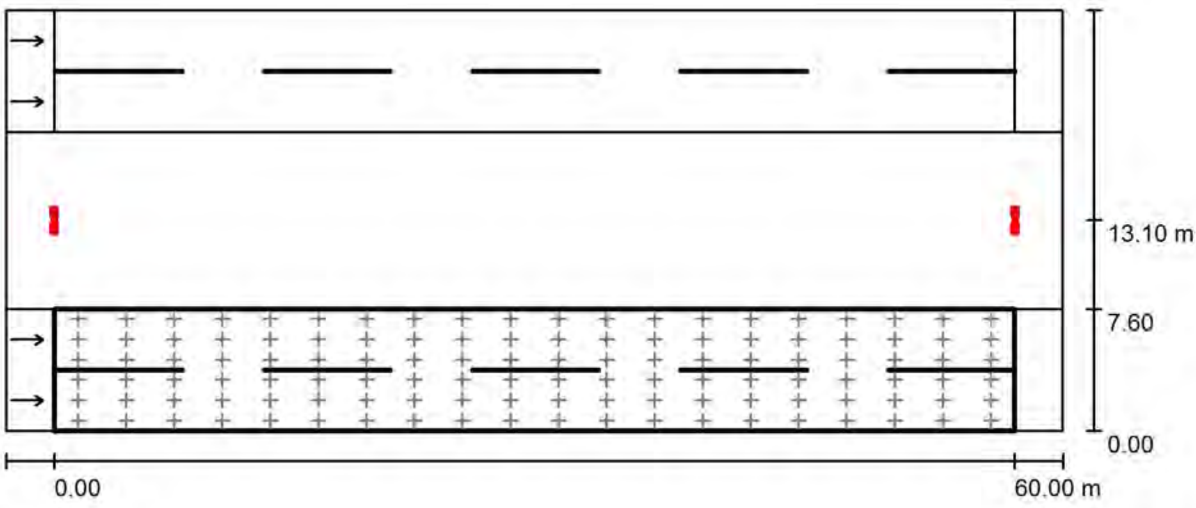
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.65	0.63	0.80	12	0.95

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.65	0.68	0.82	12
2	Observer 4	(-60.000, 24.300, 1.500)	0.77	0.63	0.80	10

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80 Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.65	0.63	0.80	12	0.95

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	0.77	0.63	0.80	10
2	Observer 2	(-60.000, 5.700, 1.500)	0.65	0.68	0.82	12

LED 1

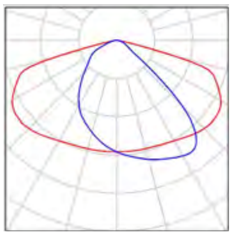
Date: 17.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

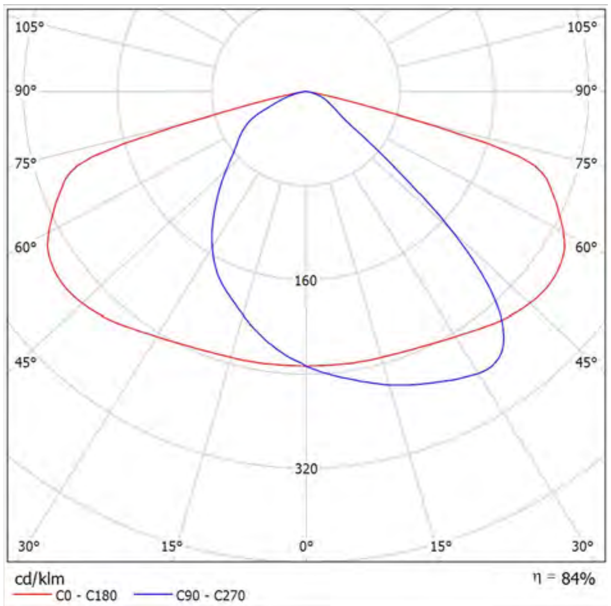
10 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1) Article No.: Luminous flux (Luminaire): 27927 lm Luminous flux (Lamps): 33147 lm Luminaire Wattage: 240.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

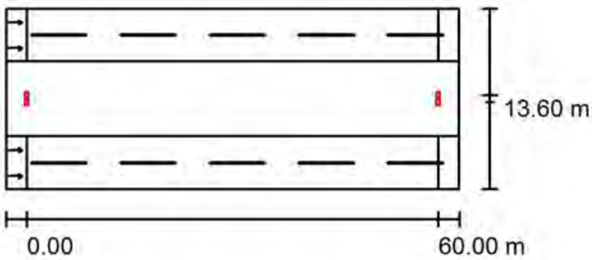
LED 1 / Planning data

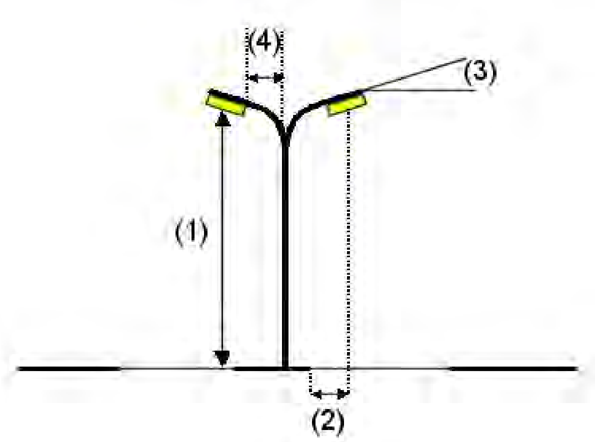
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements



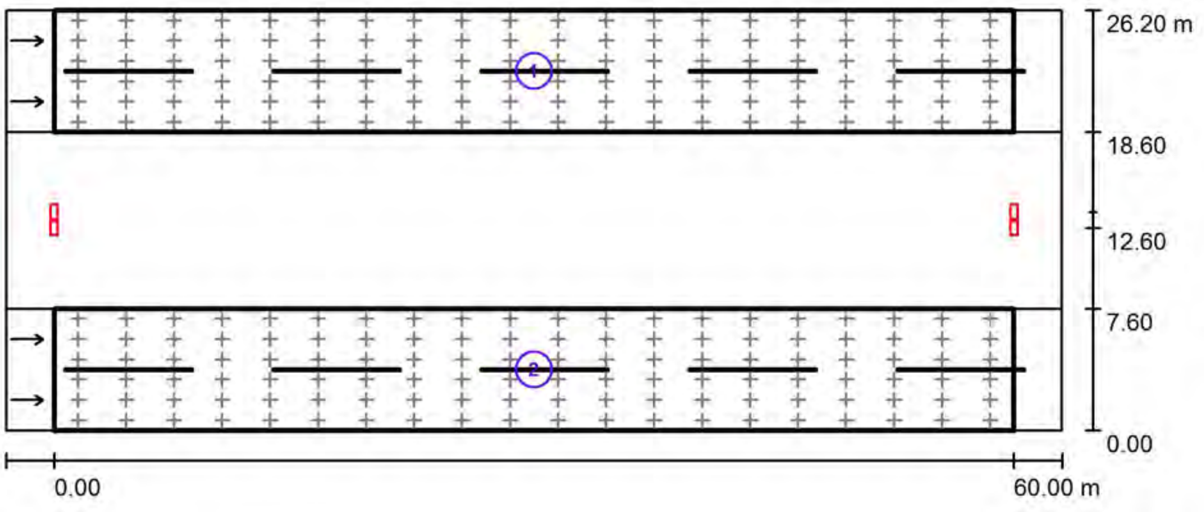


Luminaire: SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172

Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 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):	14.000 m		
Height:	13.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway

Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.52	0.71	12	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

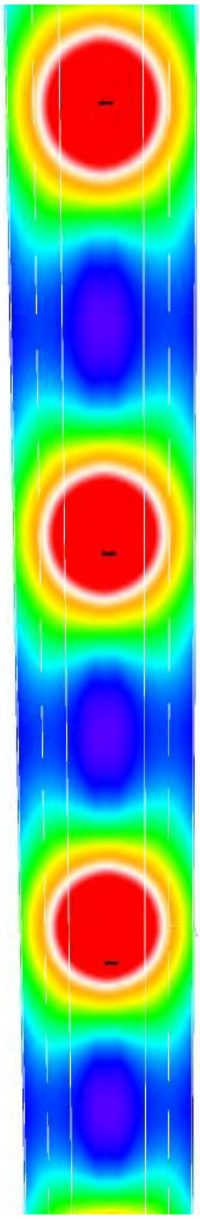
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.52	0.71	12	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

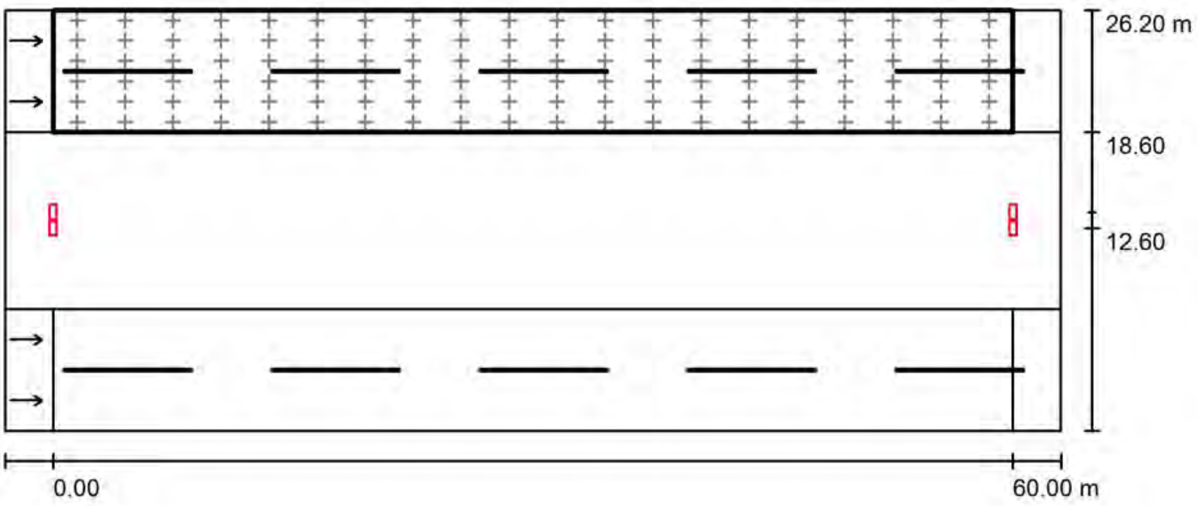
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

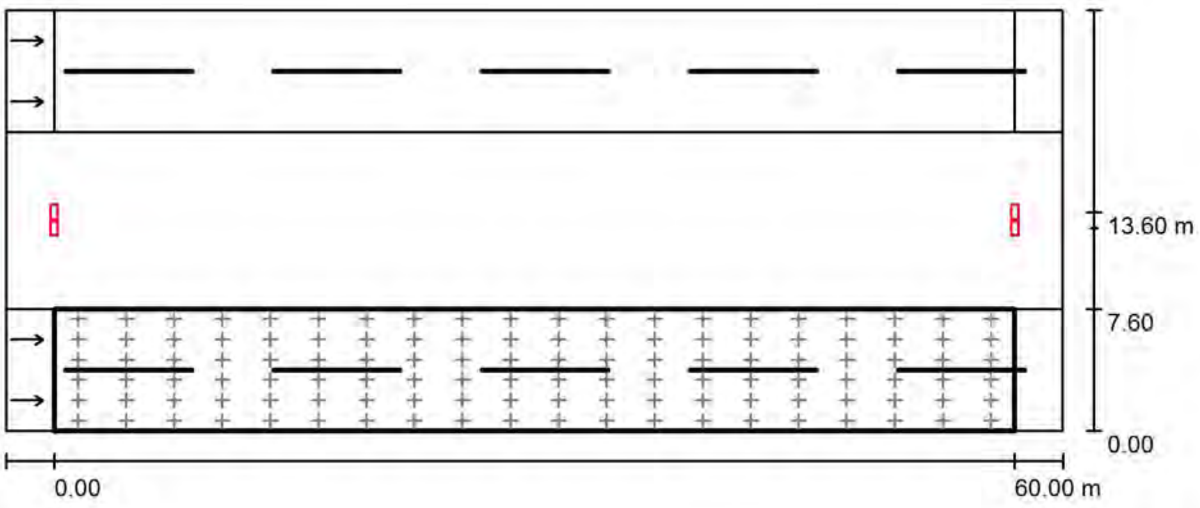
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.52	0.71	12	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.05	0.56	0.79	12
2	Observer 4	(-60.000, 24.300, 1.500)	1.21	0.52	0.71	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.05	0.52	0.71	12	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.21	0.52	0.71	8
2	Observer 2	(-60.000, 5.700, 1.500)	1.05	0.56	0.79	12

Trilux LED 3

Date: 26.02.2018
Operator: Aisha Al Shehhi

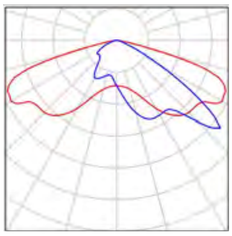
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Trilux LED 3 / Luminaire parts list

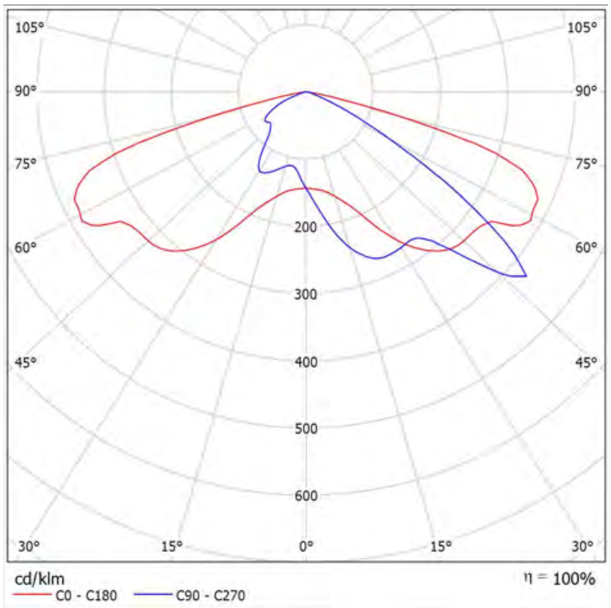
10 Pieces TRILUX LIQ 90-AB7L-LRA/13500-730 16G1S ETDD LIQ
Article No.: LIQ 90-AB7L-LRA/13500-730 16G1S ETDD
Luminous flux (Luminaire): 13499 lm
Luminous flux (Lamps): 13500 lm
Luminaire Wattage: 123.0 W
Luminaire classification according to CIE: 100
CIE flux code: 32 71 96 100 100
Fitting: 1 x LED (Correction Factor 1.000).



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

TRILUX LIQ 90-AB7L-LRA/13500-730 16G1S ETDD LIQ / Luminaire Data Sheet

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 32 71 96 100 100

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

LIQ 90-AB7L-LRA/13500-730 16G1S ET (TOC 6442440):
LED post-top and bracket-mounted luminaire. Construction size IQ 90 (960 x 325 mm). Post-top and bracket-mounted on or to post spigot Ø 76 mm. Inclination angle of 0° to 90°, can be set in 5° steps, scaled. Simple and rapid conversion from post-top to bracket-mounted luminaire via one screw accessible from outside.. Mast mounting via two stainless steel fixing screws in accordance with EN 60598-2-3. Also suitable for mounting to masts with spigot Ø 42, 48 and 60 mm via reduction pieces to be ordered separately. As MLT version (Multi-Lens Technology), consisting of highly efficient UV and temperature-resistant lens systems in 4-fold configurations. With asymmetrical wide light intensity distribution. Further beam characteristics are available for flexible adaptation to customer-specific lighting tasks. Retrofitting a rear shielding is possible, available as accessory to be ordered separately. 16 LED modules. Luminaire luminous flux 13500 lm, connected load 123 W, luminous efficiency of luminaire 110 lm/W. Light colour warm white, colour temperature 3000 K, colour rendering index Ra > 70. Service life L80(tq 25 °C) = 100,000 h. Luminaire body of die-cast aluminium. With closed side contour. Luminaire body anthracite, similar to DB 703, swivel unit silver-grey offset, similar to DB 701, with metal effect, highly weather resistant, powder-coated. Cover of heat-treated non-laminated safety glass. Cover, reflection-reduced, transmission value › 98 %, sealed in diecast frame, swung downwards and unhooked without tools. Further colour variants possible from RAL or DB colour codes. Windage area Fw= 0,10 m2. Safety class II, protection rating IP66. With connected mains cable. Cable length 12 m. With electronic transformer, switchable. Surge voltage resistance 6 kV. Configurable ballast with luminous flux stabilising (CLO). Connected load at the end of service life: 138 W. With intelligent power reduction via integral evaluation electronics. Reduction of luminaire luminous flux to 50 % for a time period of 7 hours (-2 h/+5 h).

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

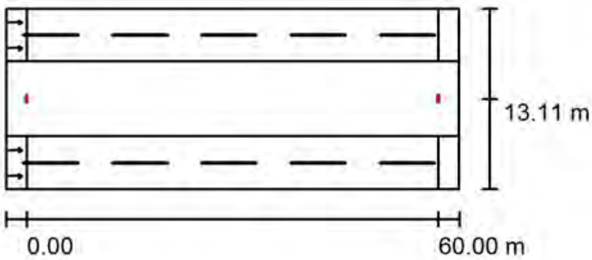
E18-KARAN-SHAAM ROAD / Planning data

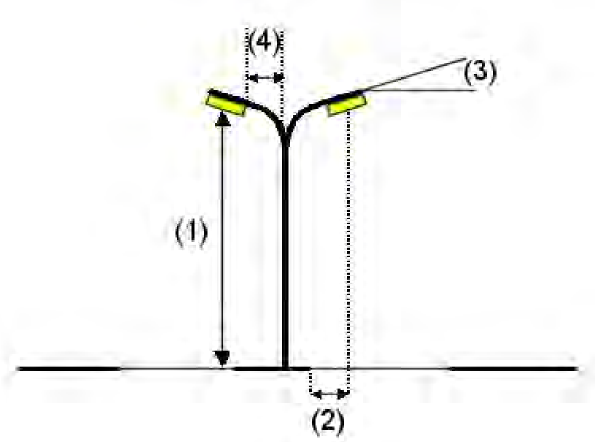
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.70

Luminaire Arrangements

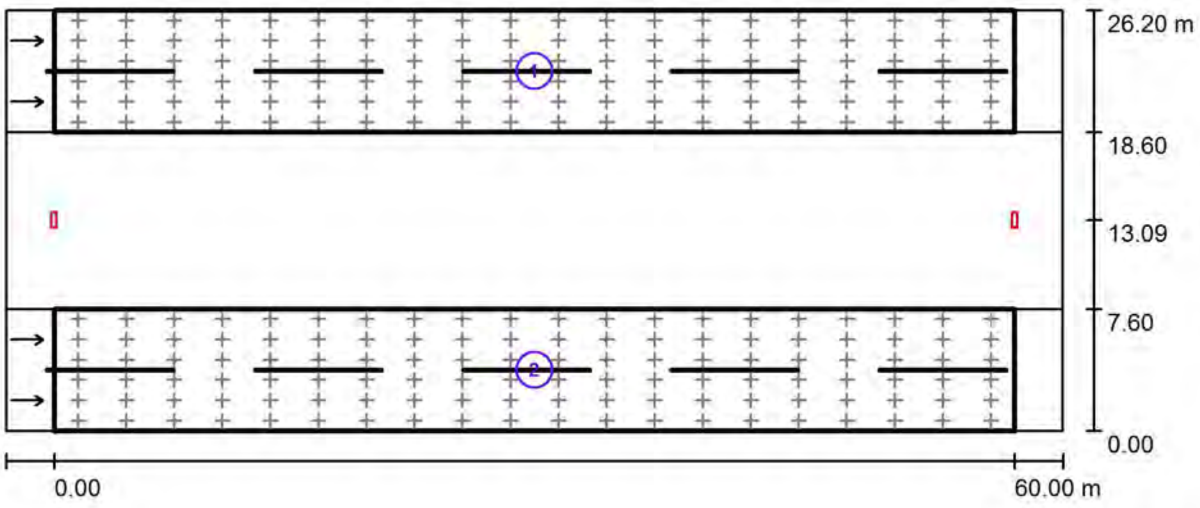




Luminaire:	TRILUX LIQ 90-AB7L-LRA/13500-730 16G1S ETDD LIQ		
Luminous flux (Luminaire):	13499 lm	Maximum luminous intensities	
Luminous flux (Lamps):	13500 lm	at 70°:	535 cd/klm
Luminaire Wattage:	123.0 W	at 80°:	145 cd/klm
Arrangement:	on Median	at 90°:	4.45 cd/klm
Pole Distance:	60.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	14.100 m	No luminous intensities above 95°.	
Overhang (2):	-5.500 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.3.	
Boom Length (4):	0.009 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Photometric Results



Light loss factor: 0.70 Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.35	0.50	0.74	10	1.04

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

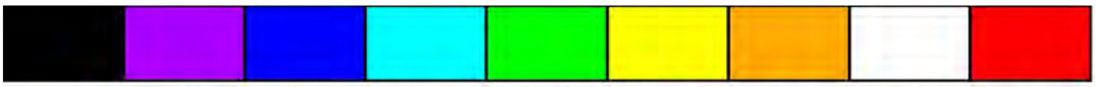
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.35	0.50	0.74	10	1.04

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / 3D Rendering

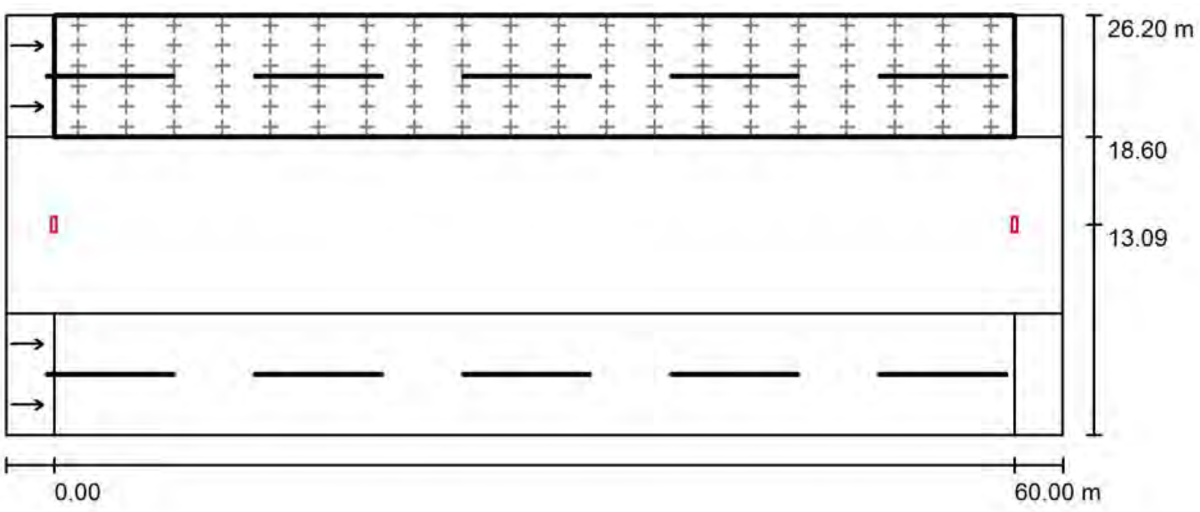
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.70

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

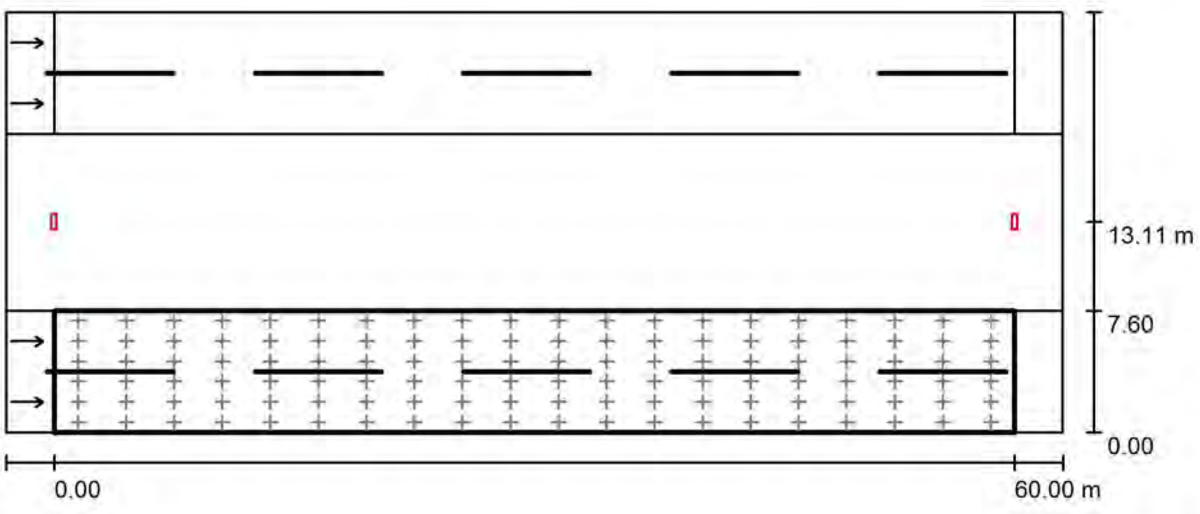
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.35	0.50	0.74	10	1.04

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.35	0.53	0.74	10
2	Observer 4	(-60.000, 24.300, 1.500)	0.41	0.50	0.78	6

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

E18-KARAN-SHAAM ROAD / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.70 Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME2

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.35	0.50	0.74	10	1.04

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	0.41	0.50	0.78	6
2	Observer 2	(-60.000, 5.700, 1.500)	0.35	0.53	0.74	10

Appendix (E)

0 - 12 - 50

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

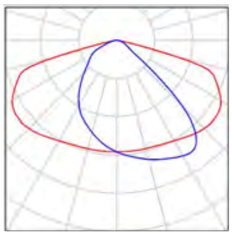
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 12 - 50 / Luminaire parts list

10 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

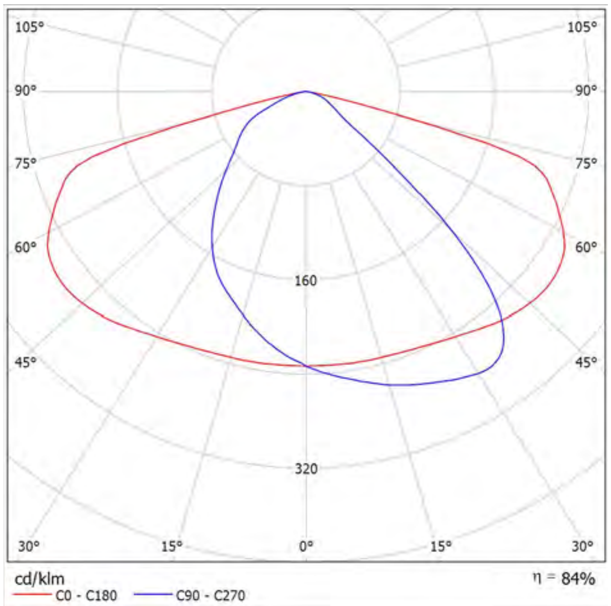


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

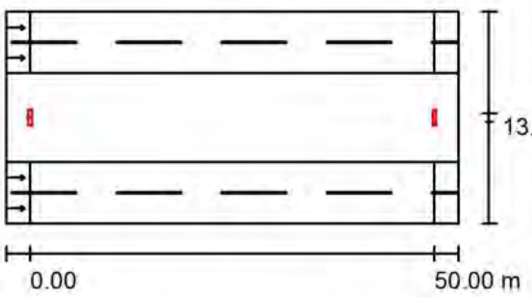
LED 1 / Planning data

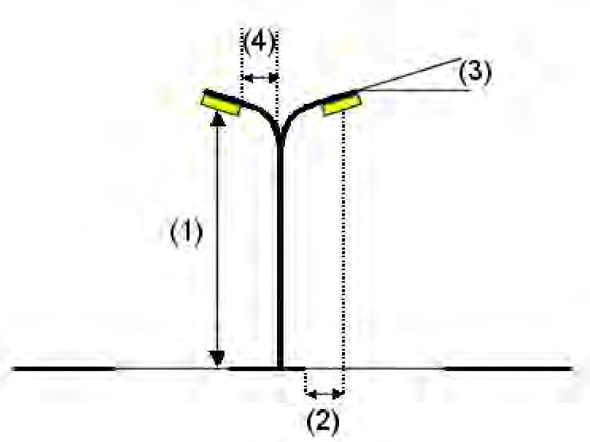
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





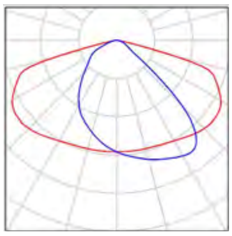
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	0.00 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	12.000 m		
Height:	11.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

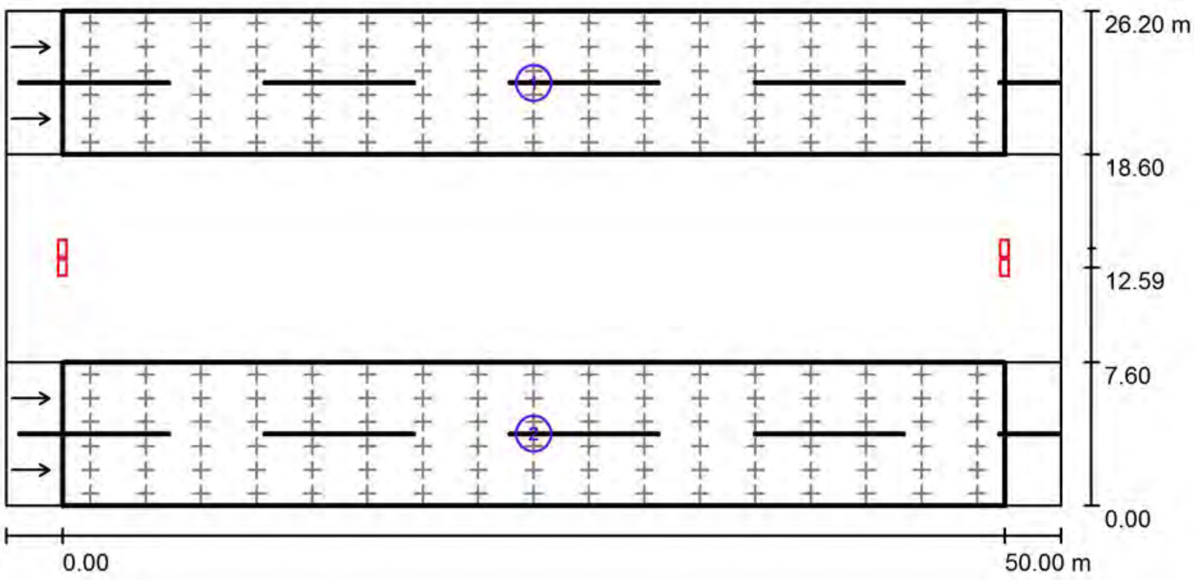
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.40	0.37	0.69	15	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

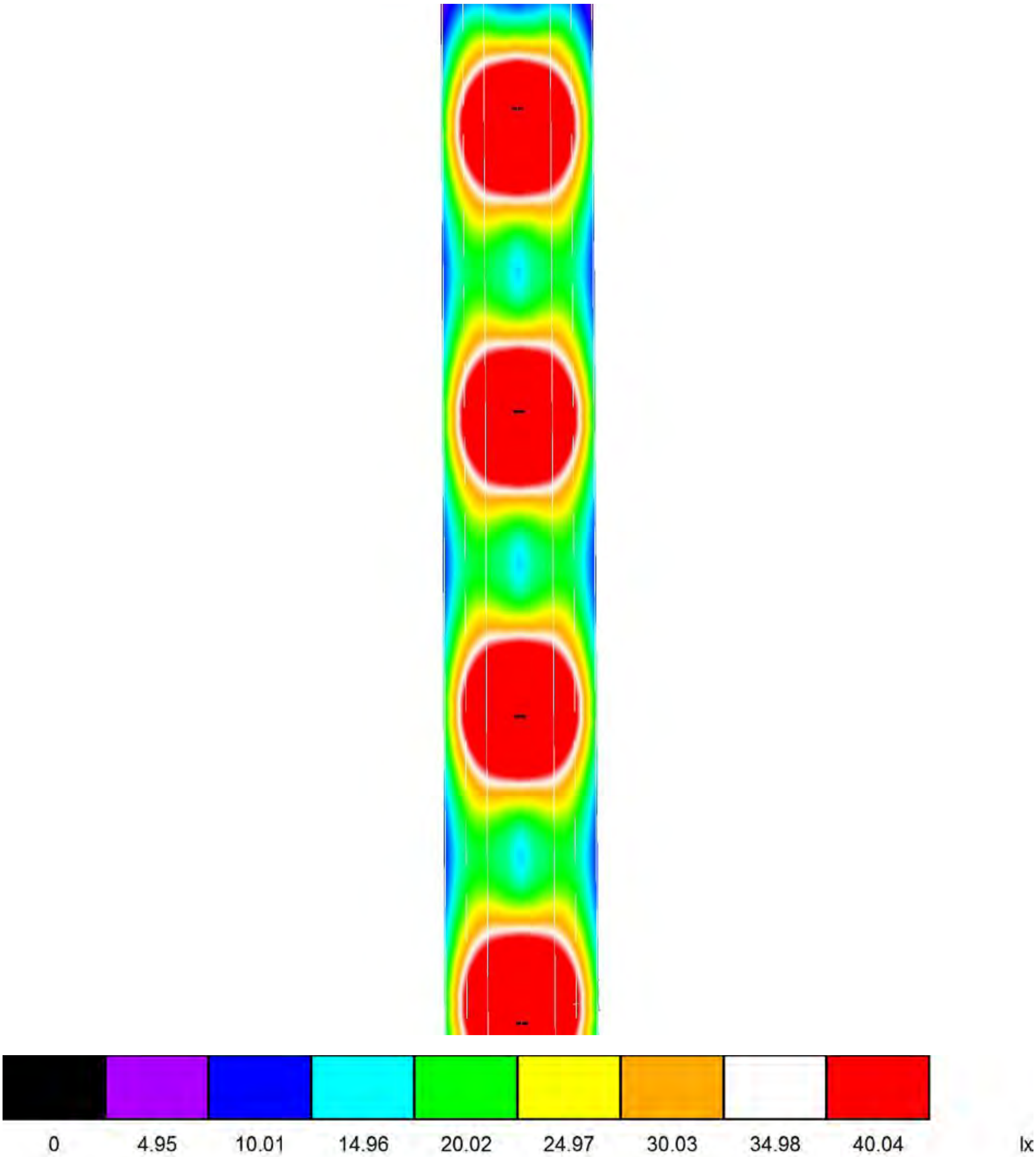
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.40	0.37	0.69	15	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

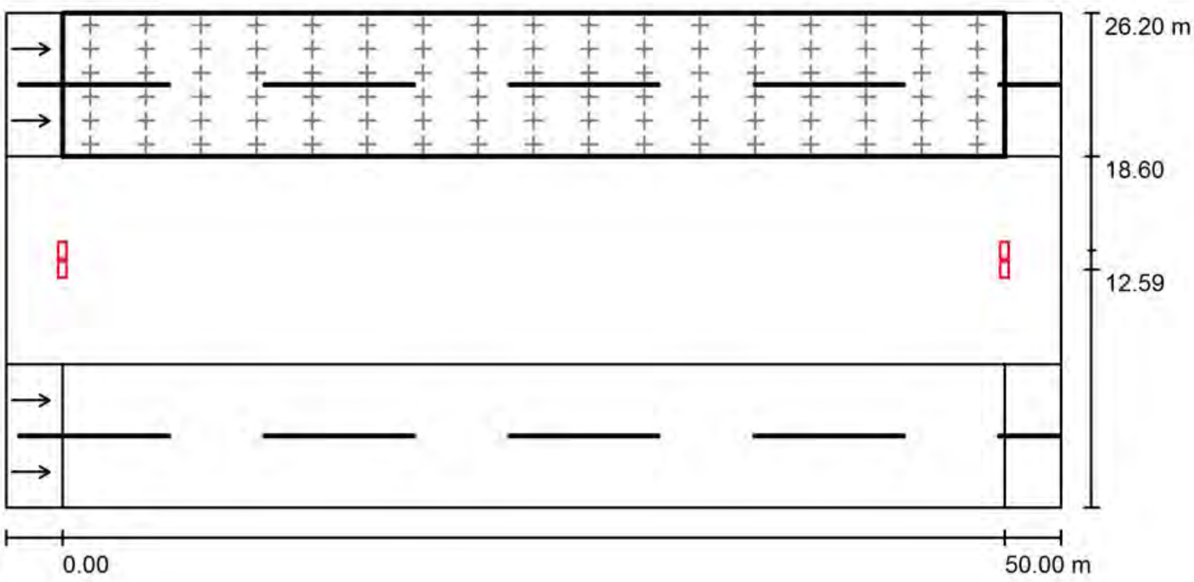
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / **Results overview**



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

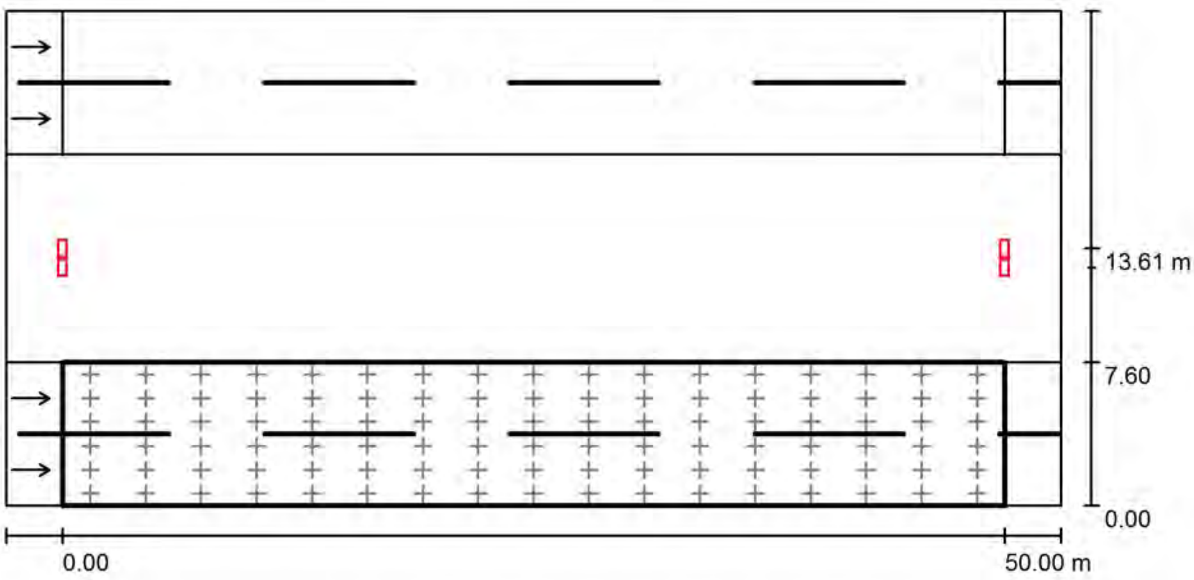
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.40	0.37	0.69	15	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.40	0.41	0.73	15
2	Observer 4	(-60.000, 24.300, 1.500)	1.61	0.37	0.69	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.40	0.37	0.69	15	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.61	0.37	0.69	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.40	0.41	0.73	15

0 - 12 - 60

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

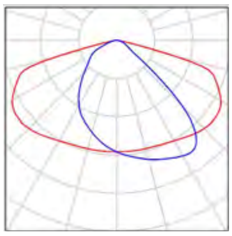
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 12 - 60 / Luminaire parts list

8 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

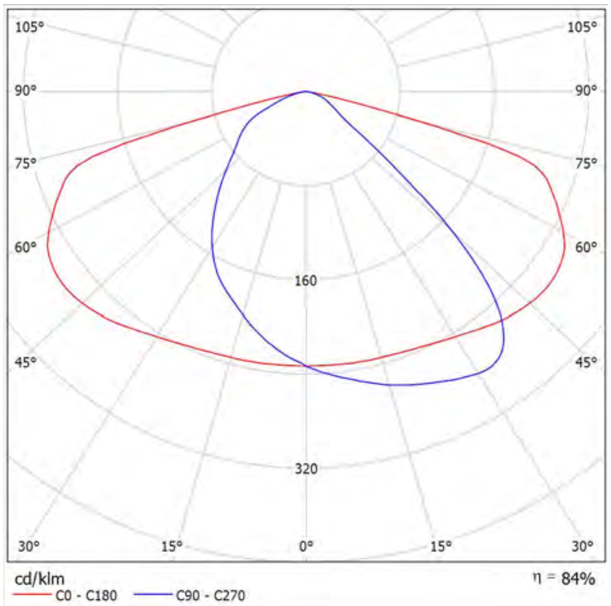


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

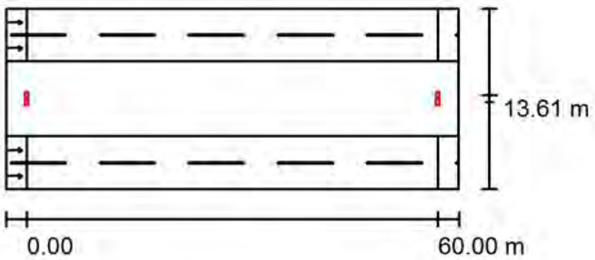
LED 1 / Planning data

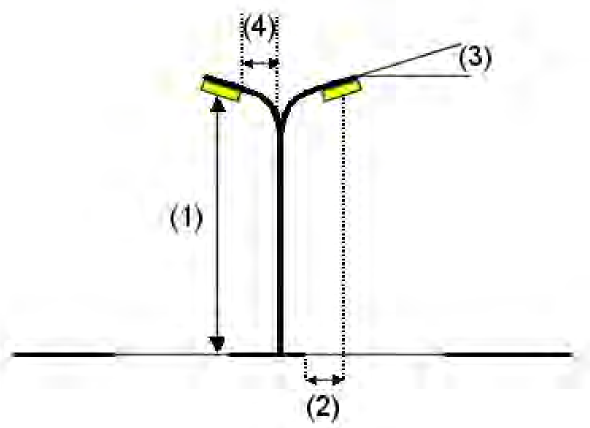
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





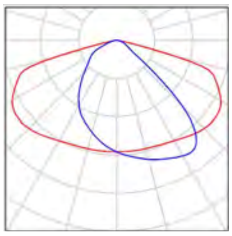
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	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):	12.000 m		
Height:	11.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

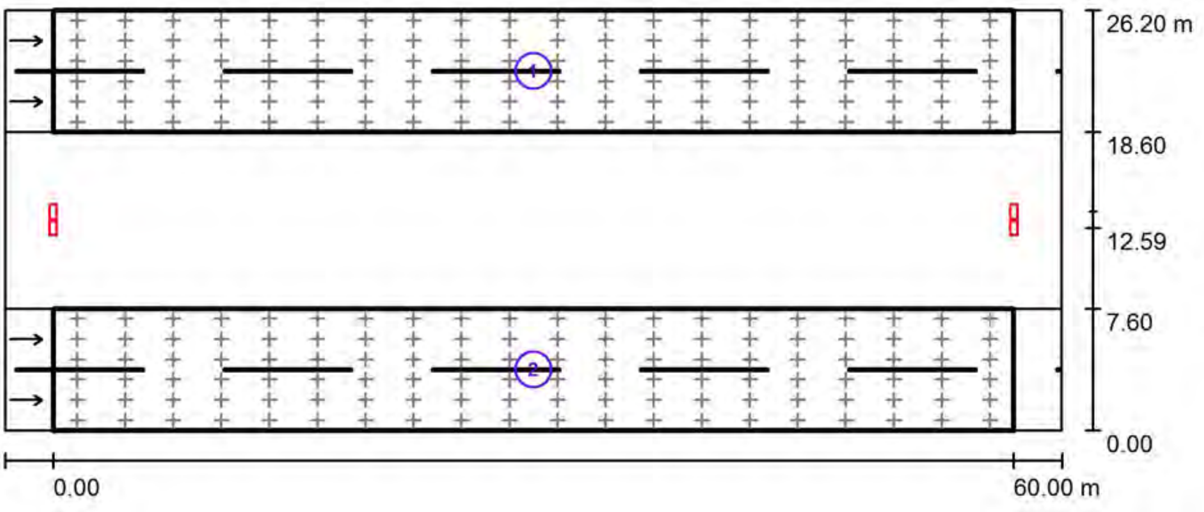
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.17	0.37	0.55	17	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

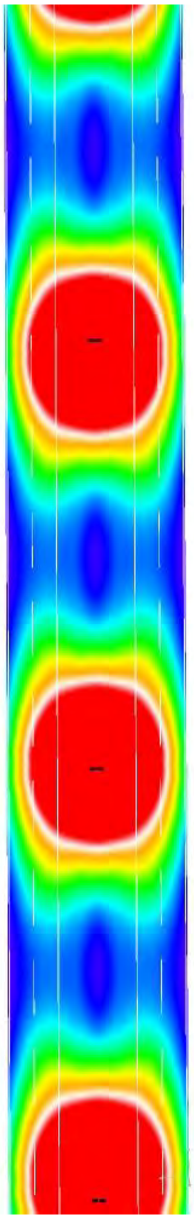
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.17	0.37	0.55	17	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

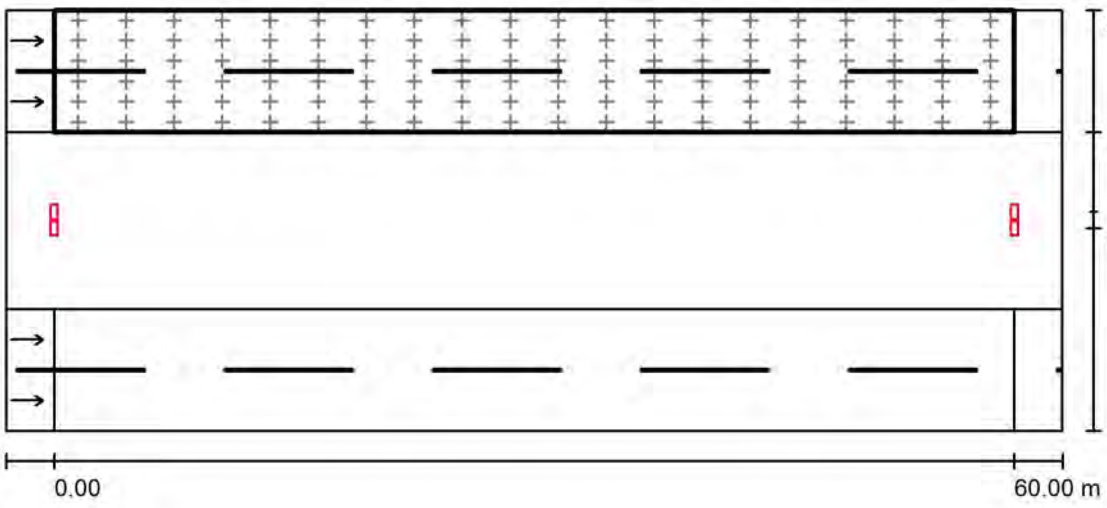
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

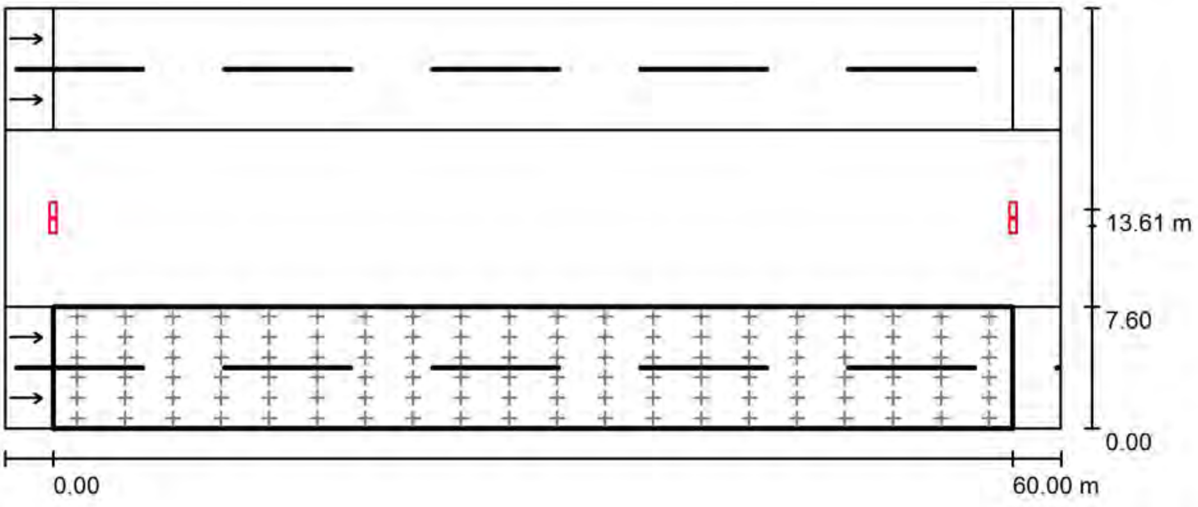
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.17	0.37	0.55	17	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.17	0.40	0.55	17
2	Observer 4	(-60.000, 24.300, 1.500)	1.33	0.37	0.61	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.17	0.37	0.55	17	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.33	0.37	0.61	8
2	Observer 2	(-60.000, 5.700, 1.500)	1.17	0.40	0.55	17

0 - 12 - 70

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

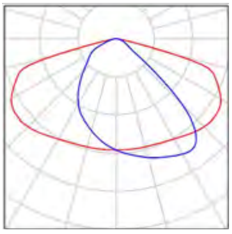
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 12 - 70 / Luminaire parts list

8 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

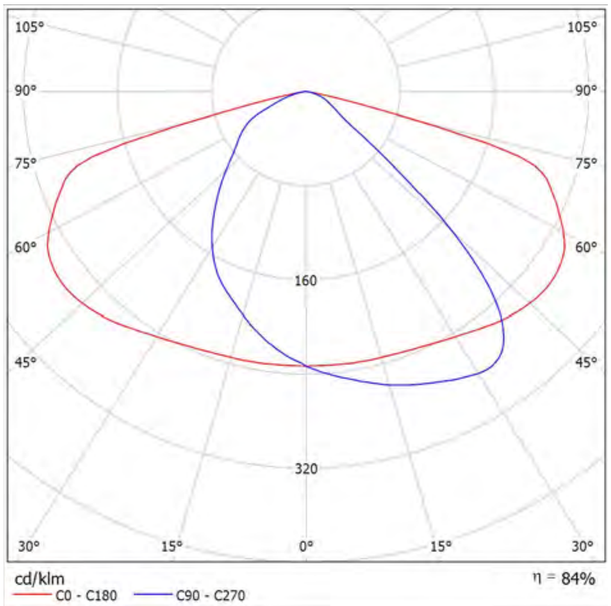


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

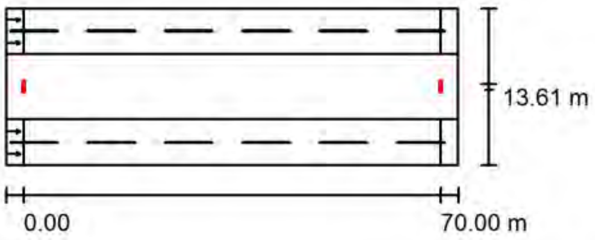
LED 1 / Planning data

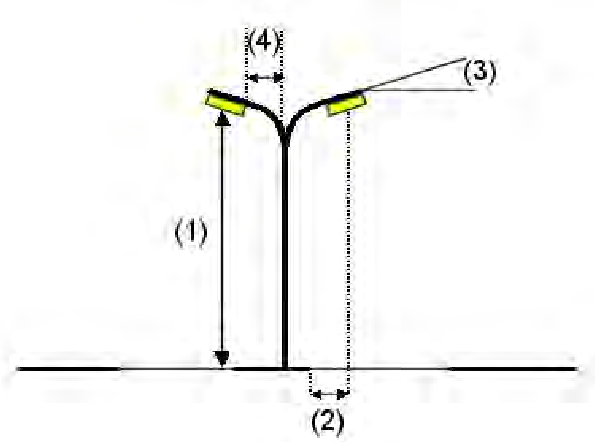
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





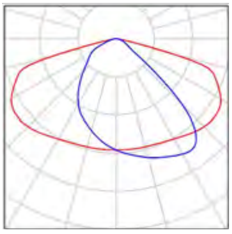
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	0.00 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	12.000 m		
Height:	11.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

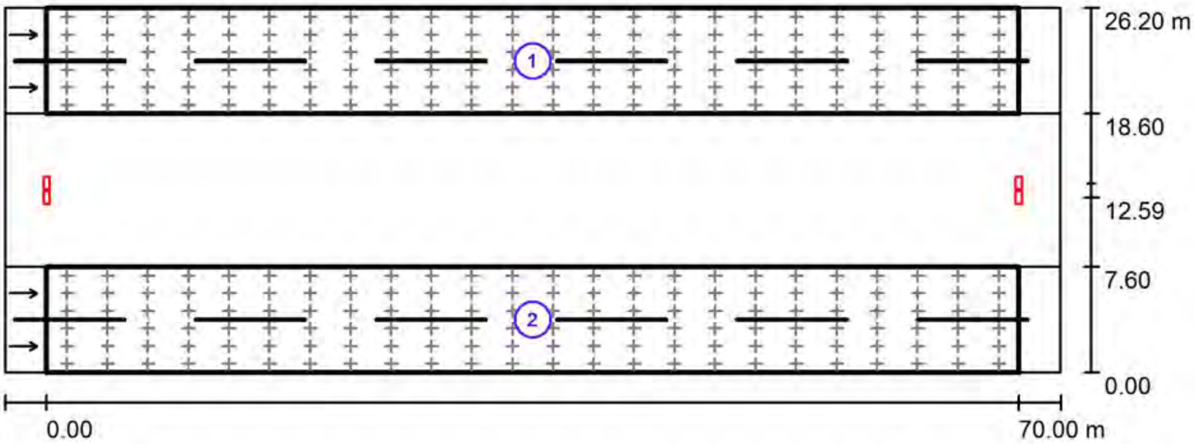
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.00	0.35	0.41	19	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

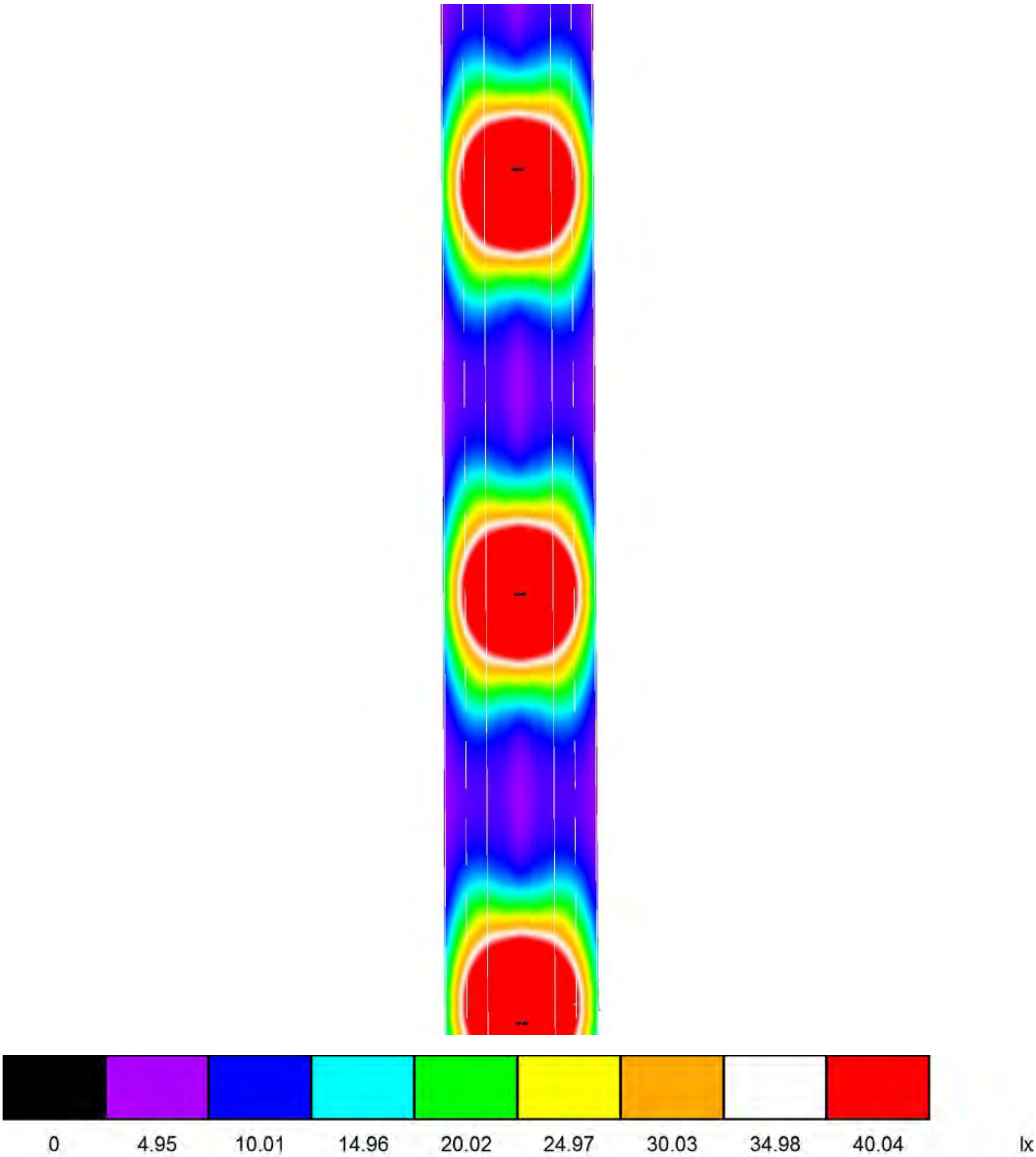
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.00	0.35	0.41	19	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

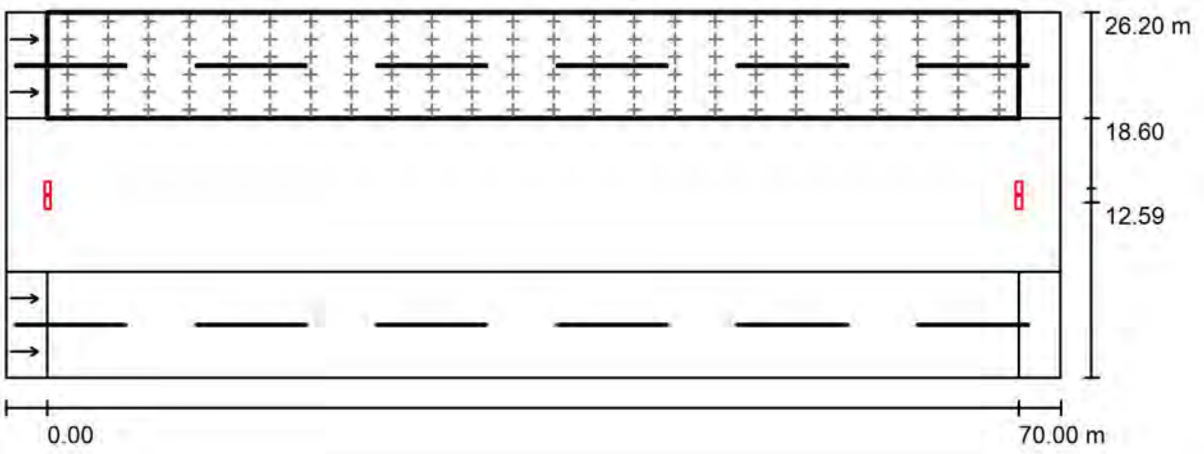
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

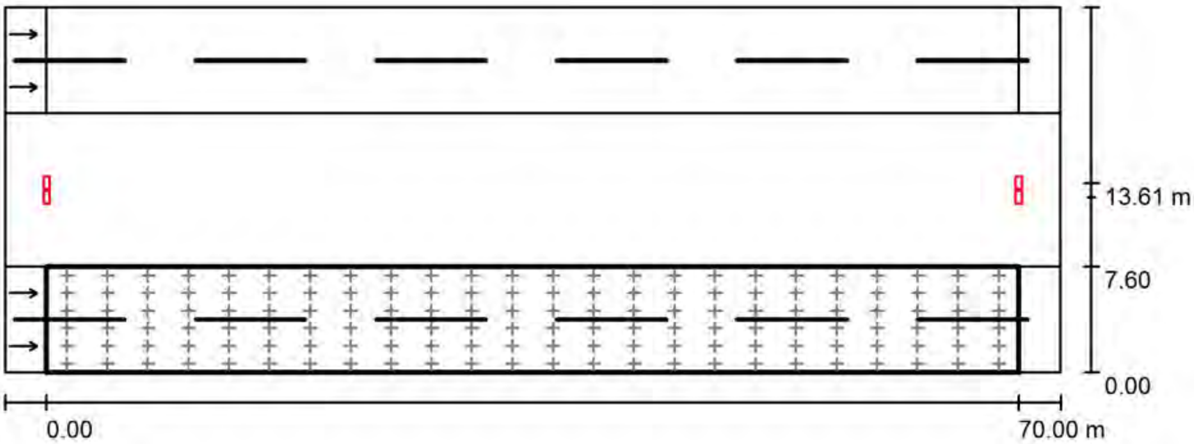
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.00	0.35	0.41	19	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.00	0.37	0.41	19
2	Observer 4	(-60.000, 24.300, 1.500)	1.12	0.35	0.51	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.00	0.35	0.41	19	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.12	0.35	0.51	9
2	Observer 2	(-60.000, 5.700, 1.500)	1.00	0.37	0.41	19

0 - 14 - 50

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

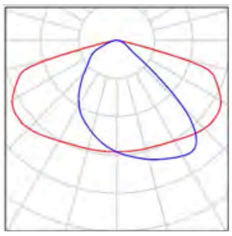
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 14 - 50 / Luminaire parts list

12 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

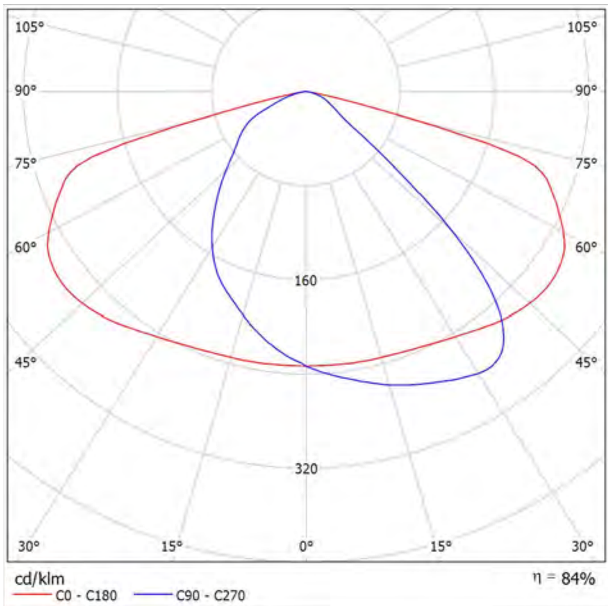


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

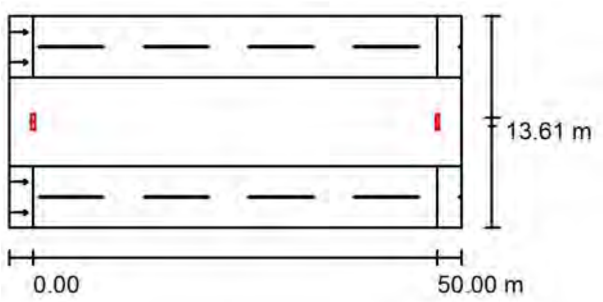
LED 1 / Planning data

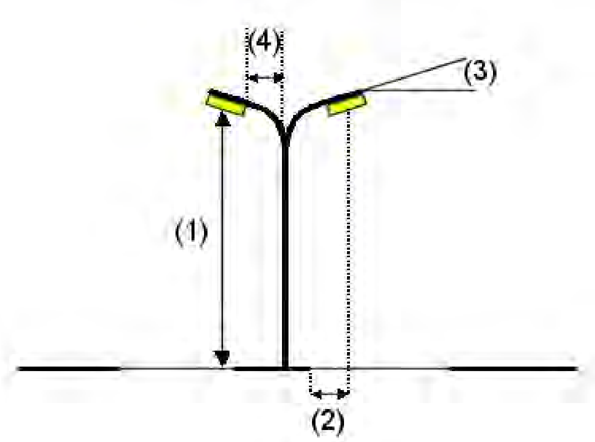
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





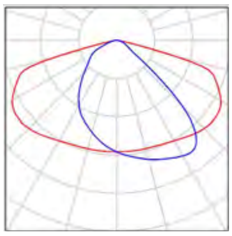
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	0.00 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

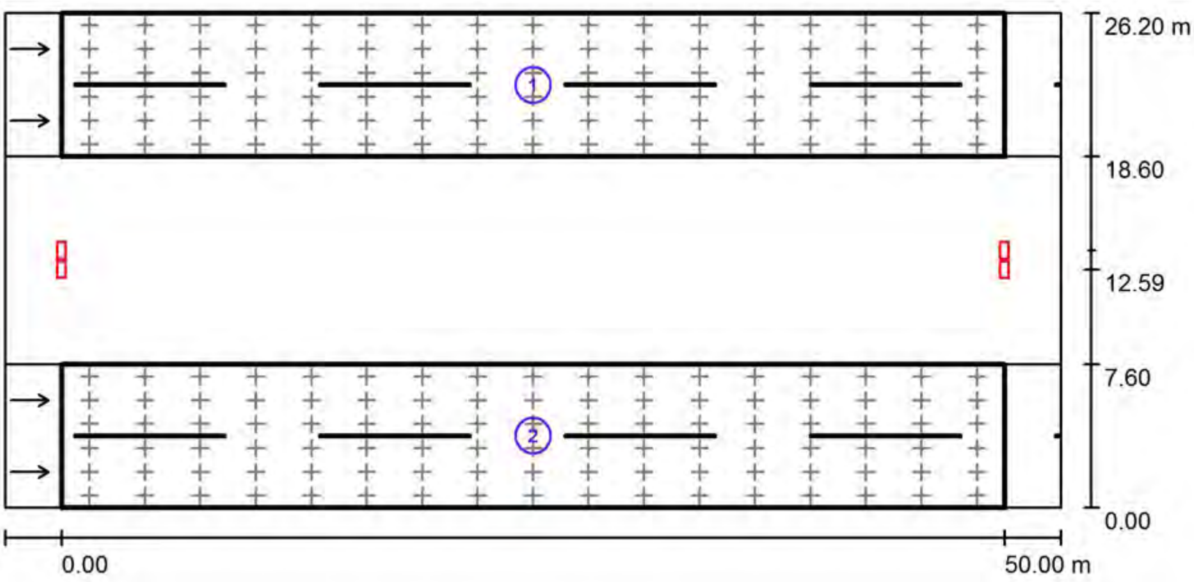
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway

Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.44	0.49	0.83	11	0.89

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

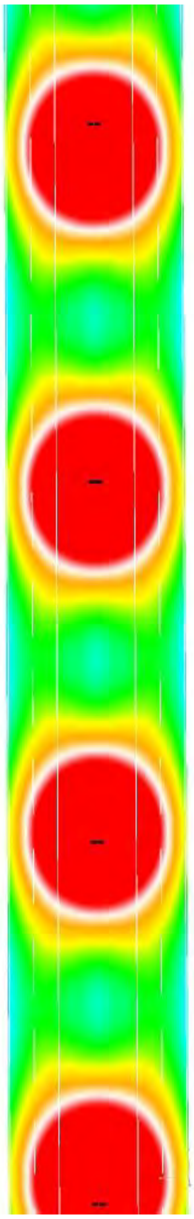
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.44	0.49	0.83	11	0.89

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

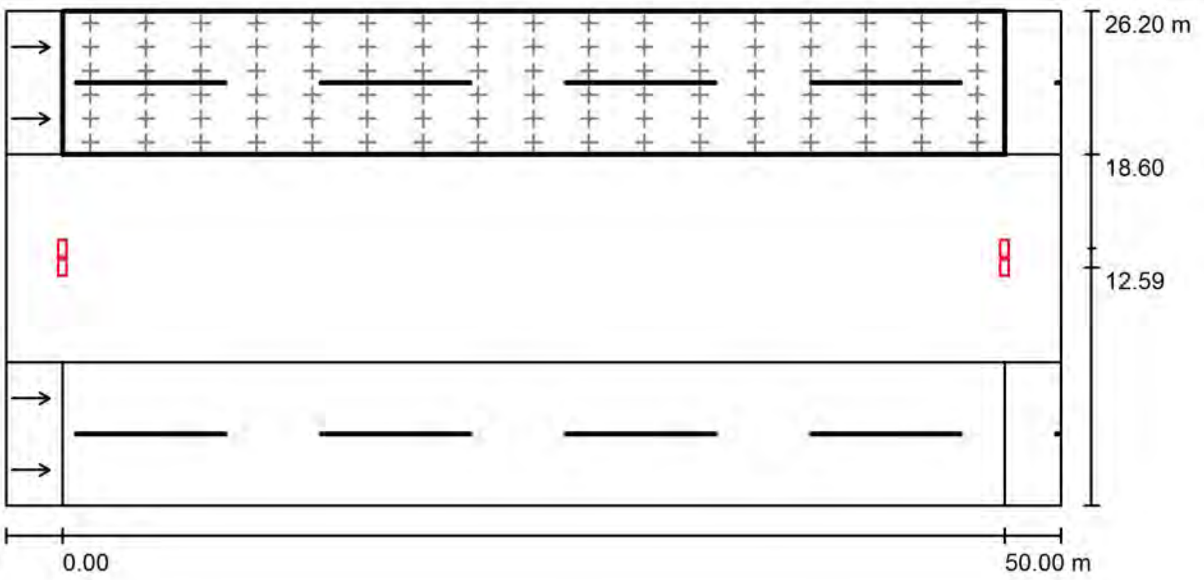
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

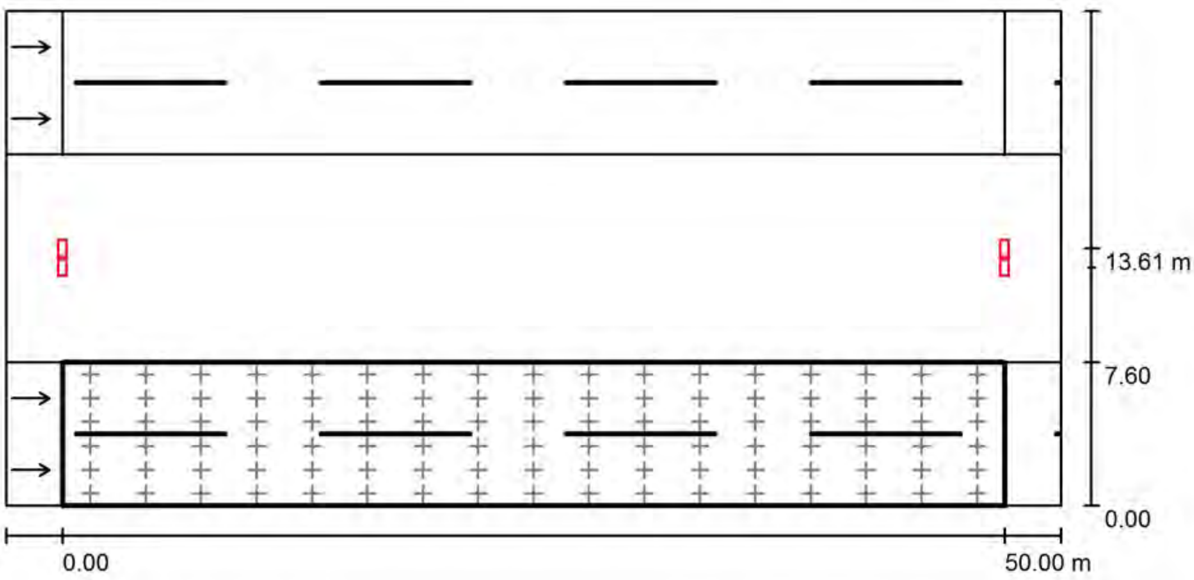
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.44	0.49	0.83	11	0.89

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.44	0.53	0.90	11
2	Observer 4	(-60.000, 24.300, 1.500)	1.67	0.49	0.83	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.44	0.49	0.83	11	0.89

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.67	0.49	0.83	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.44	0.53	0.90	11

0 - 14 - 60

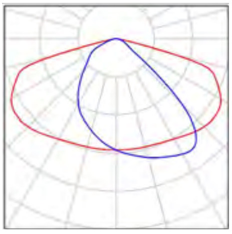
Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 14 - 60 / Luminaire parts list

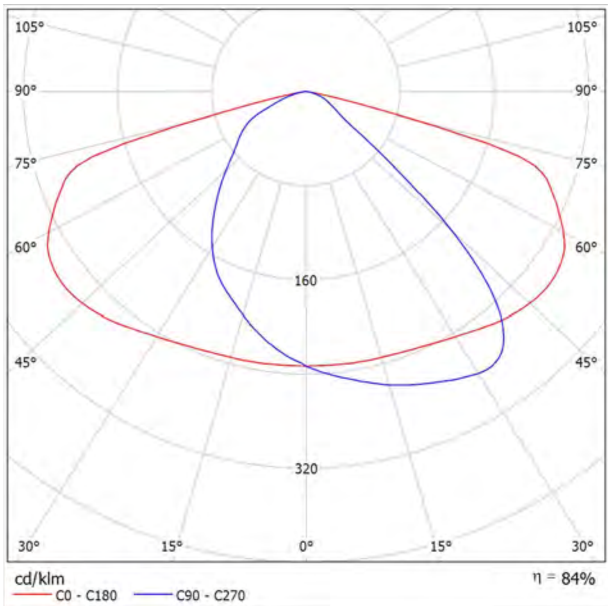
10 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 Article No.: Luminous flux (Luminaire): 30970 lm Luminous flux (Lamps): 36759 lm Luminaire Wattage: 279.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

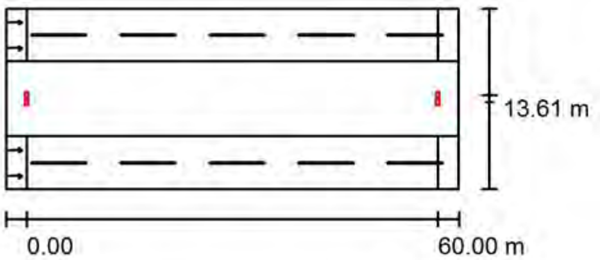
LED 1 / Planning data

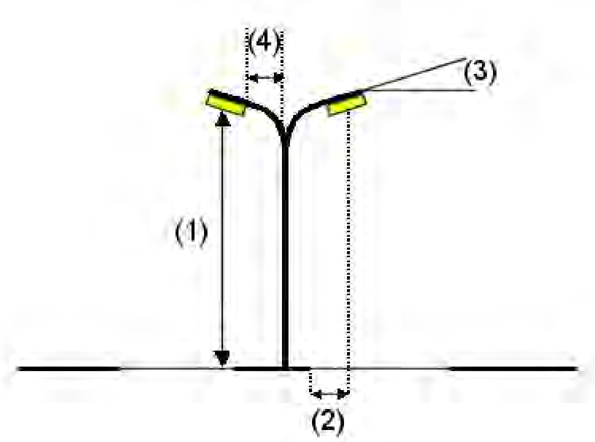
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





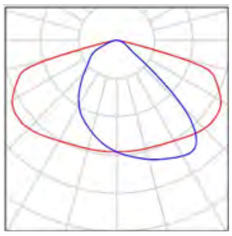
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	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):	14.000 m		
Height:	13.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

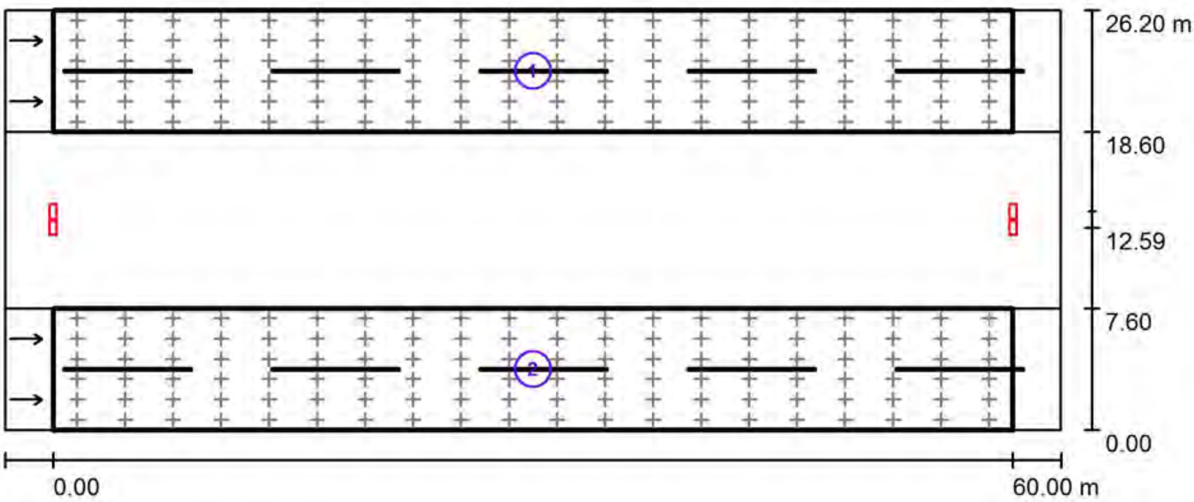
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.20	0.47	0.69	13	0.89

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

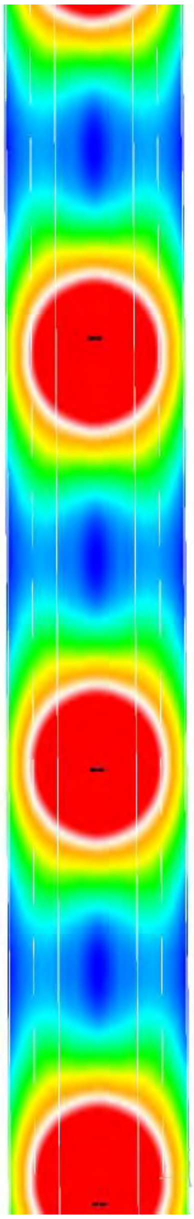
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.20	0.47	0.69	13	0.89

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

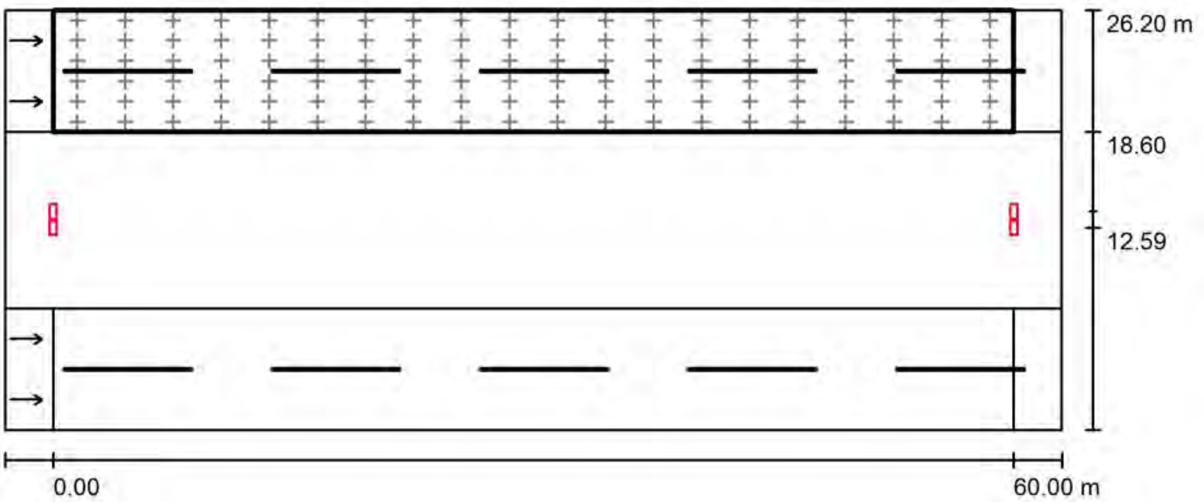
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

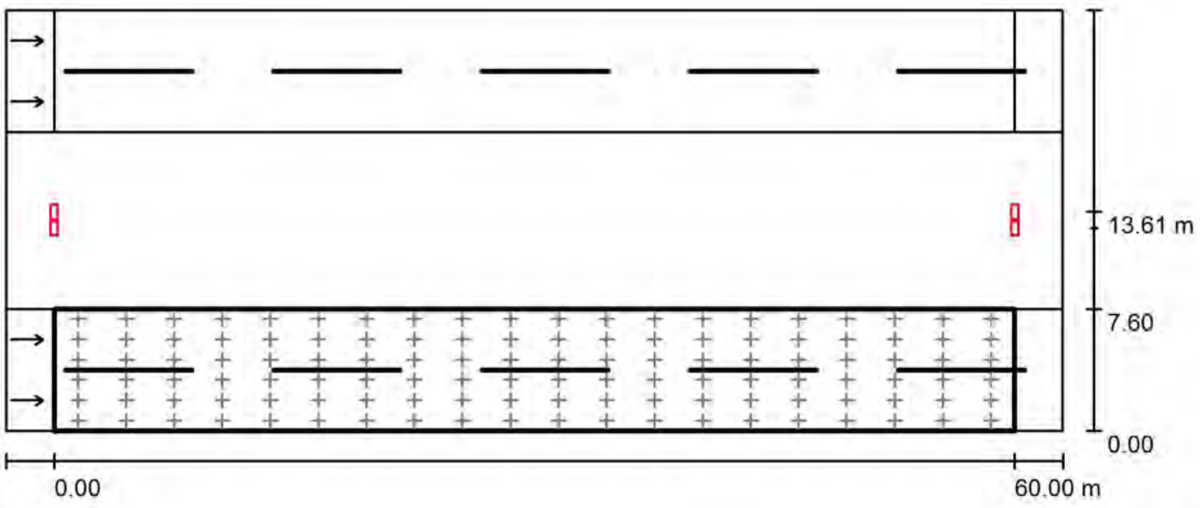
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.20	0.47	0.69	13	0.89

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.20	0.50	0.74	13
2	Observer 4	(-60.000, 24.300, 1.500)	1.38	0.47	0.69	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.20	0.47	0.69	13	0.89

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.38	0.47	0.69	8
2	Observer 2	(-60.000, 5.700, 1.500)	1.20	0.50	0.74	13

0 - 14 - 70

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

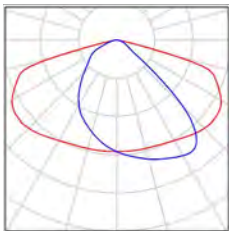
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 14 - 70 / Luminaire parts list

8 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

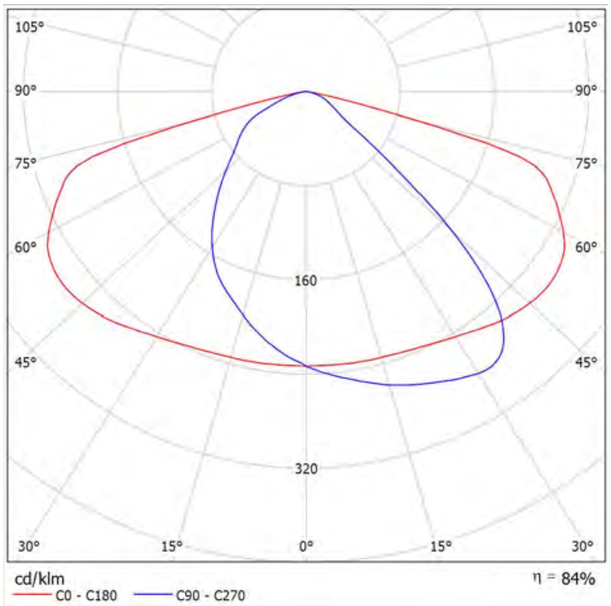


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

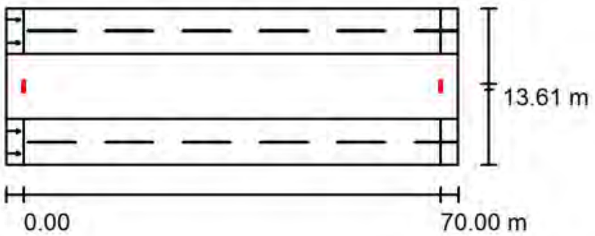
LED 1 / Planning data

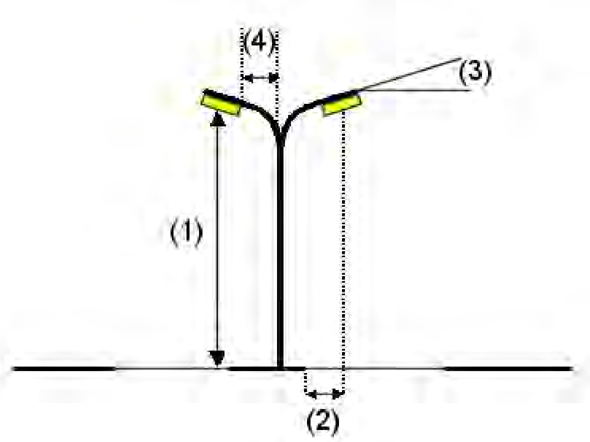
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





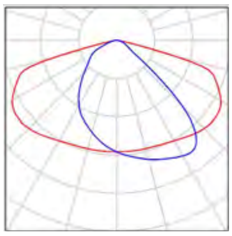
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	0.00 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

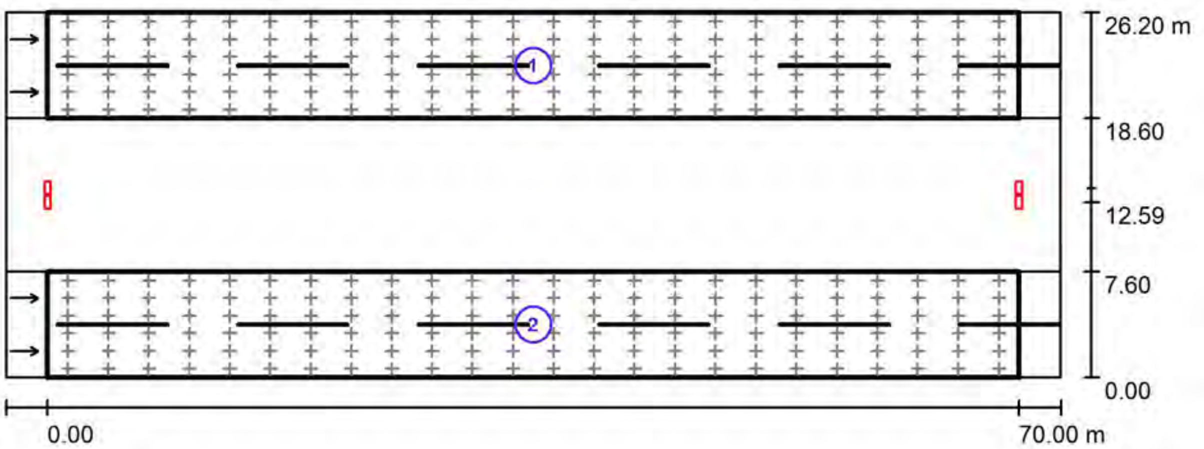
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.03	0.42	0.51	14	0.89

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

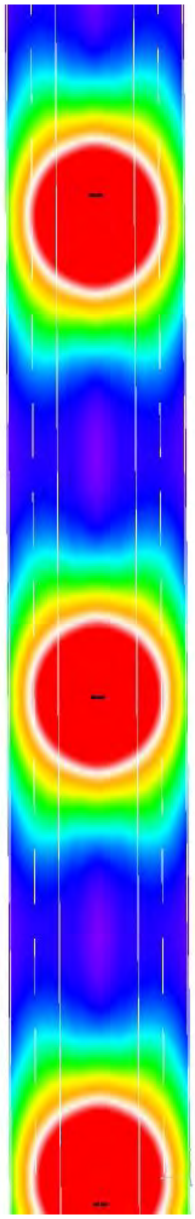
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.03	0.42	0.51	14	0.89

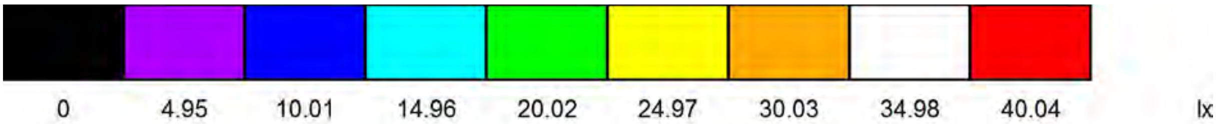
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

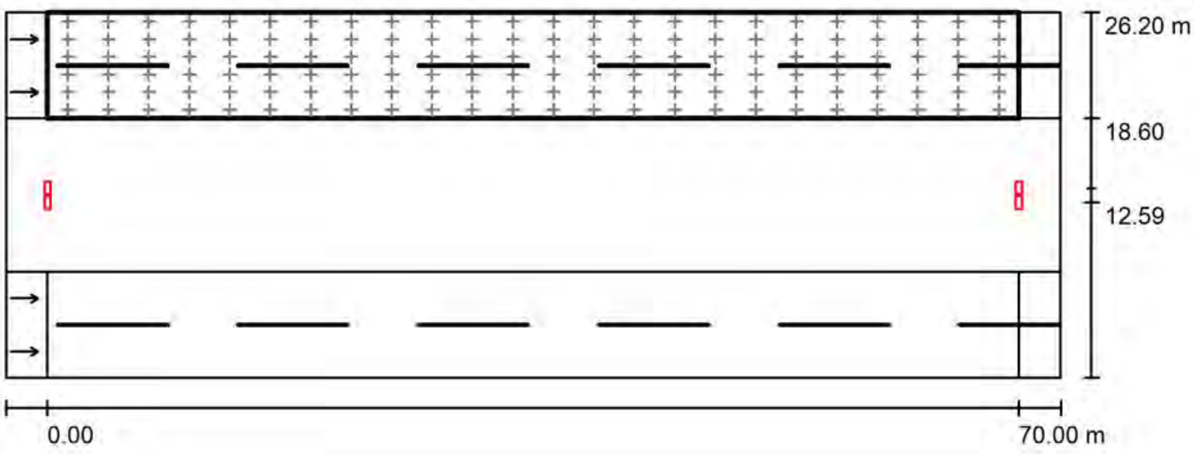
LED 1 / False Color Rendering





Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

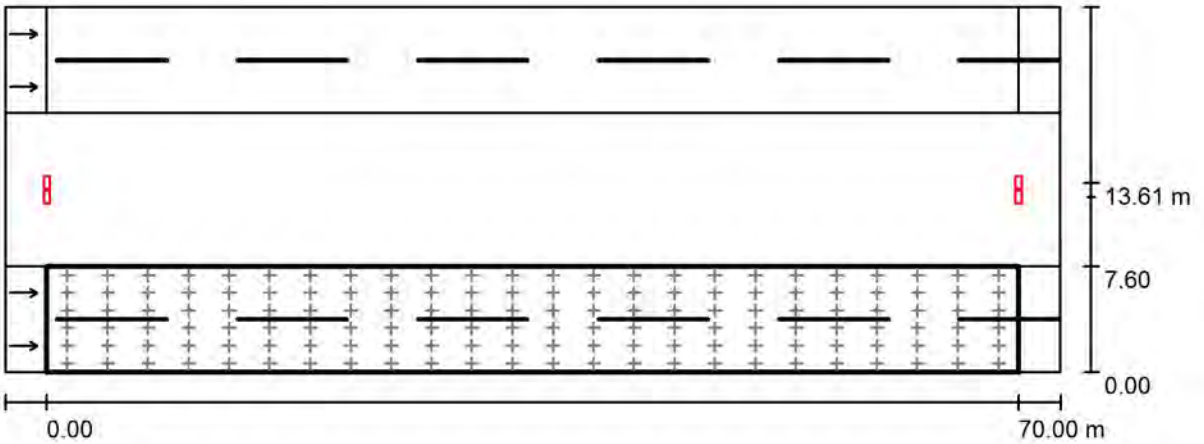
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.03	0.42	0.51	14	0.89

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.03	0.46	0.51	14
2	Observer 4	(-60.000, 24.300, 1.500)	1.17	0.42	0.60	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.03	0.42	0.51	14	0.89

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.17	0.42	0.60	9
2	Observer 2	(-60.000, 5.700, 1.500)	1.03	0.46	0.51	14

0 - 16 - 50

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

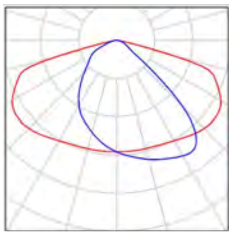
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 16 - 50 / Luminaire parts list

12 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

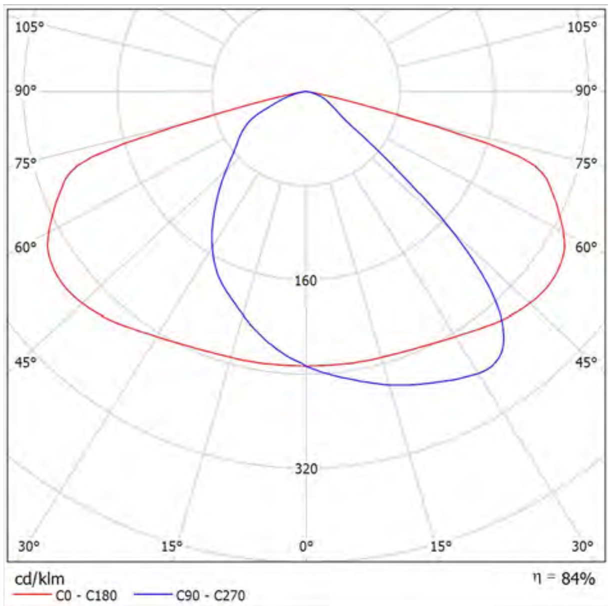


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

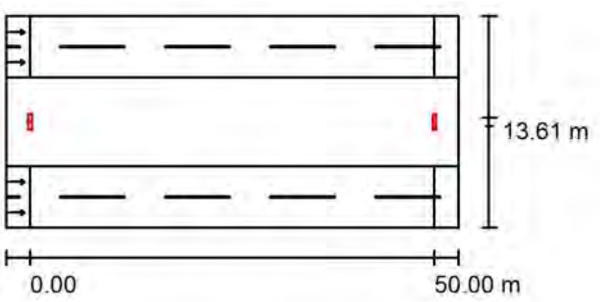
LED 1 / Planning data

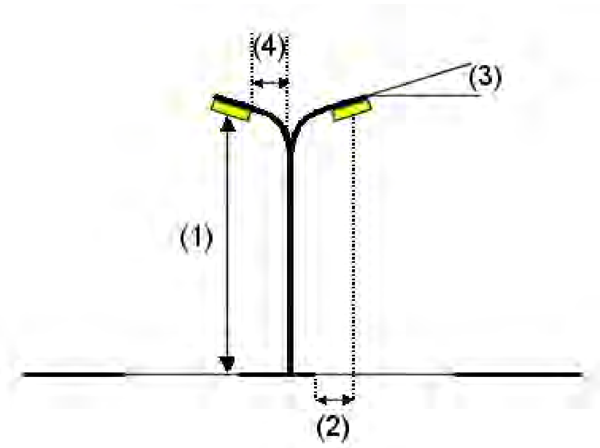
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





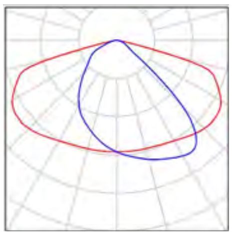
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	0.00 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	16.000 m		
Height:	15.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

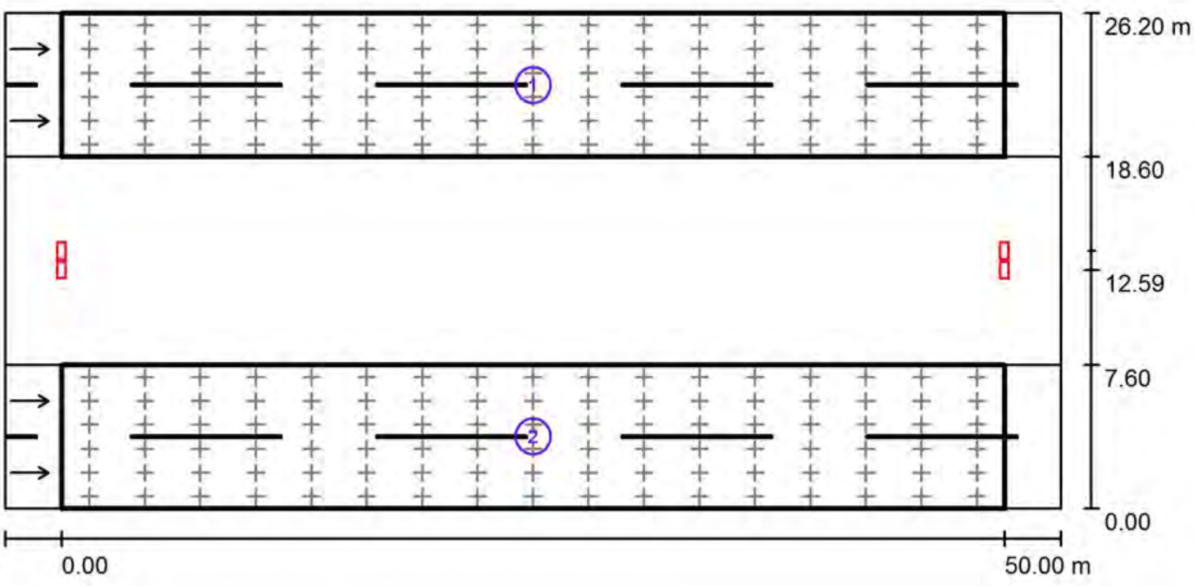
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway

Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.43	0.57	0.89	9	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

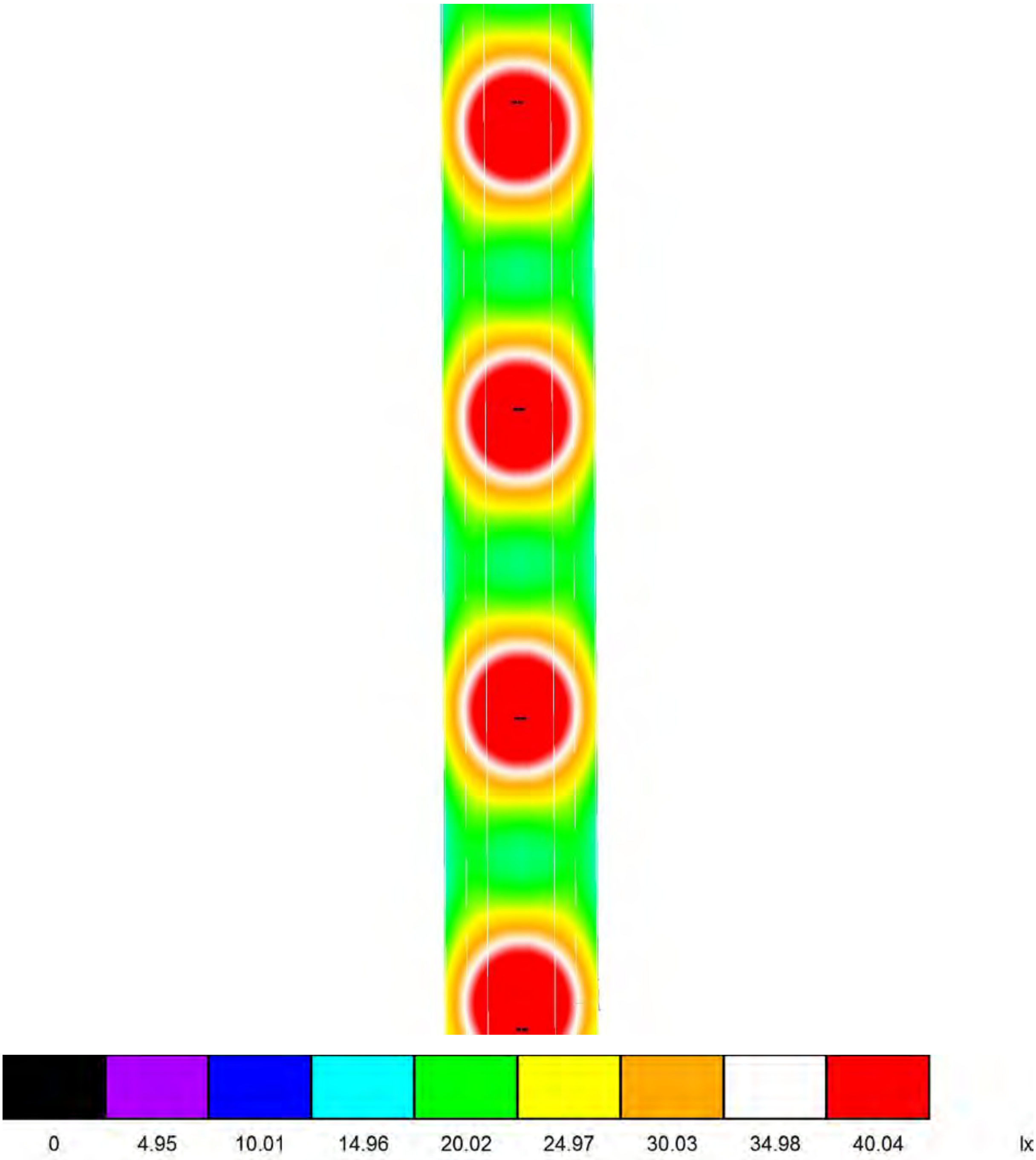
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.43	0.57	0.89	9	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

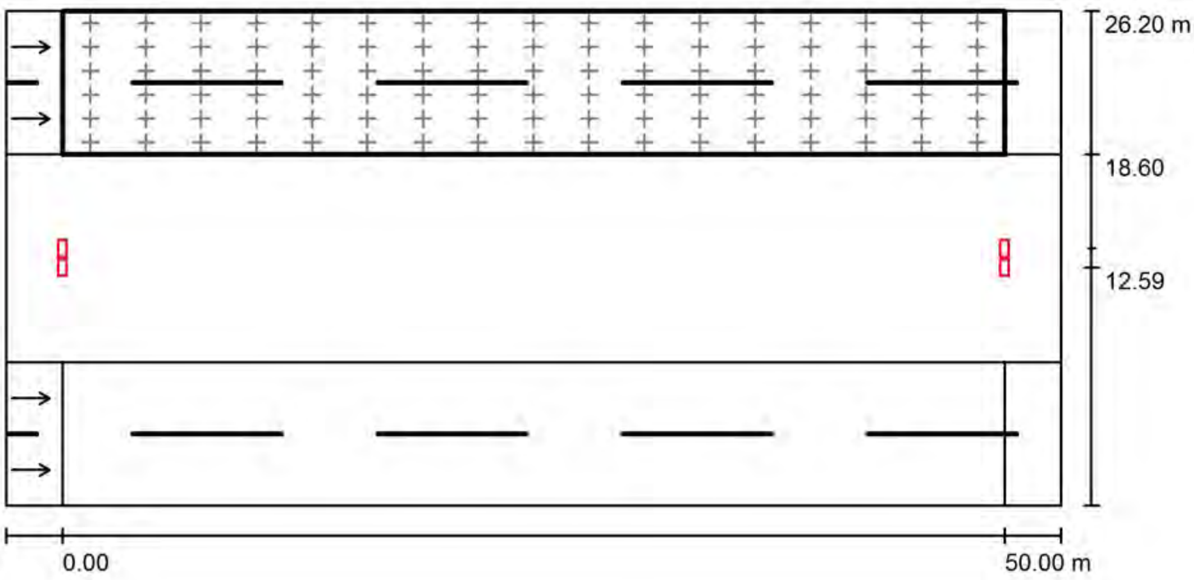
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

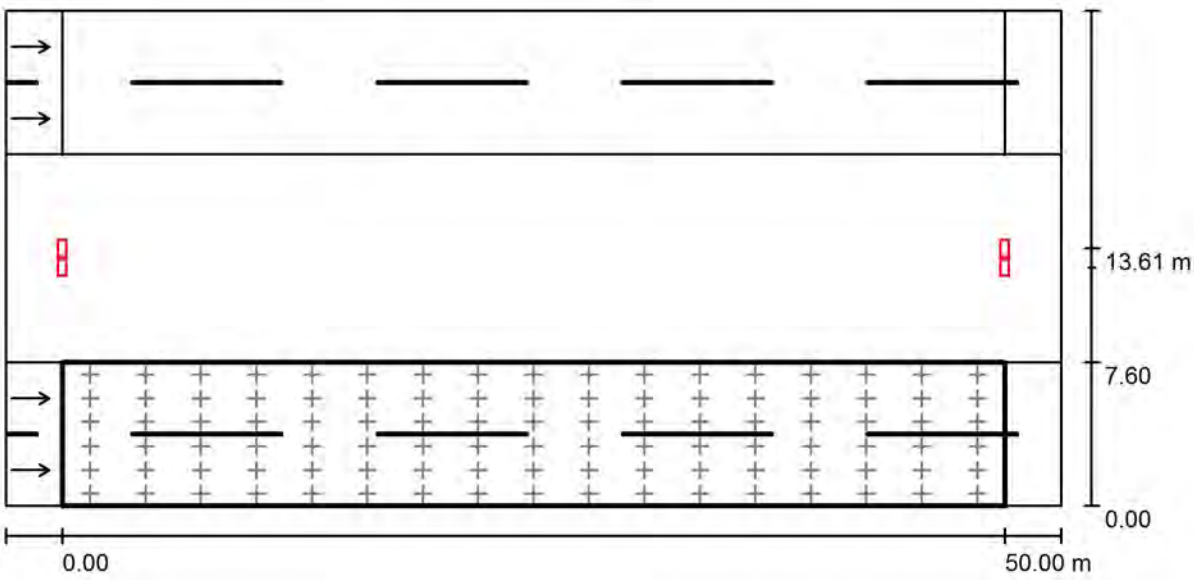
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.43	0.57	0.89	9	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.43	0.63	0.89	9
2	Observer 4	(-60.000, 24.300, 1.500)	1.66	0.57	0.92	6

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.43	0.57	0.89	9	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.66	0.57	0.92	6
2	Observer 2	(-60.000, 5.700, 1.500)	1.43	0.63	0.89	9

0 - 16 - 60

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

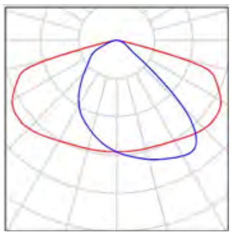
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 16 - 60 / Luminaire parts list

12 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

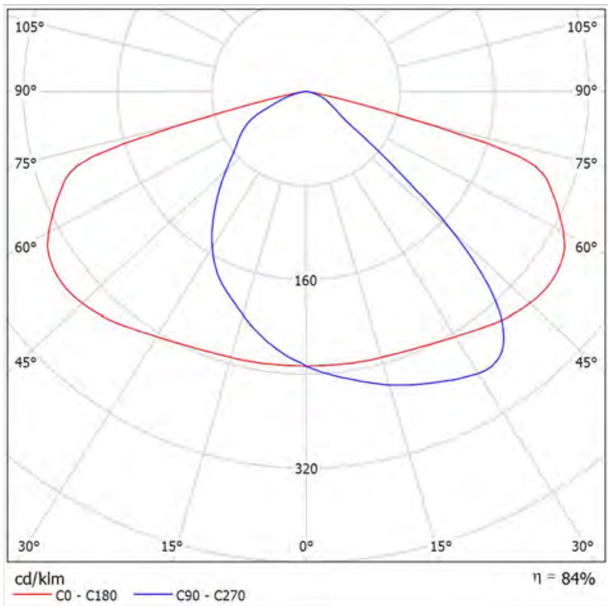


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

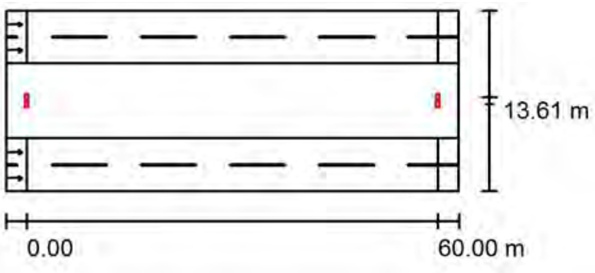
LED 1 / Planning data

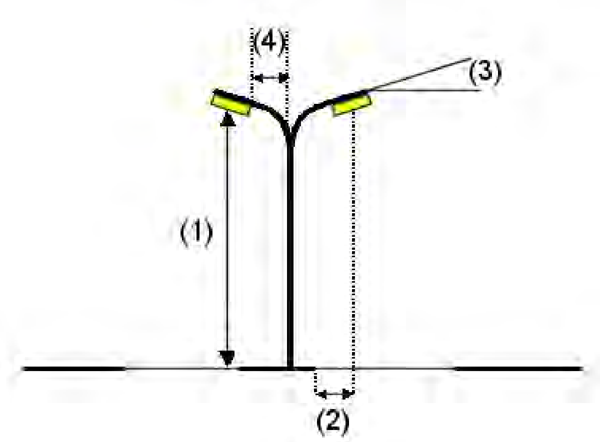
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





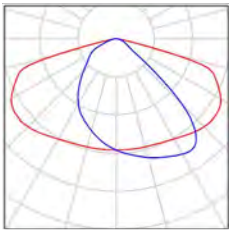
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	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):	16.000 m		
Height:	15.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

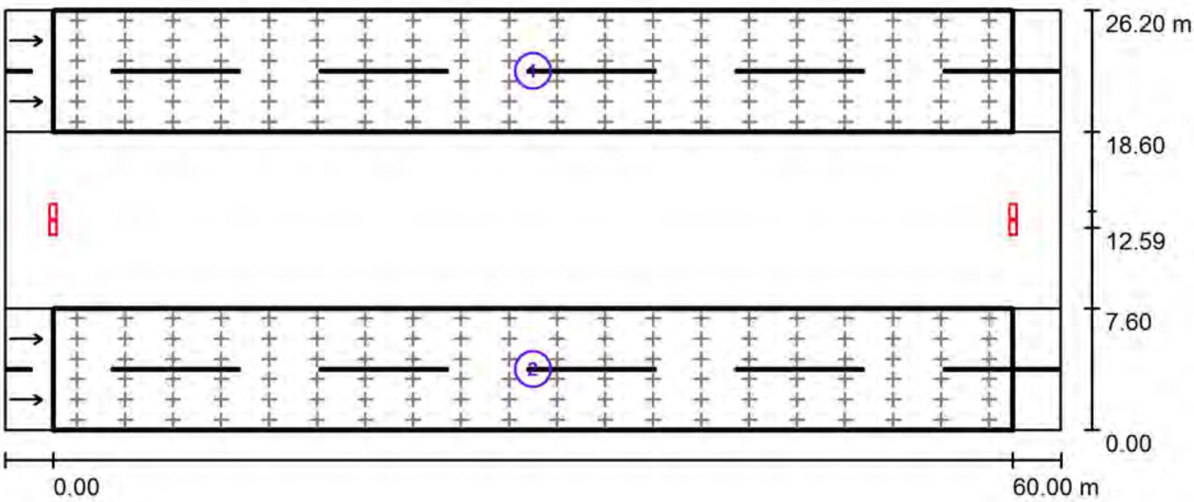
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.19	0.56	0.79	10	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

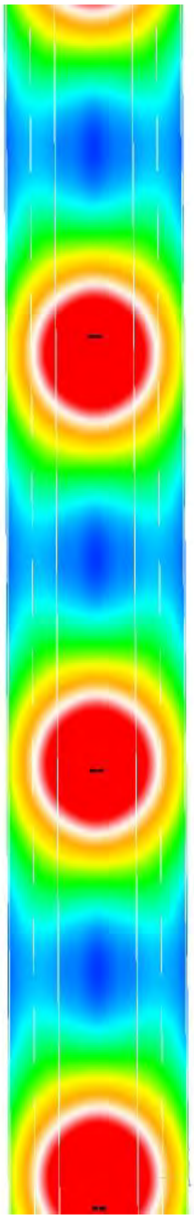
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.19	0.56	0.79	10	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

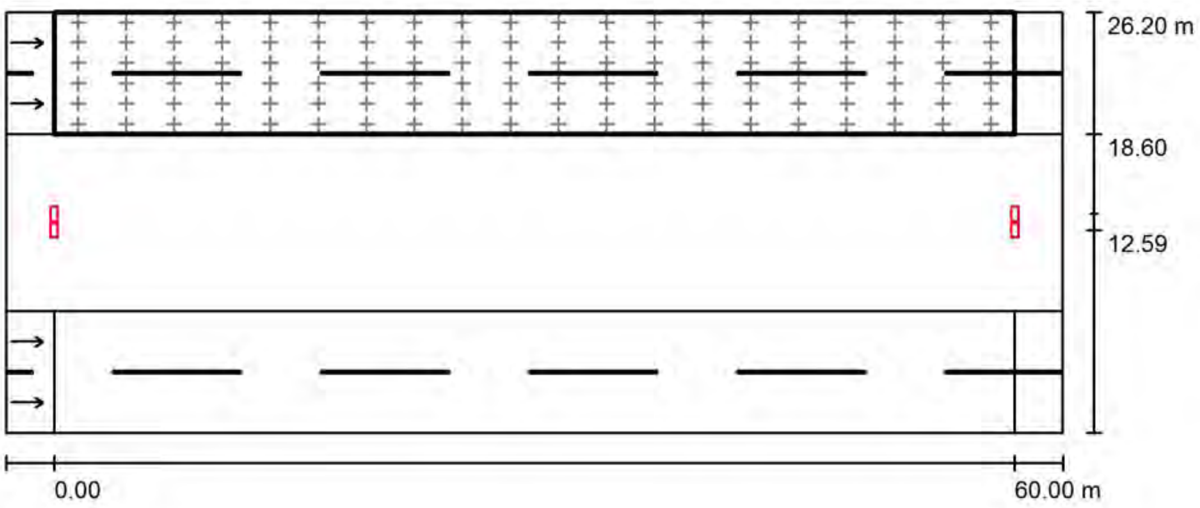
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

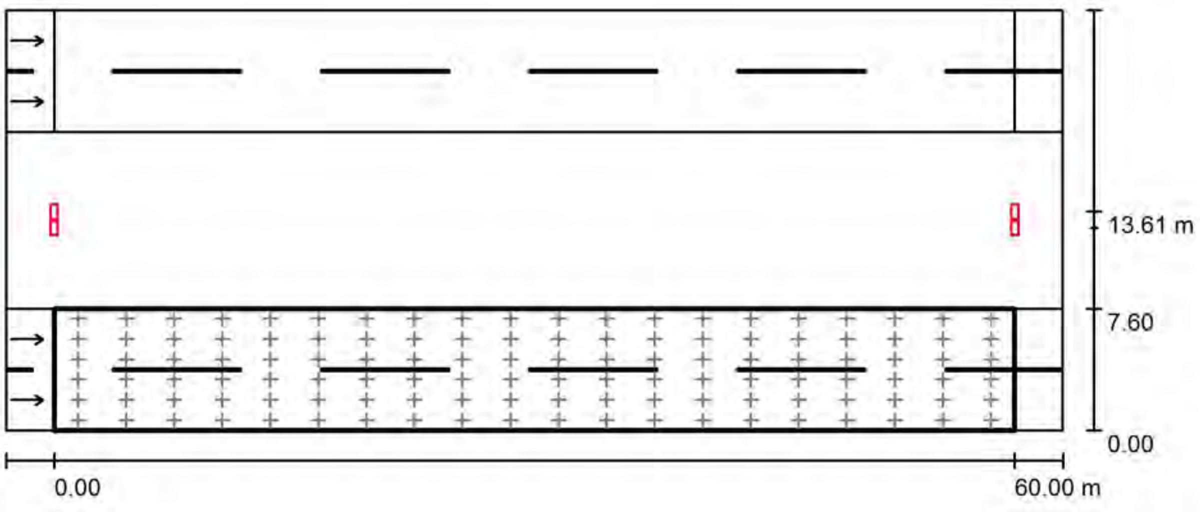
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.19	0.56	0.79	10	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.19	0.59	0.90	10
2	Observer 4	(-60.000, 24.300, 1.500)	1.38	0.56	0.79	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.19	0.56	0.79	10	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.38	0.56	0.79	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.19	0.59	0.90	10

0 - 16 - 70

Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

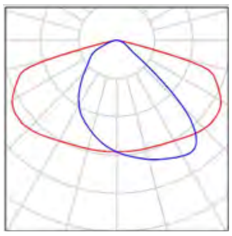
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

0 - 16 - 70 / Luminaire parts list

10 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

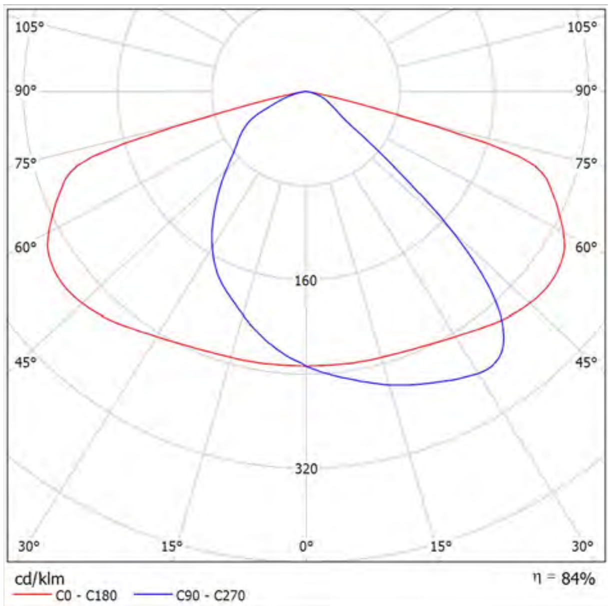


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

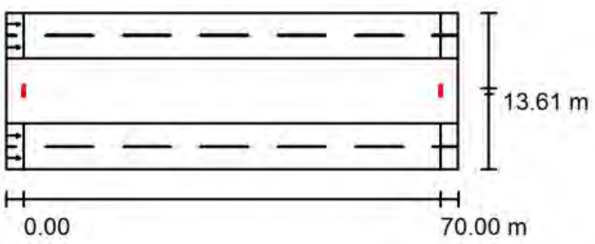
LED 1 / Planning data

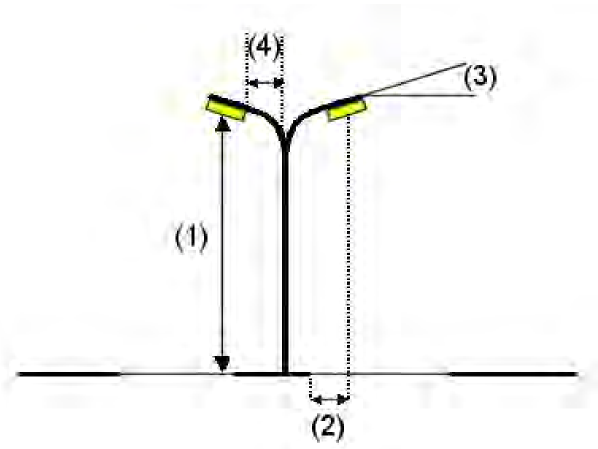
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





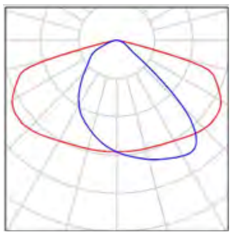
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	583 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	47 cd/klm
Arrangement:	on Median	at 90°:	0.00 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	16.000 m		
Height:	15.865 m	No luminous intensities above 90°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	0.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.512 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

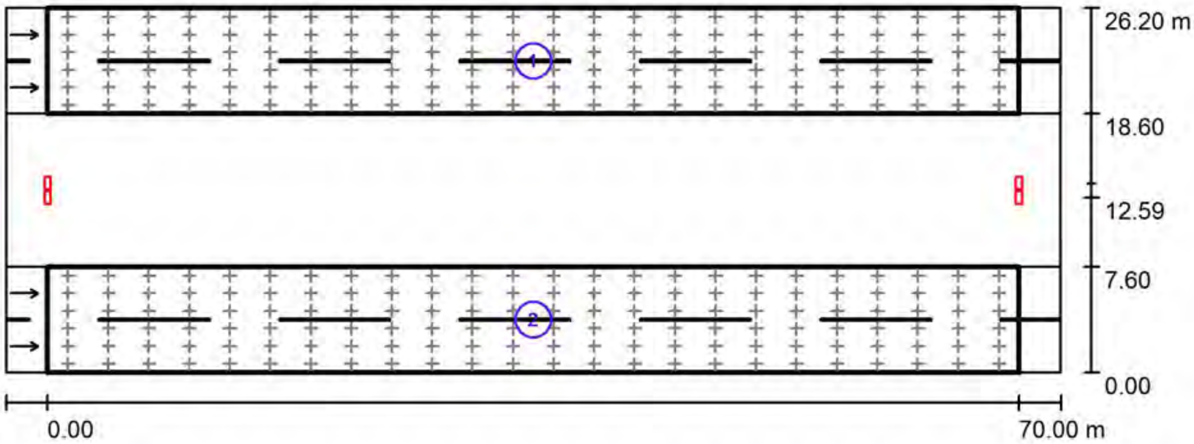
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.02	0.48	0.68	11	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

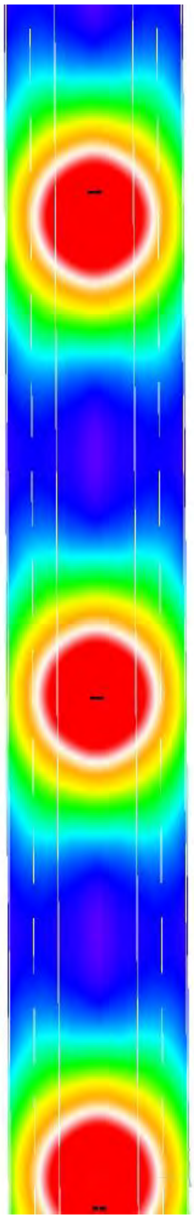
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.02	0.48	0.68	11	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

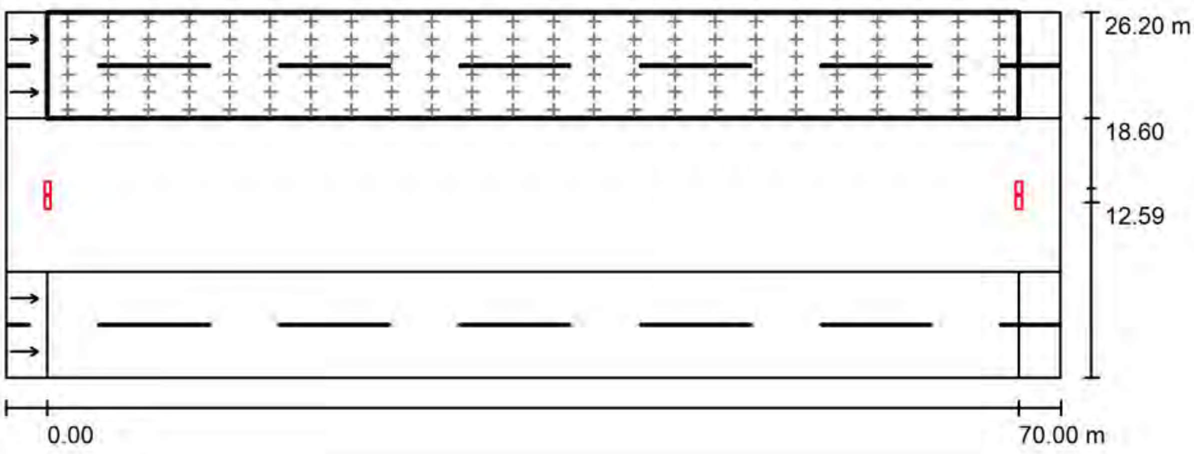
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

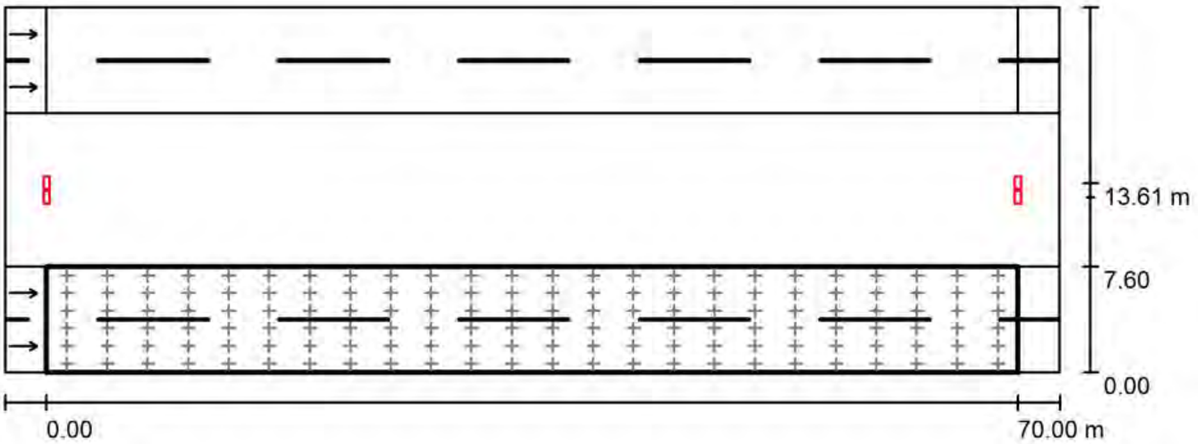
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.02	0.48	0.68	11	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.02	0.53	0.71	11
2	Observer 4	(-60.000, 24.300, 1.500)	1.17	0.48	0.68	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.02	0.48	0.68	11	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.17	0.48	0.68	8
2	Observer 2	(-60.000, 5.700, 1.500)	1.02	0.53	0.71	11

Appendix (F)

2 - 12 - 50

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

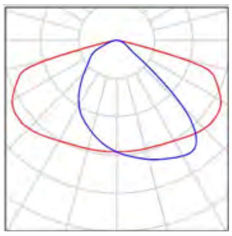
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 12 - 50 / Luminaire parts list

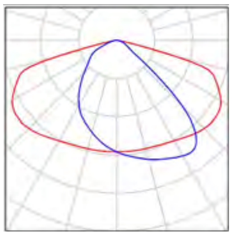
4 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



6 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

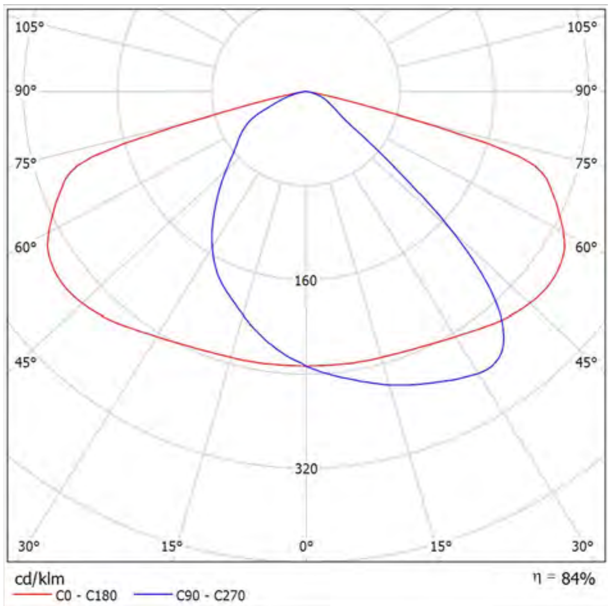


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

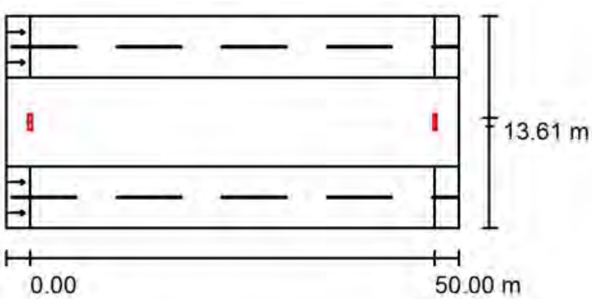
LED 1 / Planning data

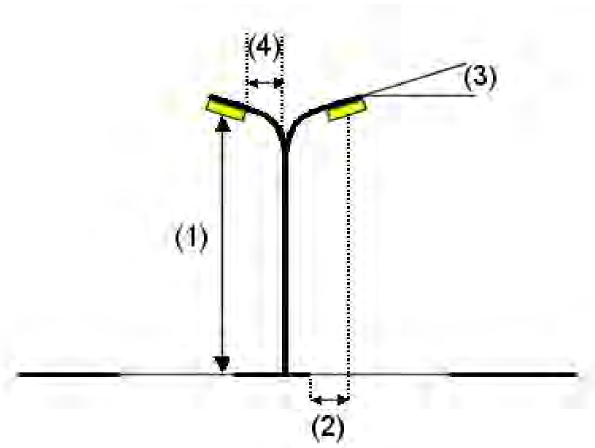
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

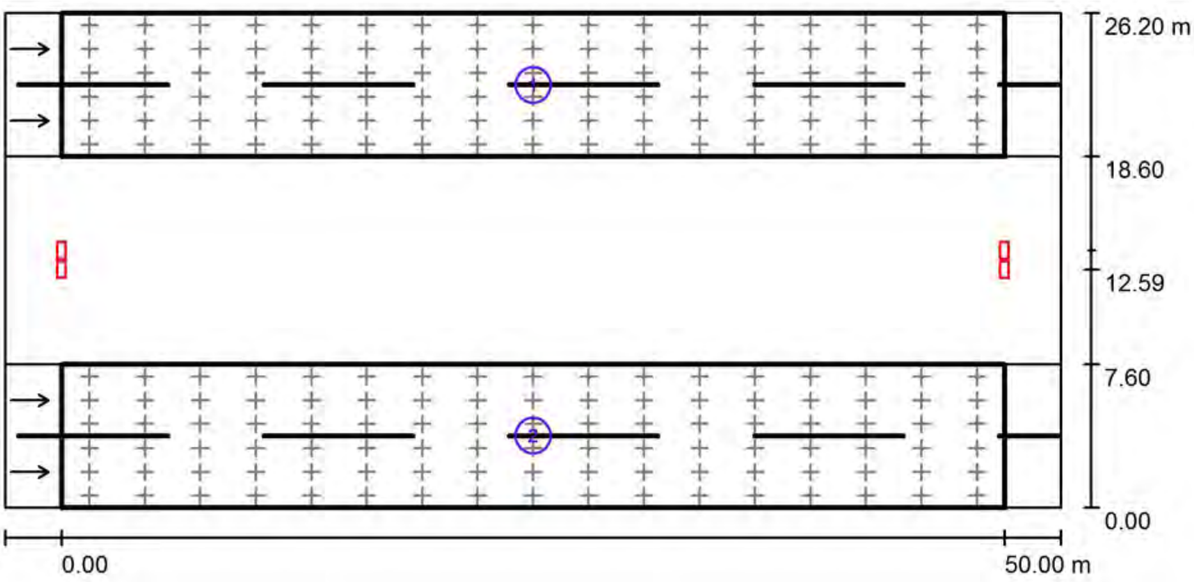




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	12.000 m		
Height:	11.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.27	0.42	0.70	15	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

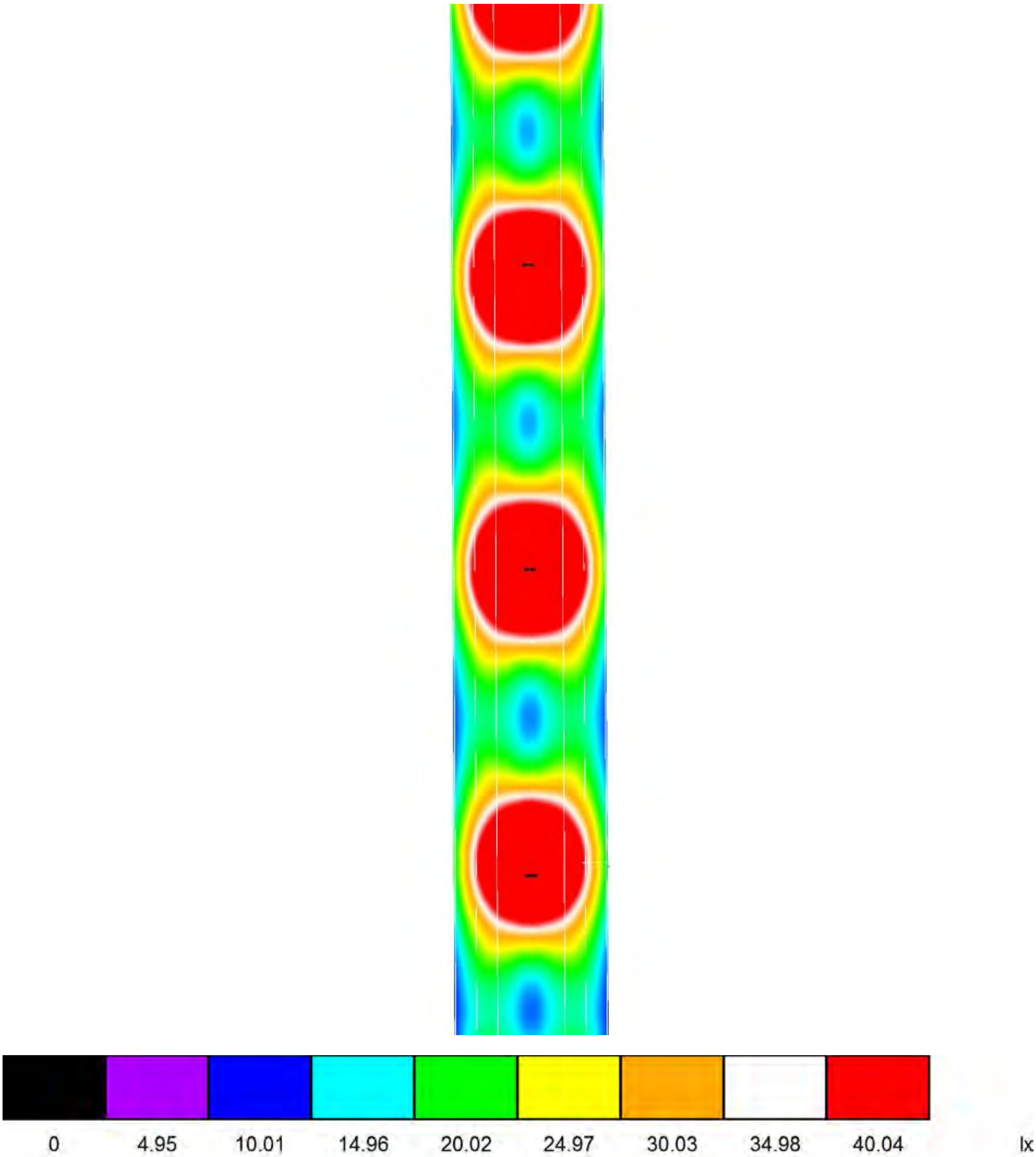
L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.27	0.42	0.70	15	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

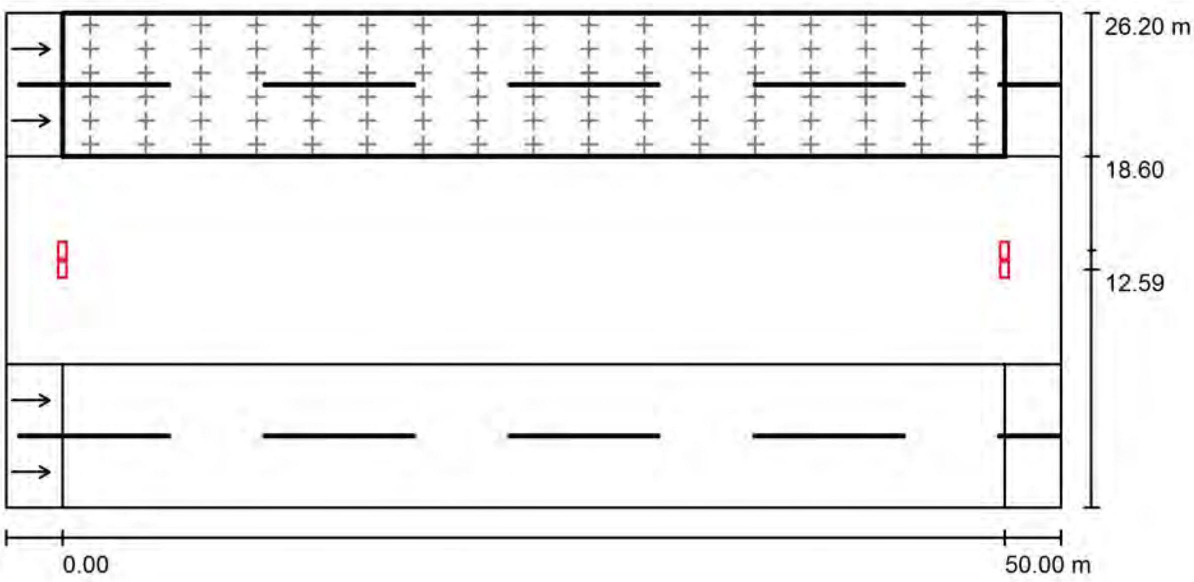
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

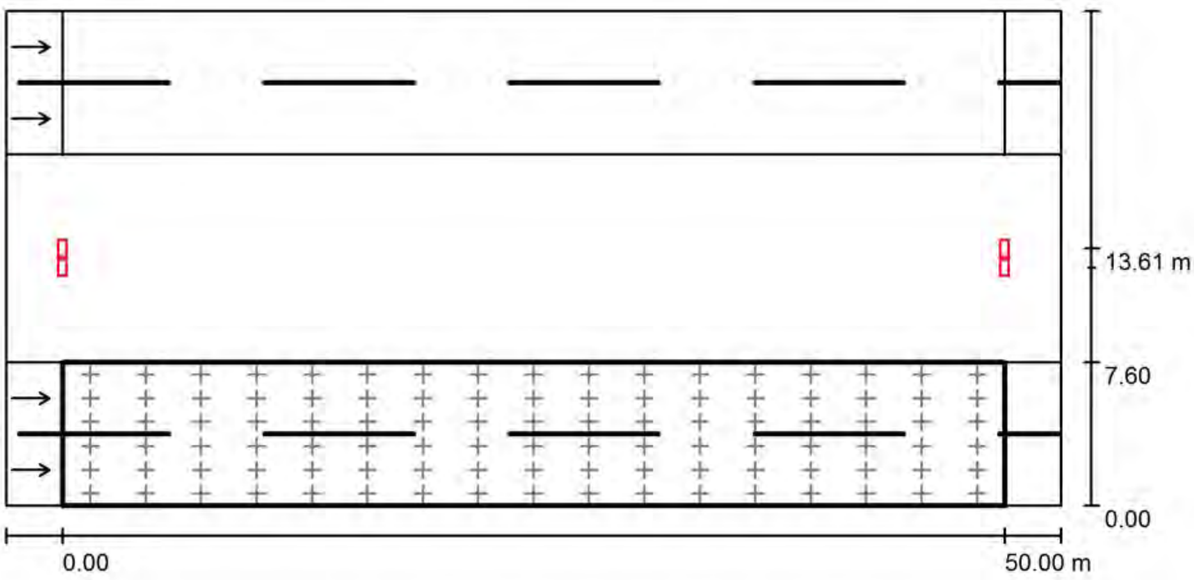
L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.27	0.42	0.70	15	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.27	0.46	0.74	15
2	Observer 4	(-60.000, 24.300, 1.500)	1.46	0.42	0.70	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.27	0.42	0.70	15	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.46	0.42	0.70	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.27	0.46	0.74	15

2 - 12 - 60

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

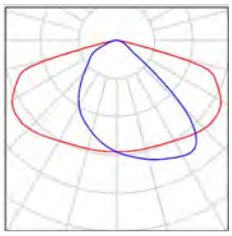
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 12 - 60 / Luminaire parts list

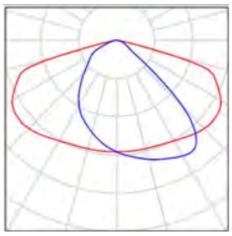
4 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



4 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

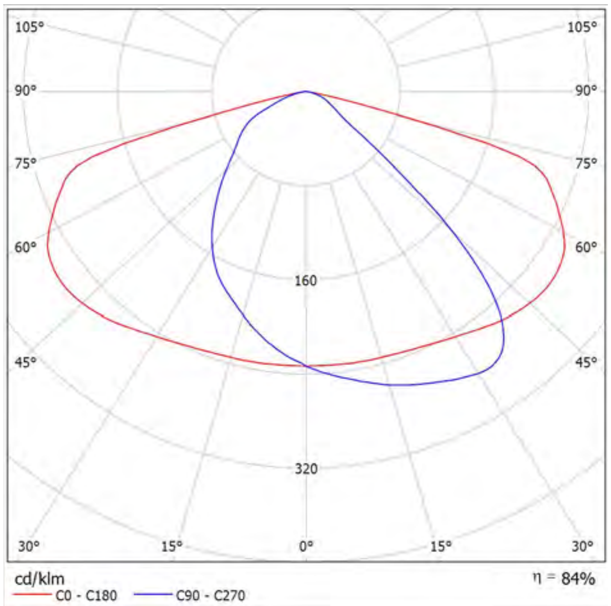


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

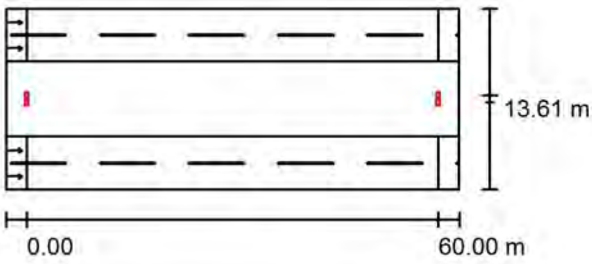
LED 1 / Planning data

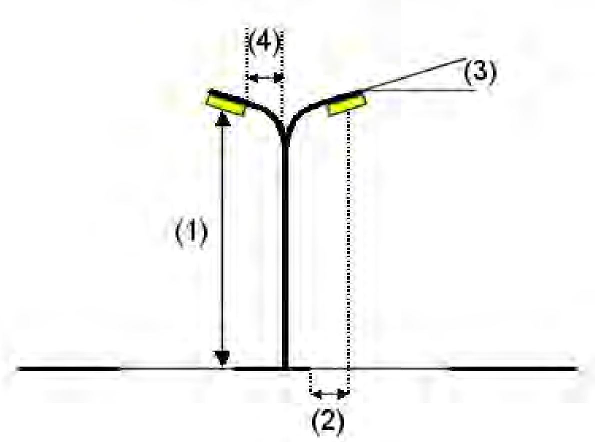
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

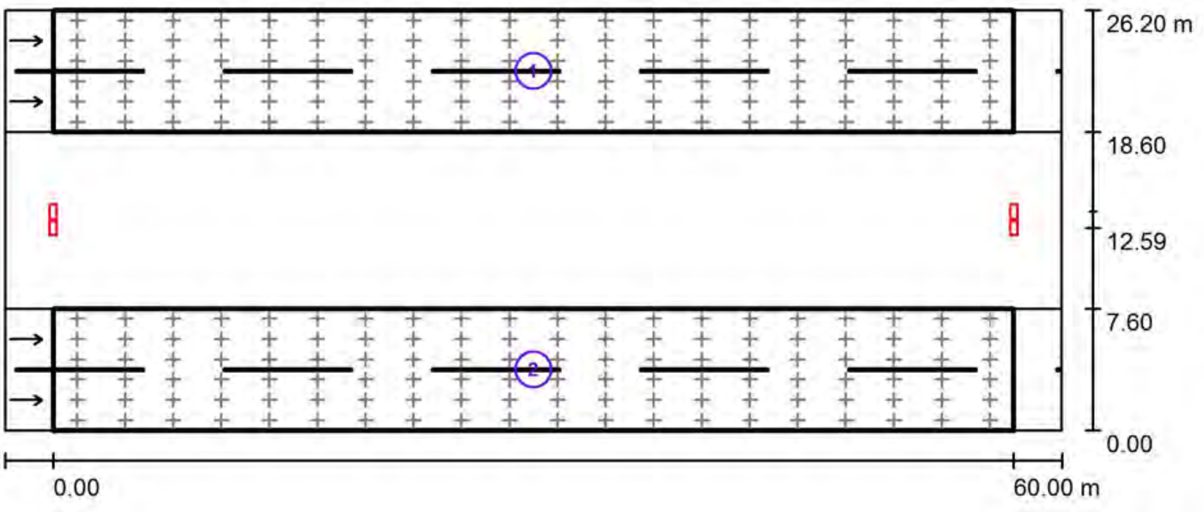




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 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):	12.000 m		
Height:	11.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.06	0.41	0.55	17	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

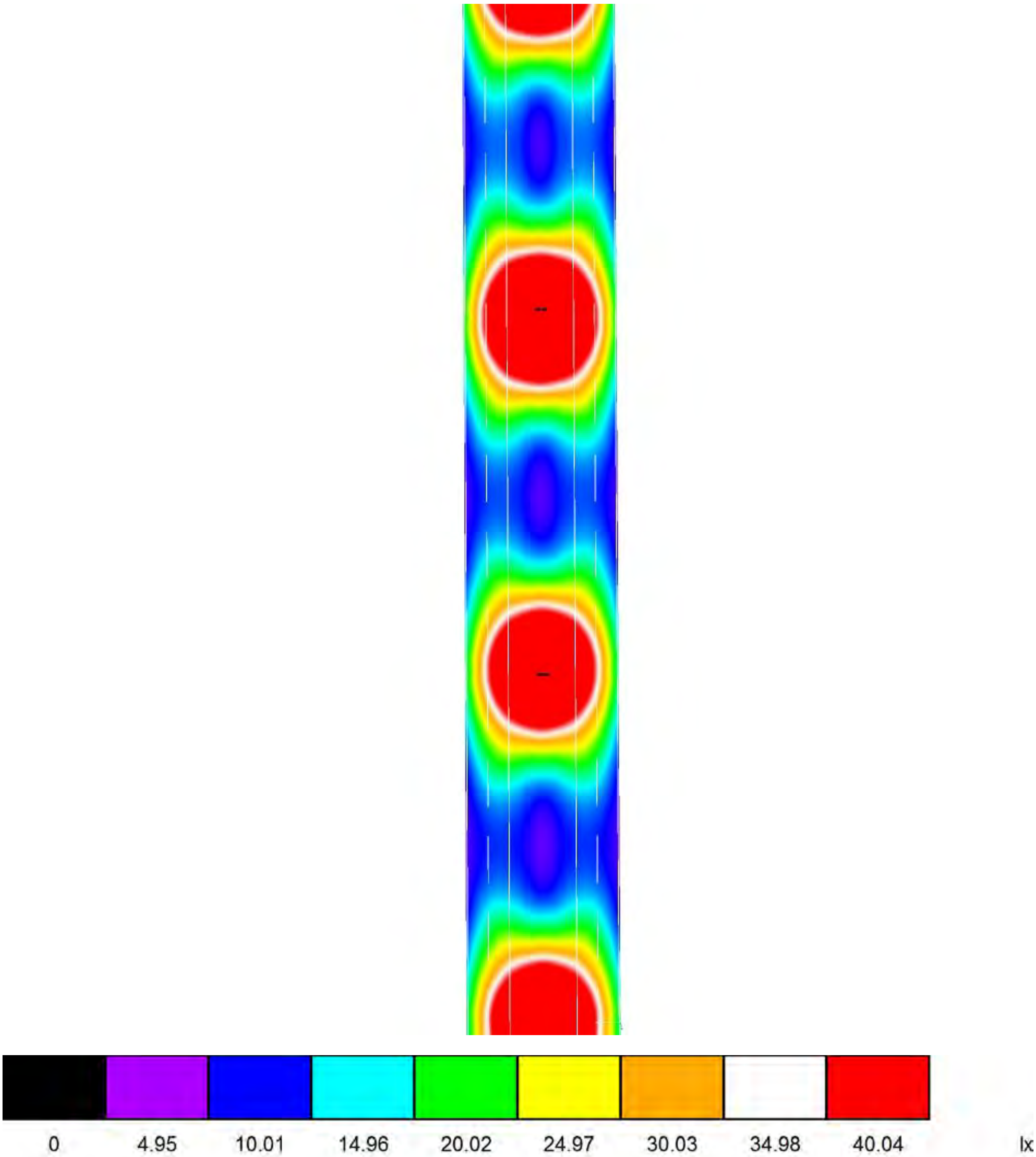
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.06	0.41	0.55	17	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

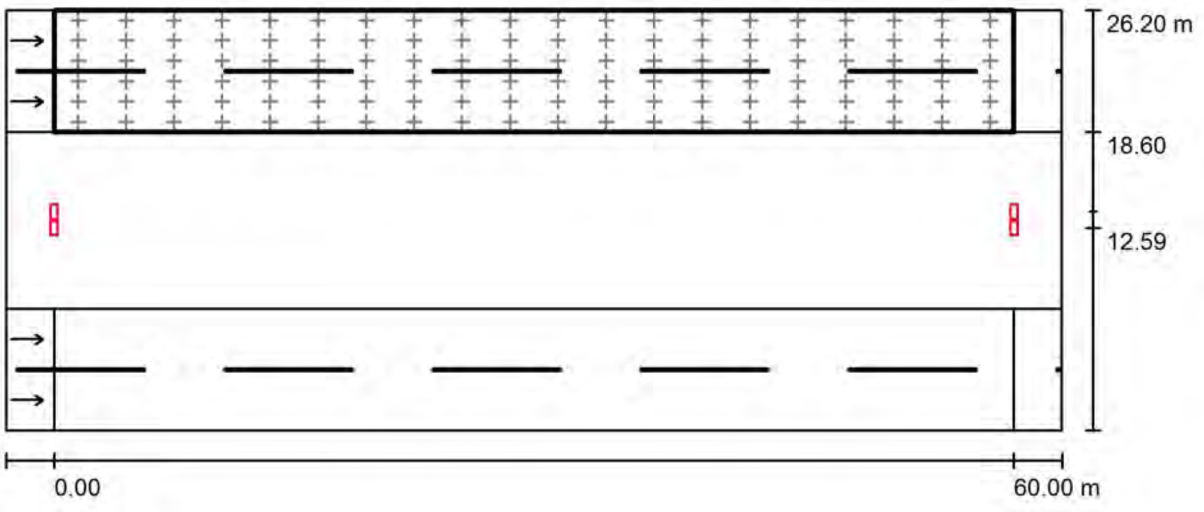
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

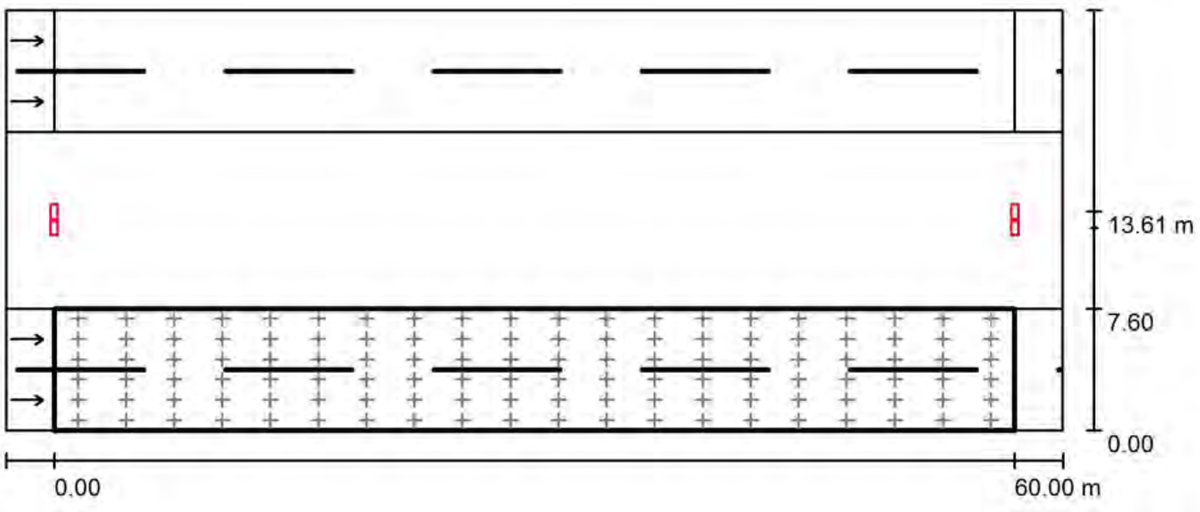
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.06	0.41	0.55	17	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.06	0.44	0.55	17
2	Observer 4	(-60.000, 24.300, 1.500)	1.20	0.41	0.62	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.06	0.41	0.55	17	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.20	0.41	0.62	9
2	Observer 2	(-60.000, 5.700, 1.500)	1.06	0.44	0.55	17

2 - 12 - 70

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

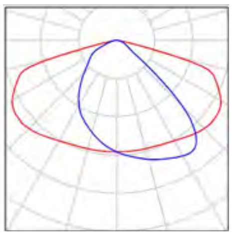
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 12 - 70 / Luminaire parts list

4 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

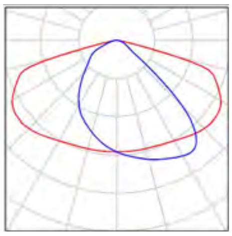
See our luminaire catalog for an image of the luminaire.



4 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

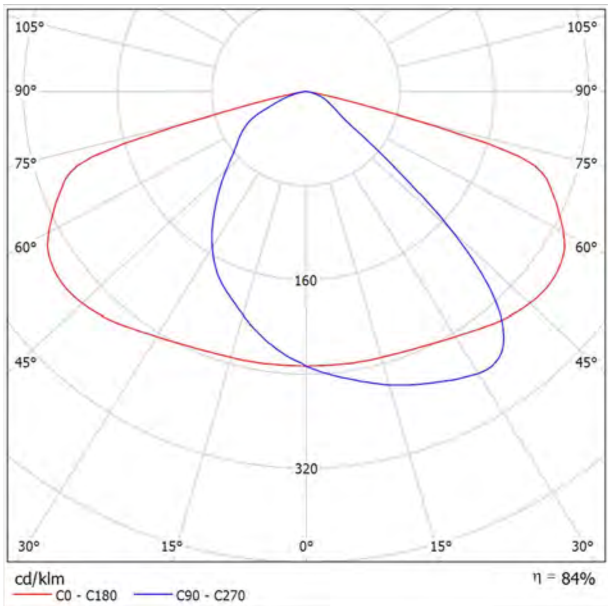


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

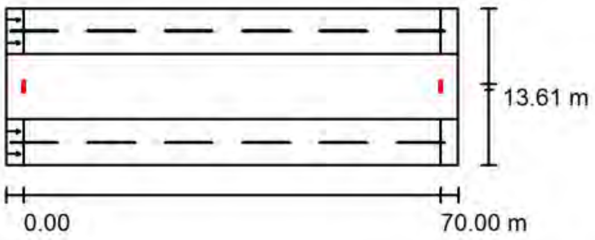
LED 1 / Planning data

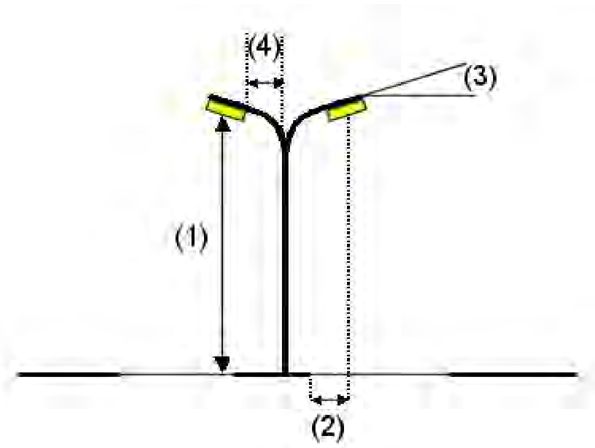
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

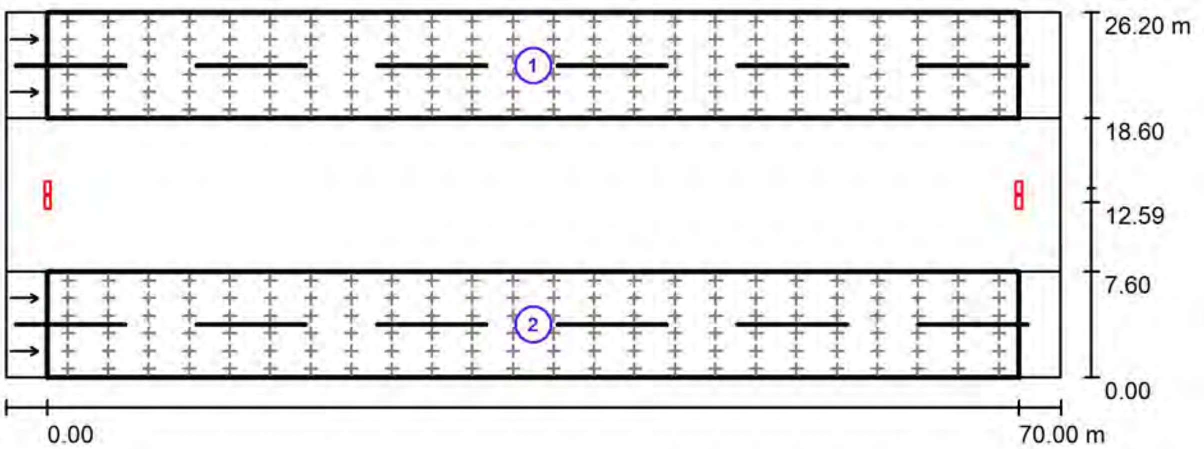




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	12.000 m		
Height:	11.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.91	0.39	0.42	19	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

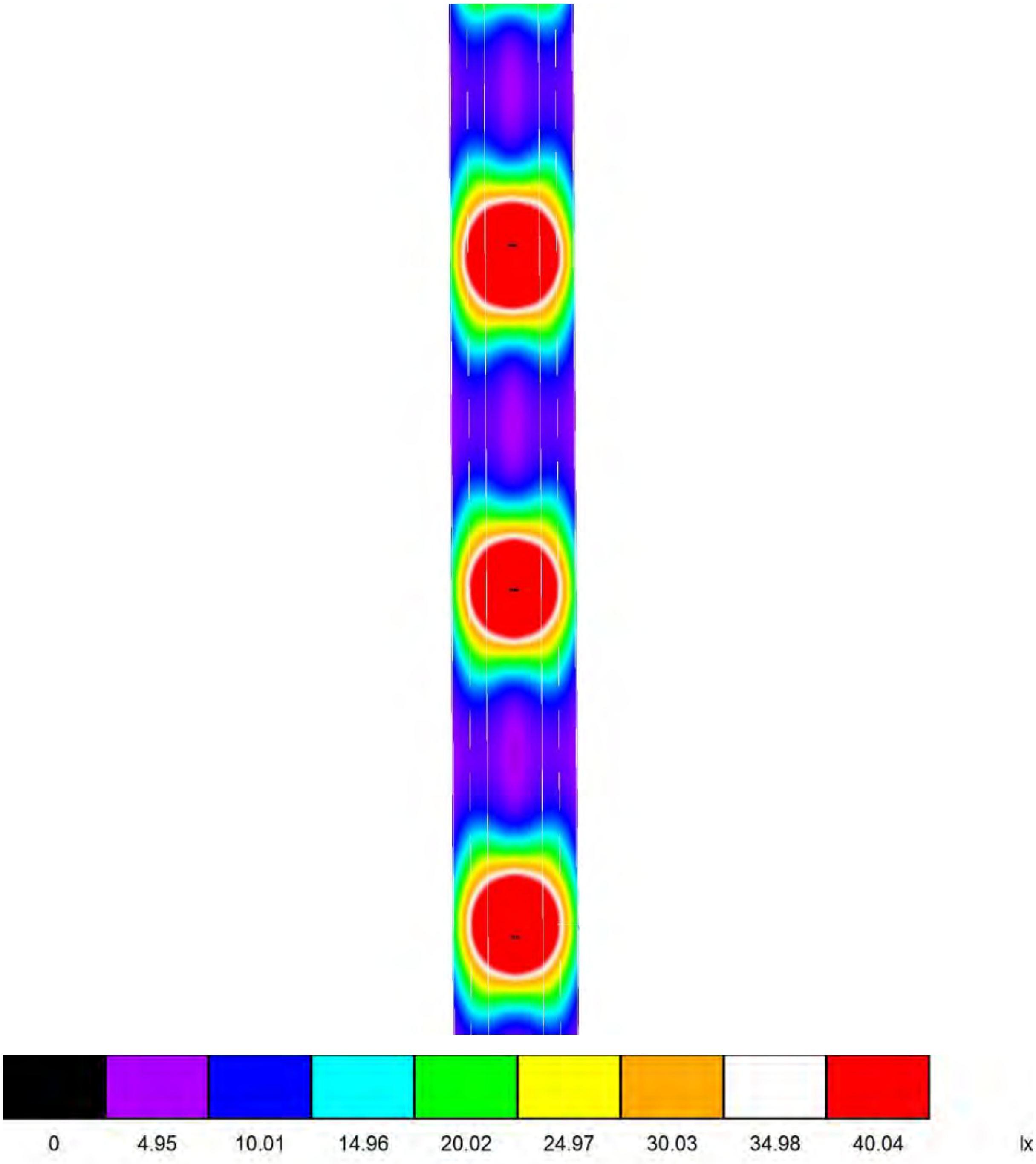
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.91	0.39	0.42	19	0.90

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

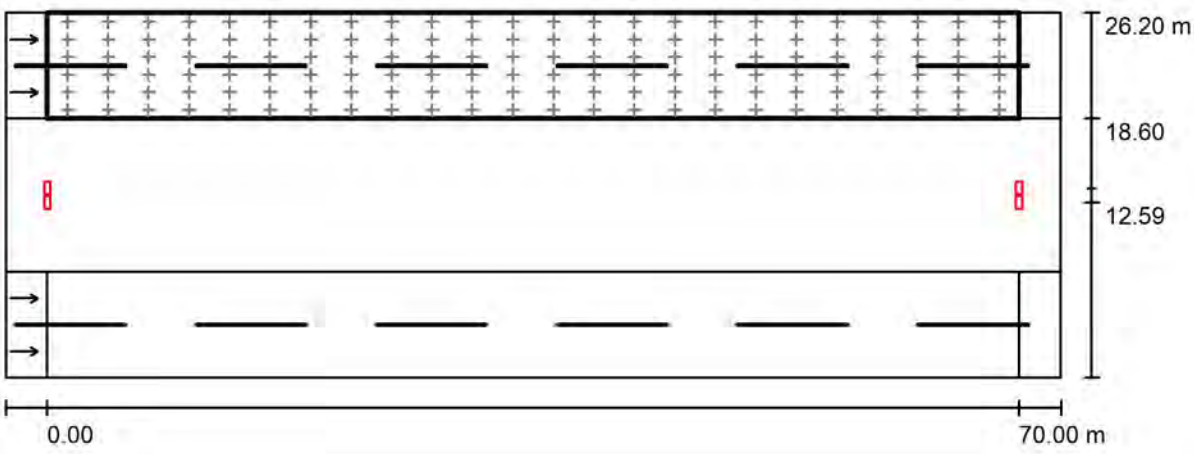
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

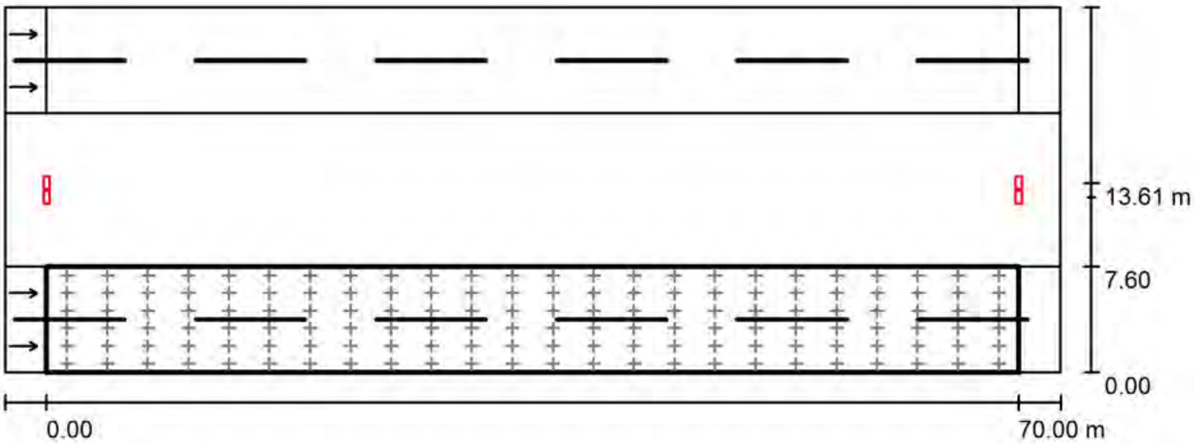
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.91	0.39	0.42	19	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.91	0.41	0.42	19
2	Observer 4	(-60.000, 24.300, 1.500)	1.02	0.39	0.52	10

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.91	0.39	0.42	19	0.90

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.02	0.39	0.52	10
2	Observer 2	(-60.000, 5.700, 1.500)	0.91	0.41	0.42	19

2 - 14 - 50

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

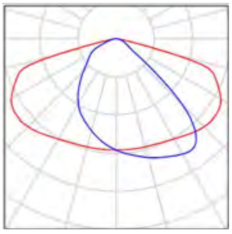
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 14 - 50 / Luminaire parts list

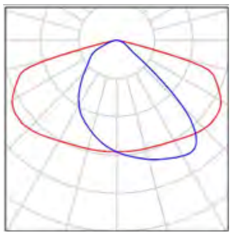
8 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



4 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

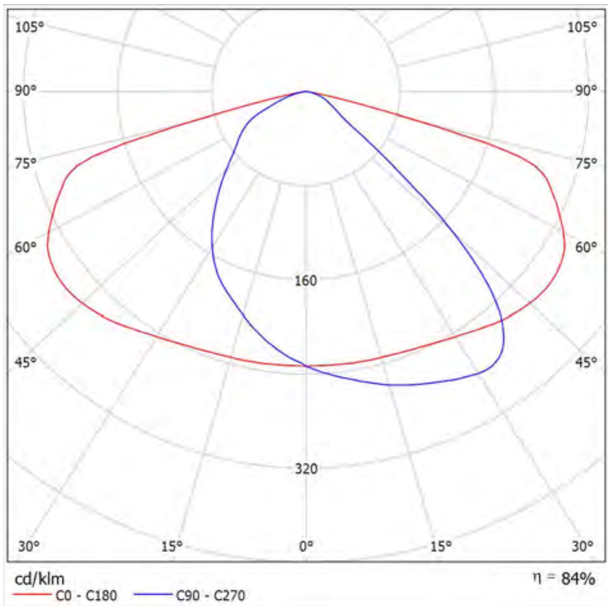


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

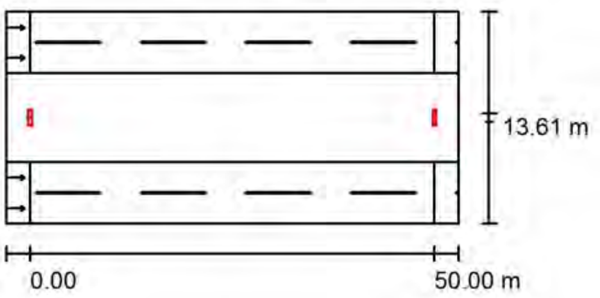
LED 1 / Planning data

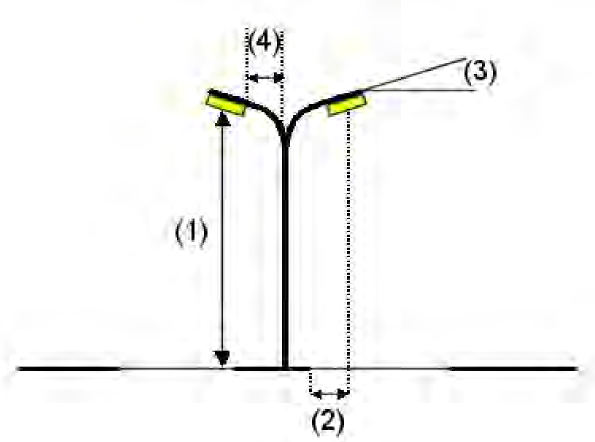
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

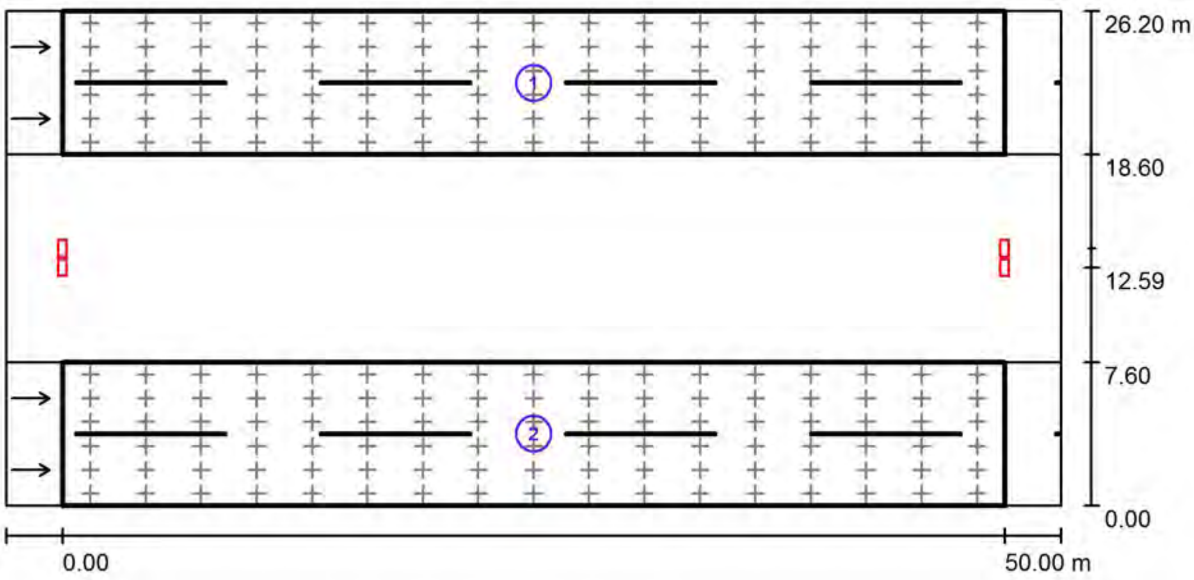




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.29	0.52	0.83	11	0.91

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

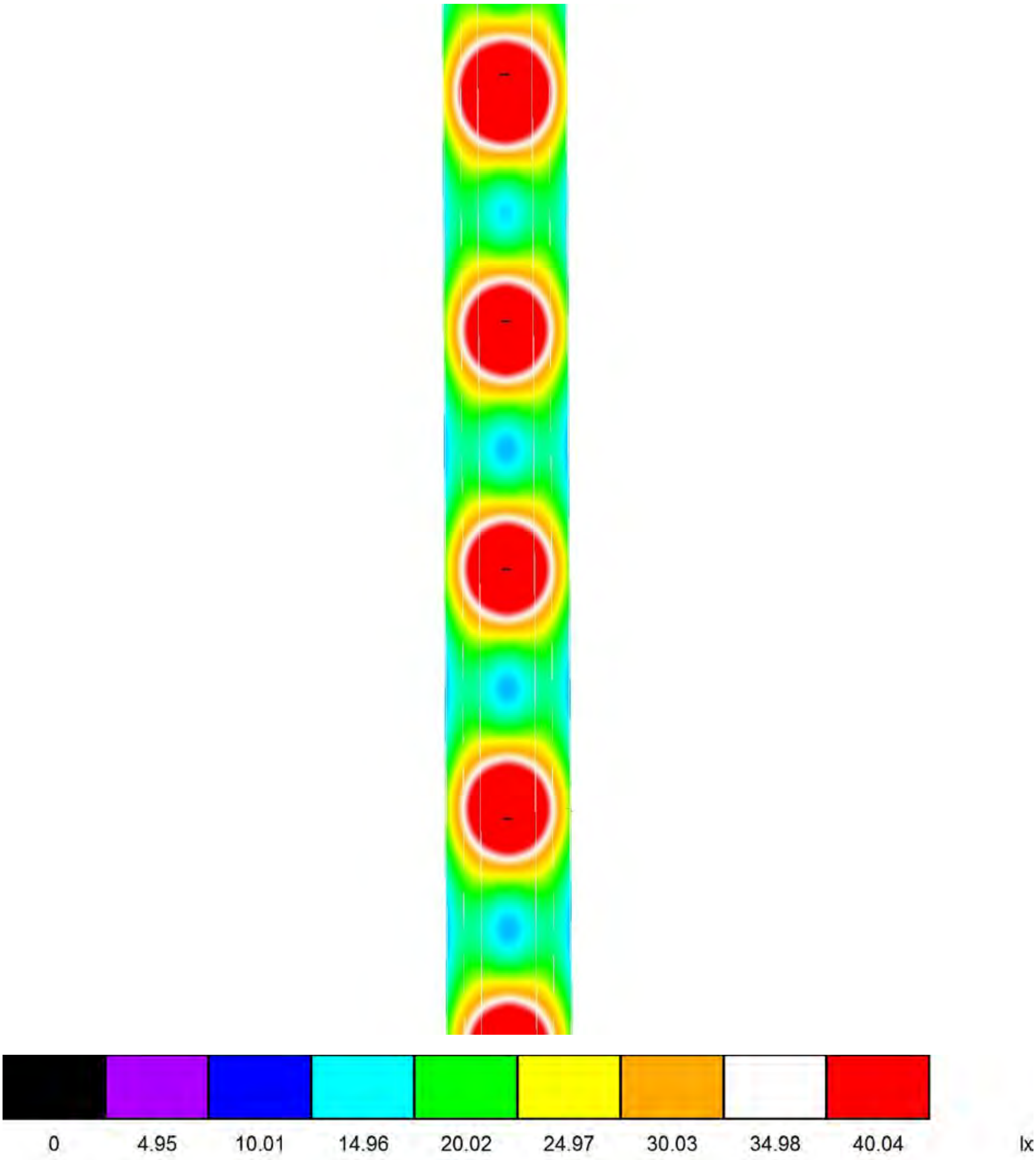
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.29	0.52	0.83	11	0.91

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

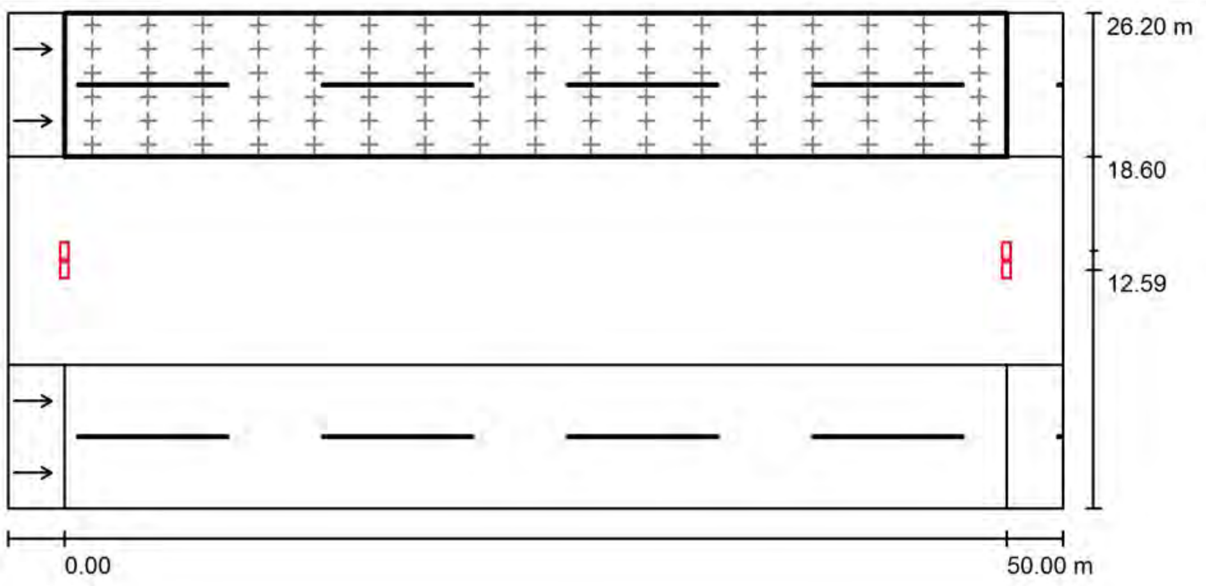
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

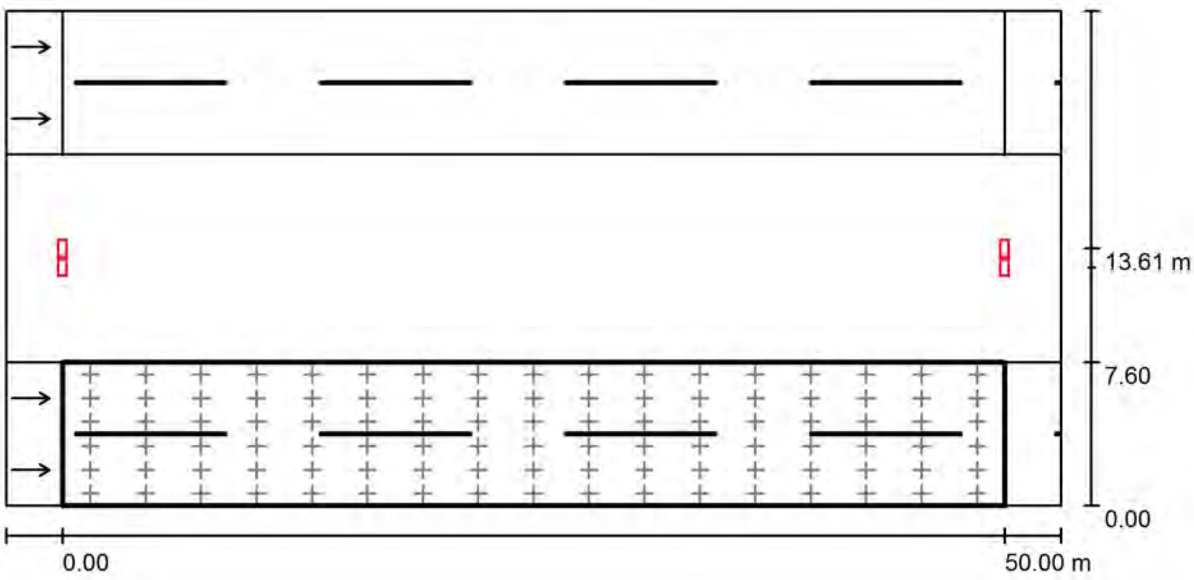
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.29	0.52	0.83	11	0.91

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.29	0.56	0.89	11
2	Observer 4	(-60.000, 24.300, 1.500)	1.49	0.52	0.83	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.29	0.52	0.83	11	0.91

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.49	0.52	0.83	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.29	0.56	0.89	11

2 - 14 - 60

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

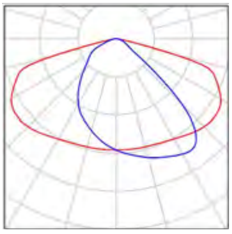
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 14 - 60 / Luminaire parts list

6 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

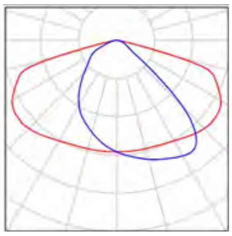
See our luminaire catalog for an image of the luminaire.



4 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

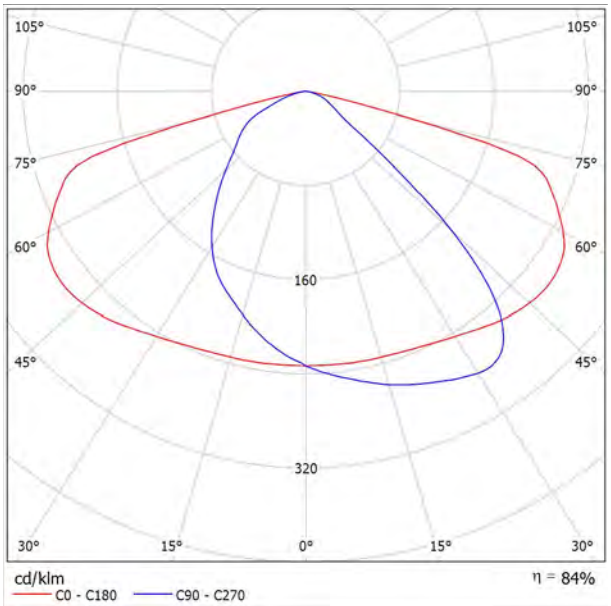


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

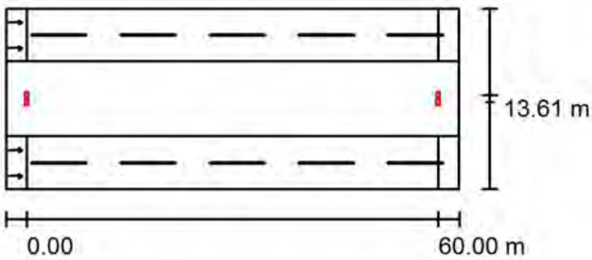
LED 1 / Planning data

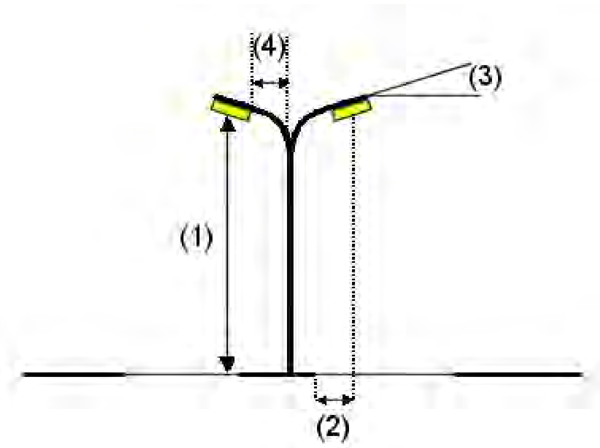
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

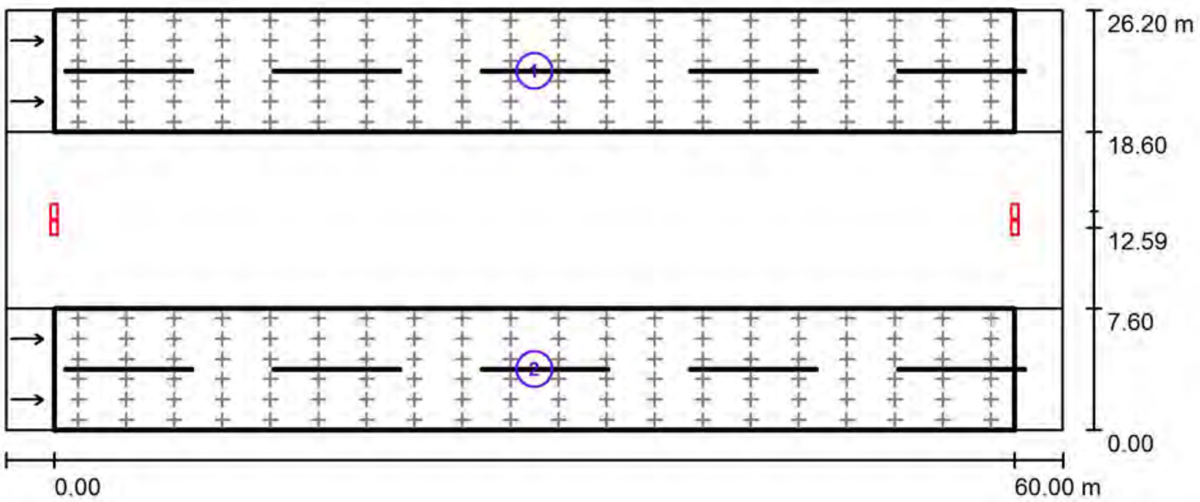




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 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):	14.000 m		
Height:	13.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.07	0.49	0.70	12	0.91

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

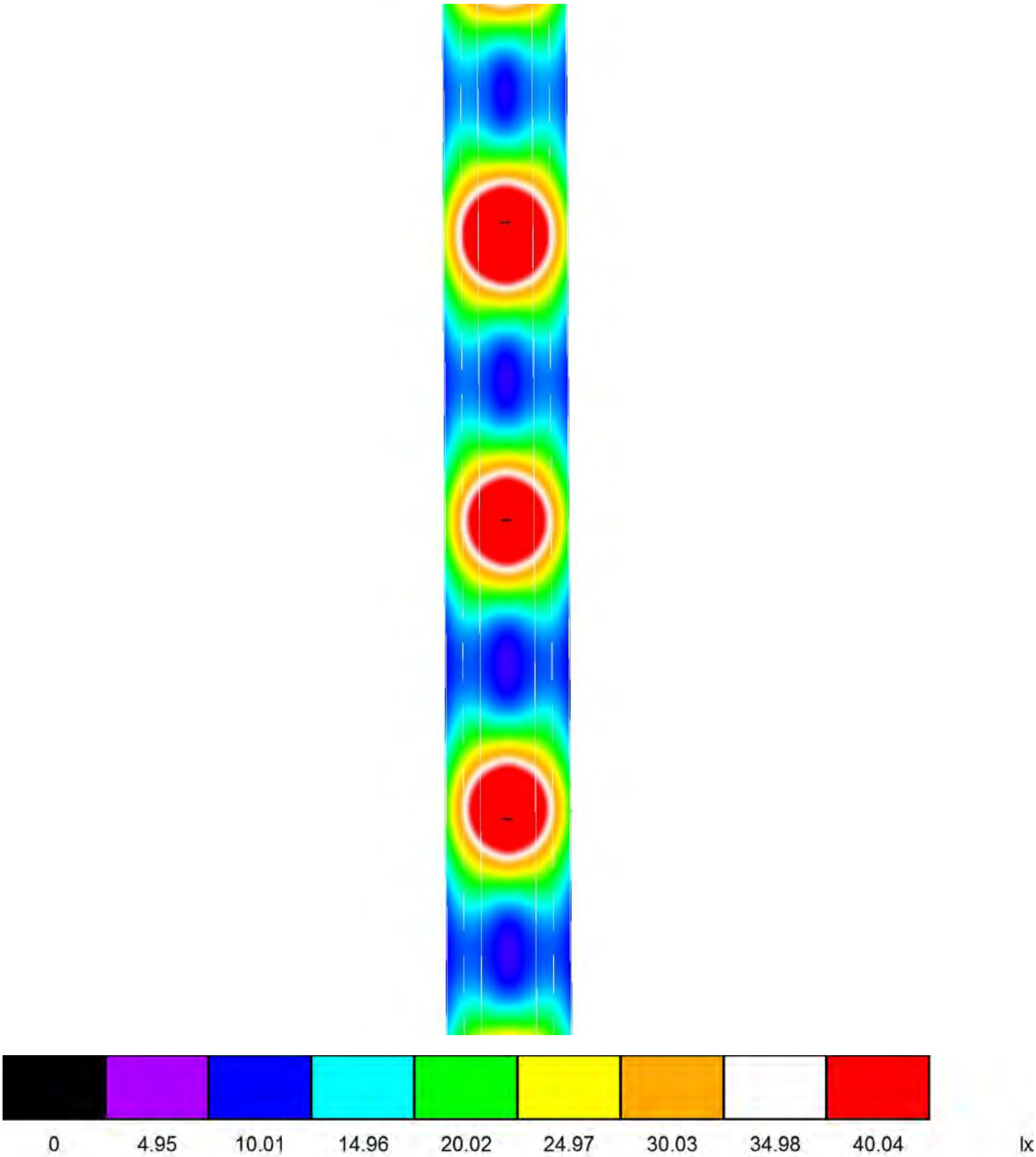
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.07	0.49	0.70	12	0.91

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

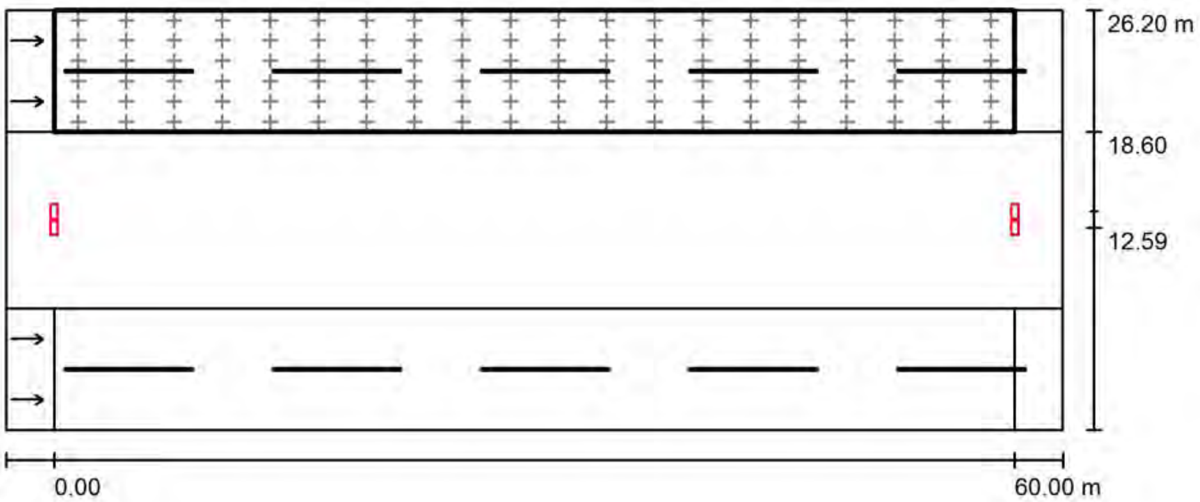
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

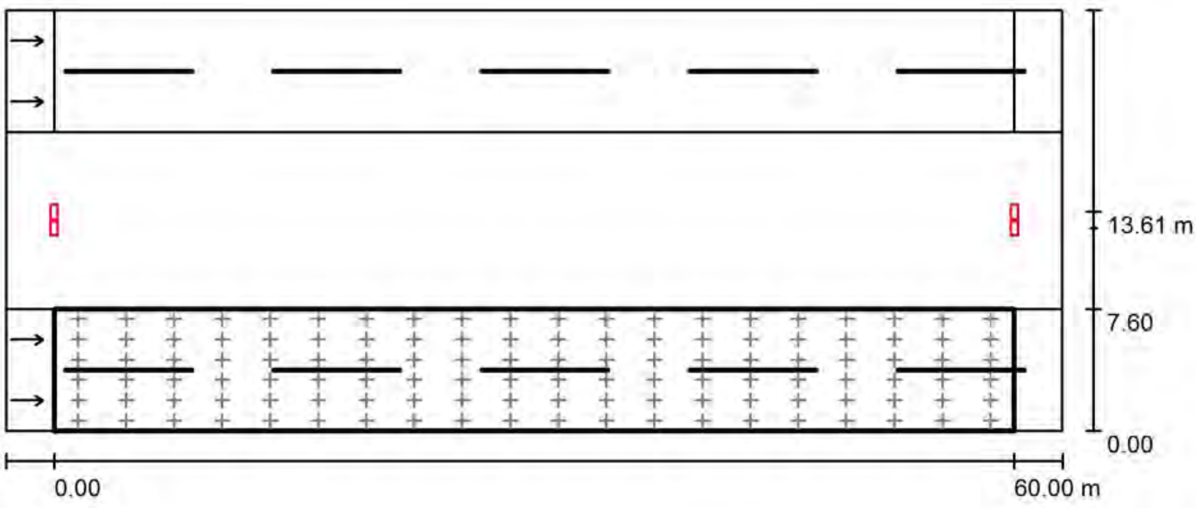
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.07	0.49	0.70	12	0.91

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.07	0.53	0.76	12
2	Observer 4	(-60.000, 24.300, 1.500)	1.23	0.49	0.70	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.07	0.49	0.70	12	0.91

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.23	0.49	0.70	8
2	Observer 2	(-60.000, 5.700, 1.500)	1.07	0.53	0.76	12

2 - 14 - 70

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

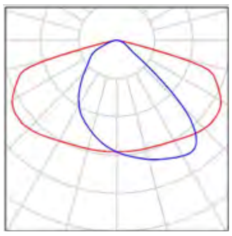
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 14 - 70 / Luminaire parts list

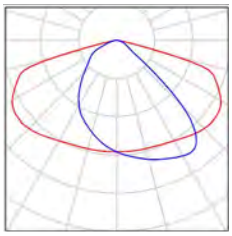
4 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



4 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

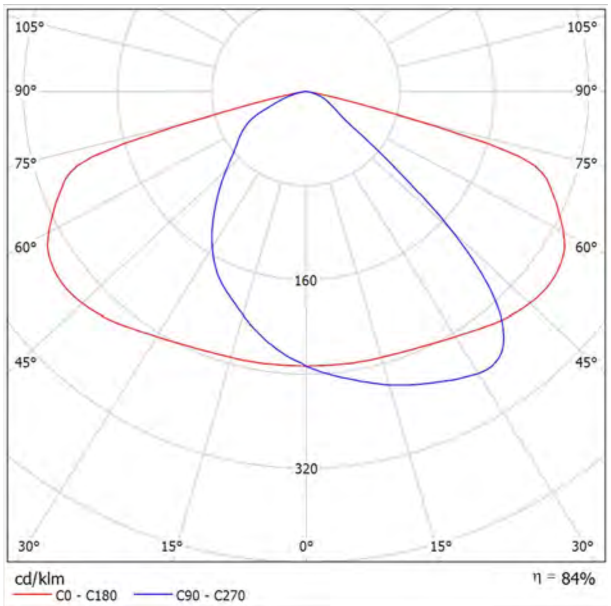


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

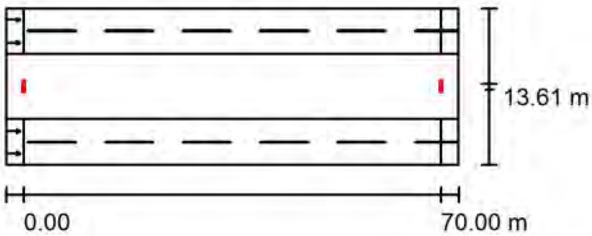
LED 1 / Planning data

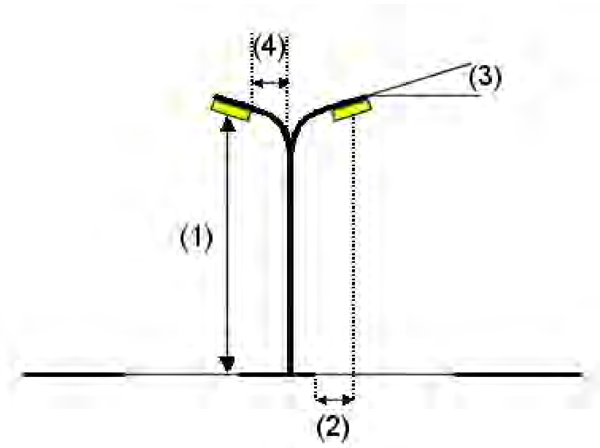
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

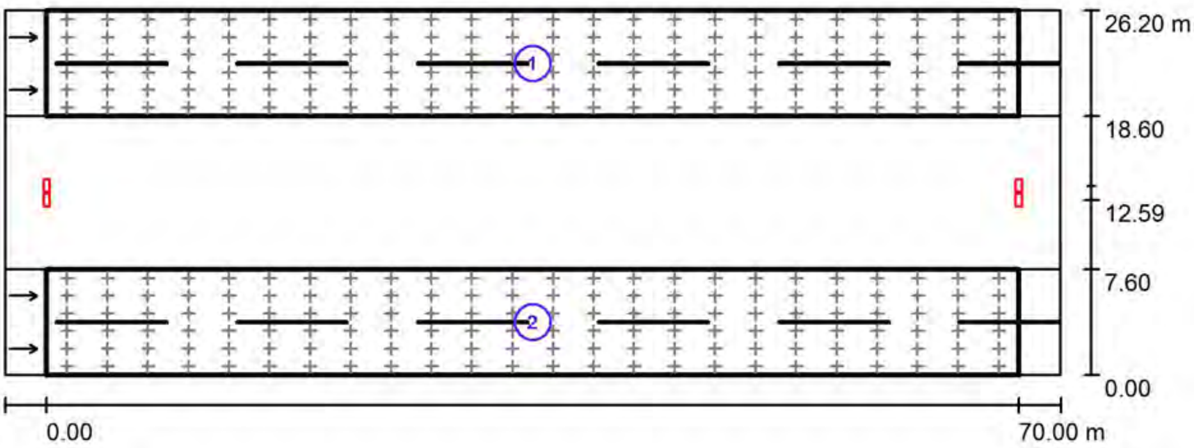




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.92	0.44	0.53	14	0.91

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

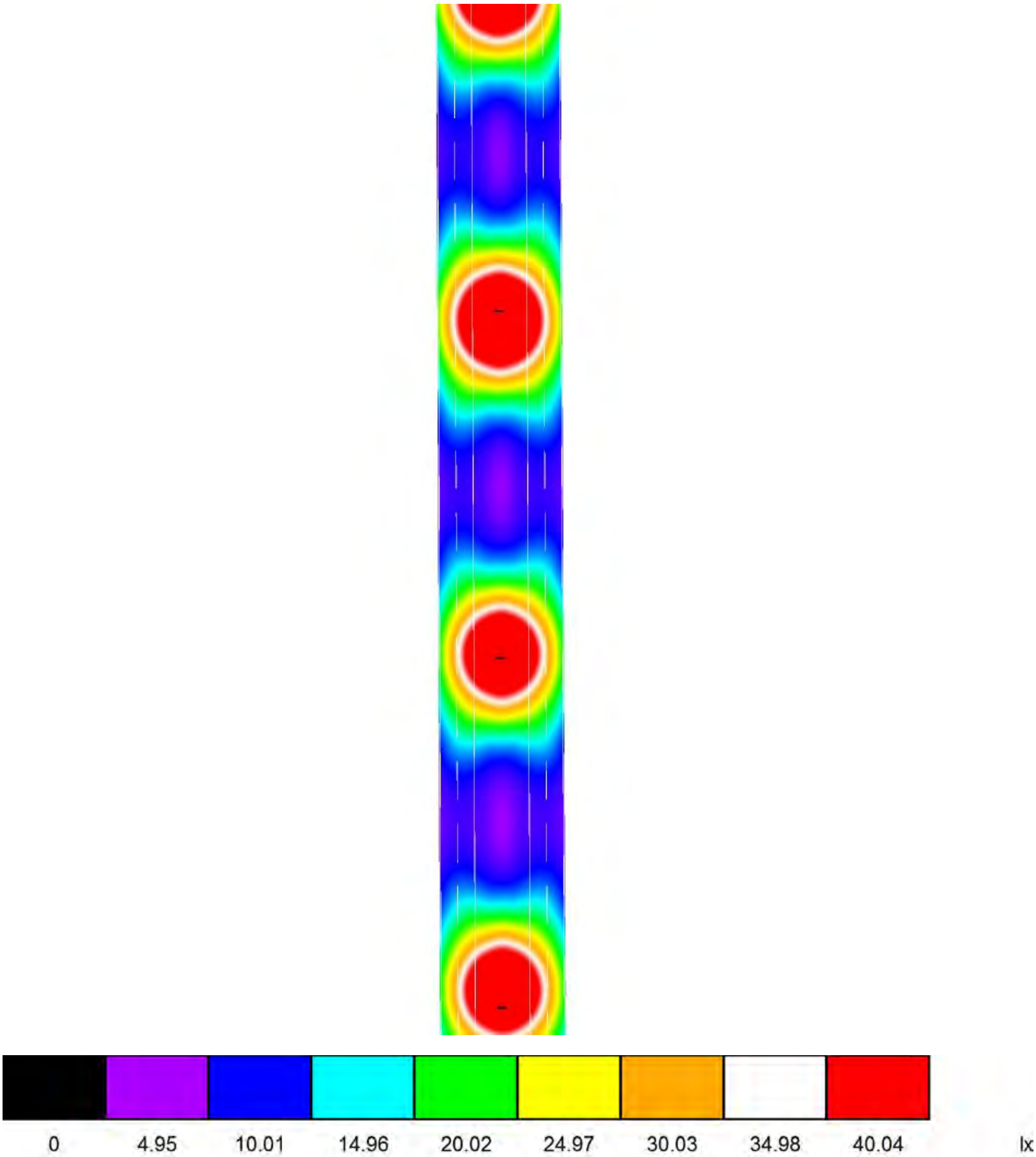
L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.92	0.44	0.53	14	0.91

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

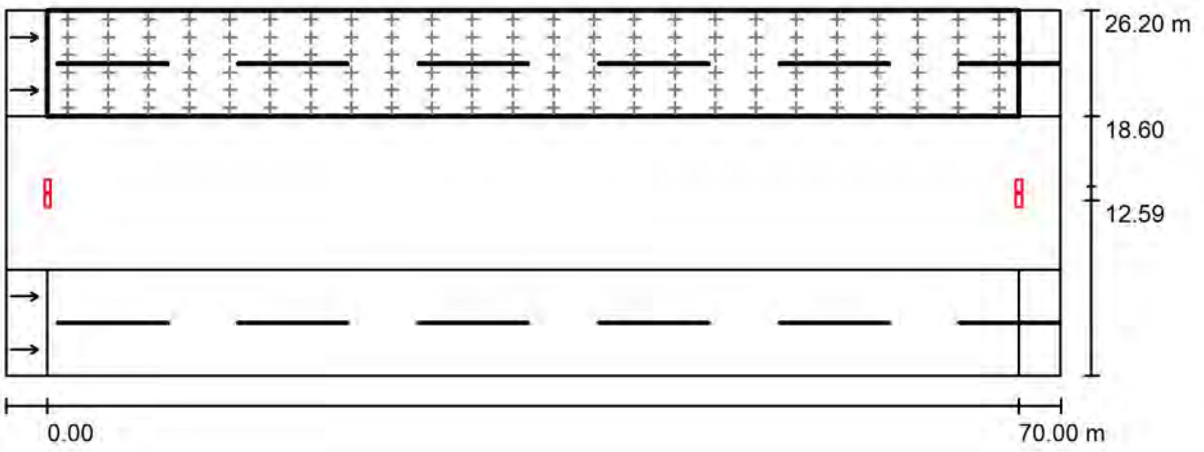
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

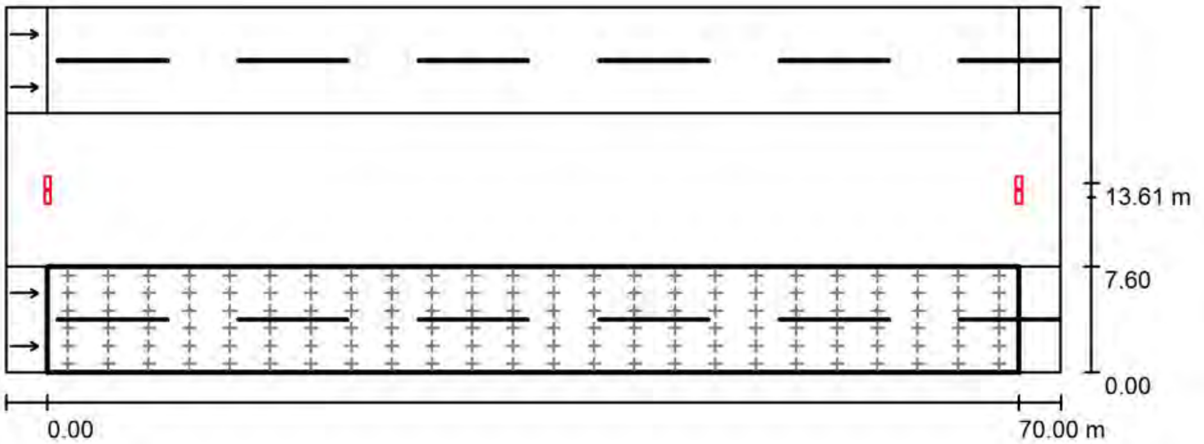
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.92	0.44	0.53	14	0.91

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.92	0.49	0.53	14
2	Observer 4	(-60.000, 24.300, 1.500)	1.05	0.44	0.61	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80 Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.92	0.44	0.53	14	0.91

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.05	0.44	0.61	9
2	Observer 2	(-60.000, 5.700, 1.500)	0.92	0.49	0.53	14

2 - 16 - 50

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

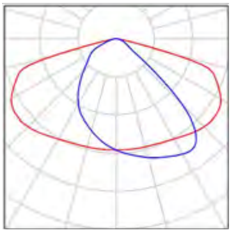
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 16 - 50 / Luminaire parts list

8 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

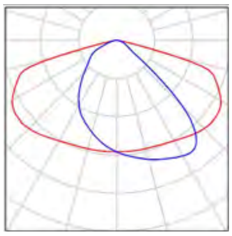
See our luminaire catalog for an image of the luminaire.



4 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

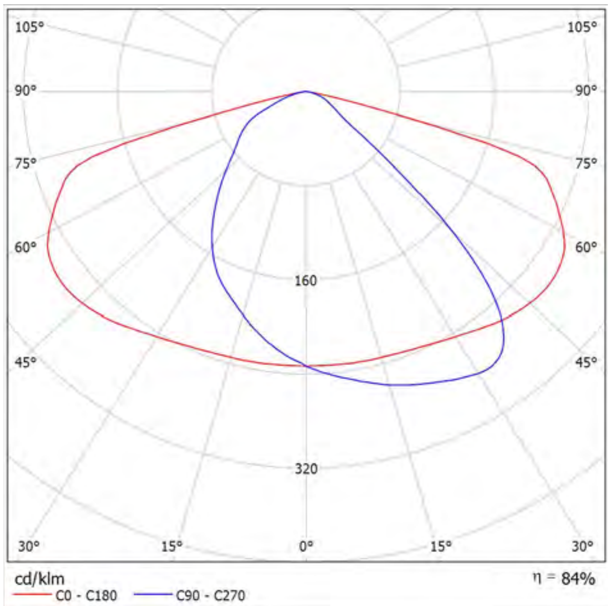


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

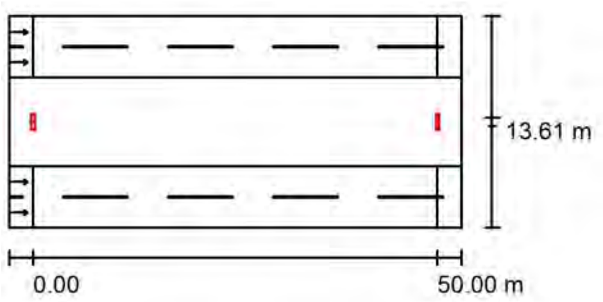
LED 1 / Planning data

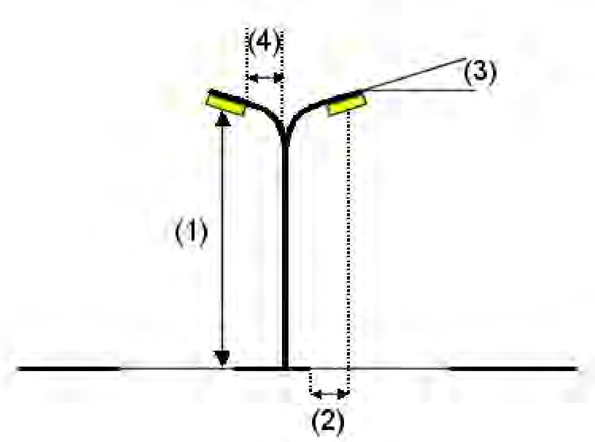
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

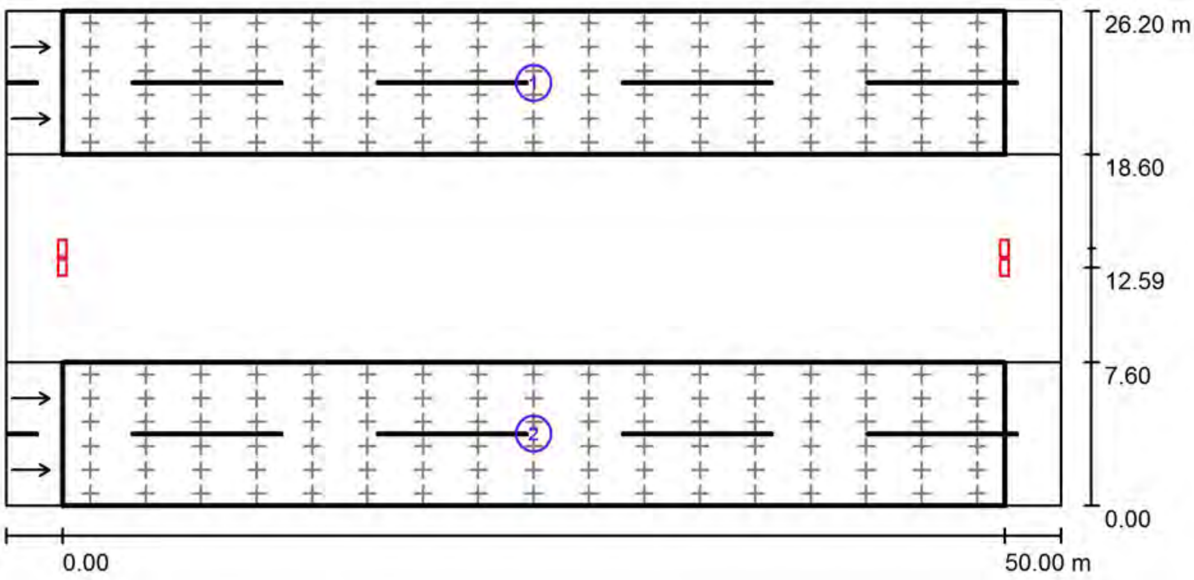




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	16.000 m		
Height:	15.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.26	0.58	0.87	8	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

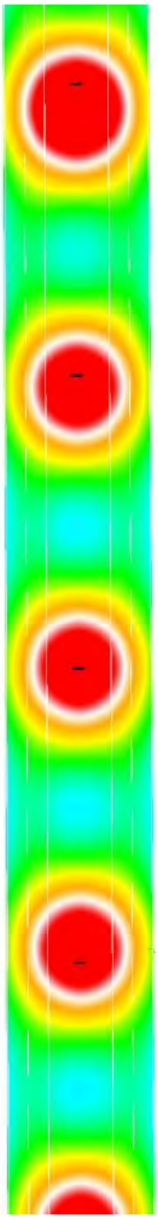
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.26	0.58	0.87	8	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

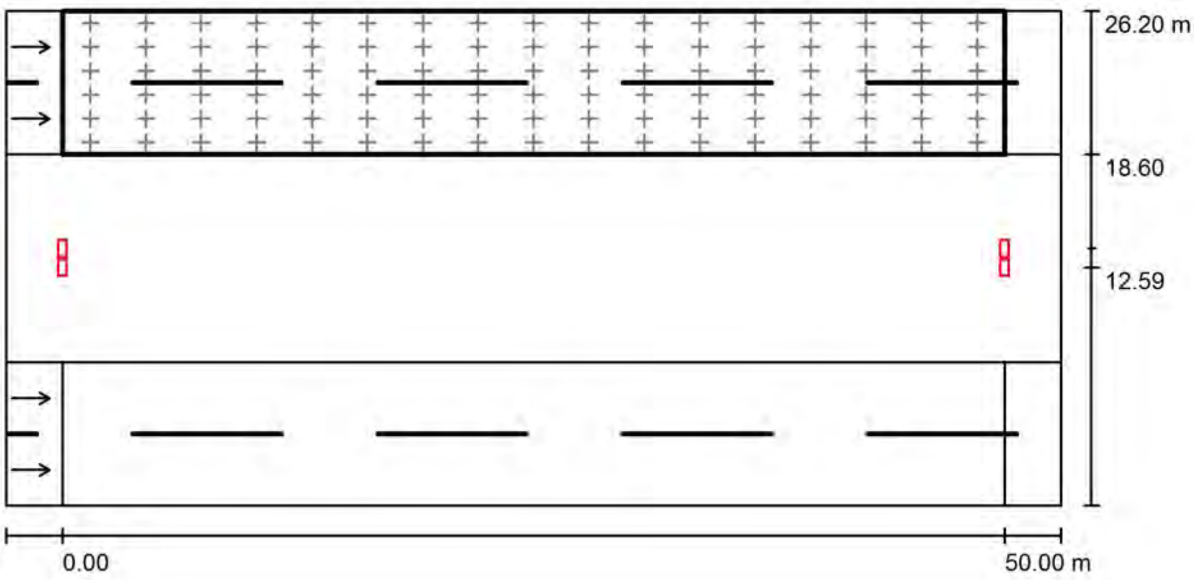
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

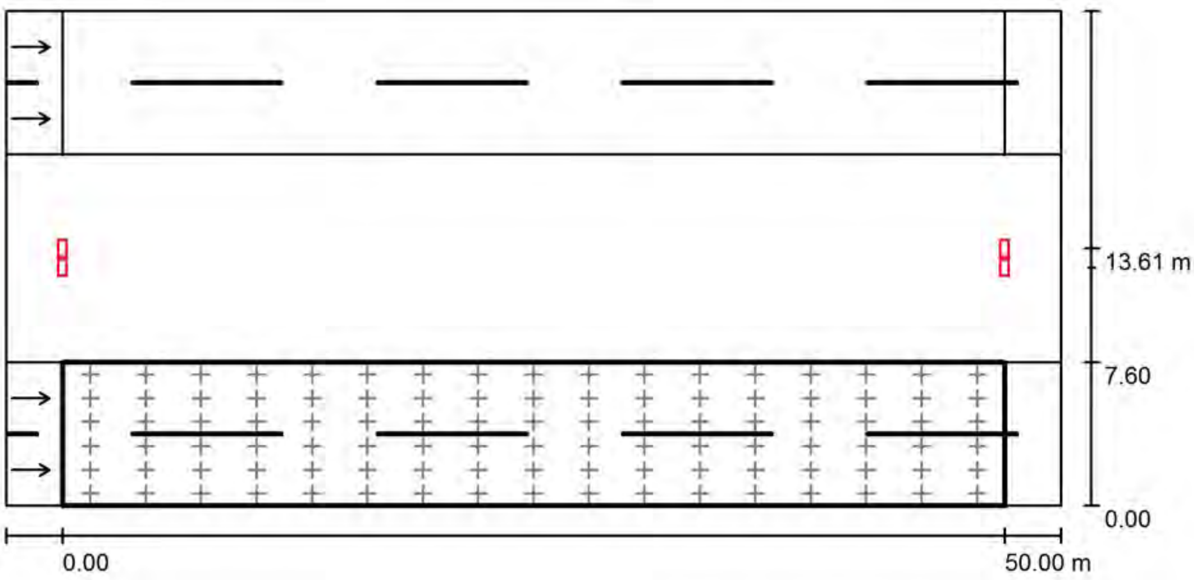
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.26	0.58	0.87	8	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.26	0.65	0.87	8
2	Observer 4	(-60.000, 24.300, 1.500)	1.47	0.58	0.91	6

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.26	0.58	0.87	8	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.47	0.58	0.91	6
2	Observer 2	(-60.000, 5.700, 1.500)	1.26	0.65	0.87	8

2 - 16 - 60

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

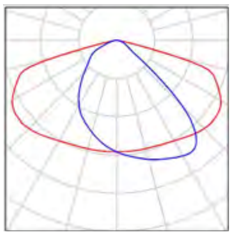
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 16 - 60 / Luminaire parts list

8 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

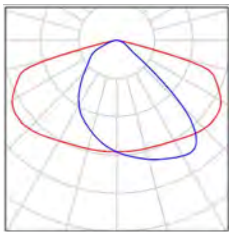
See our luminaire catalog for an image of the luminaire.



4 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

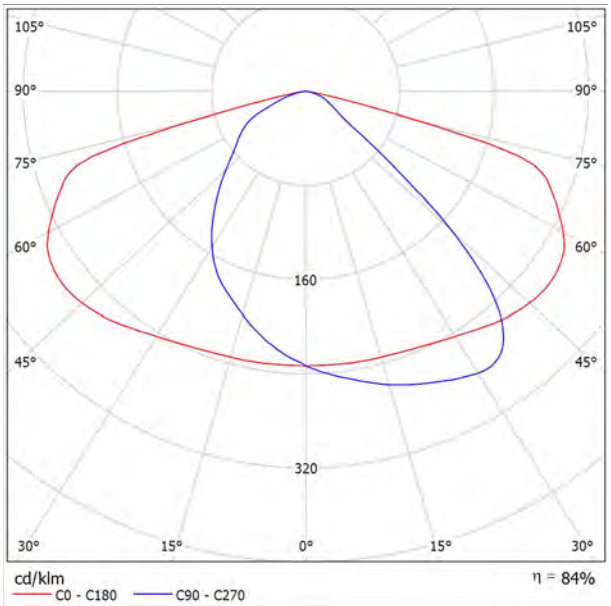


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

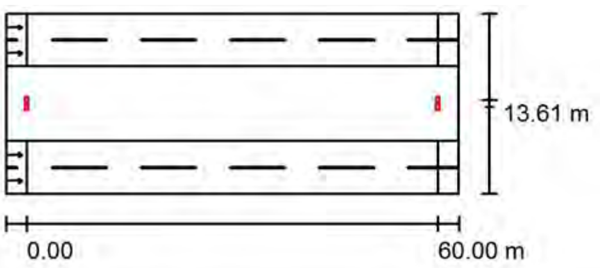
LED 1 / Planning data

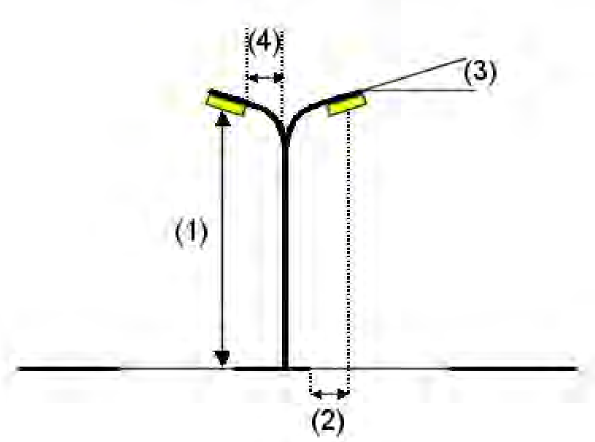
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

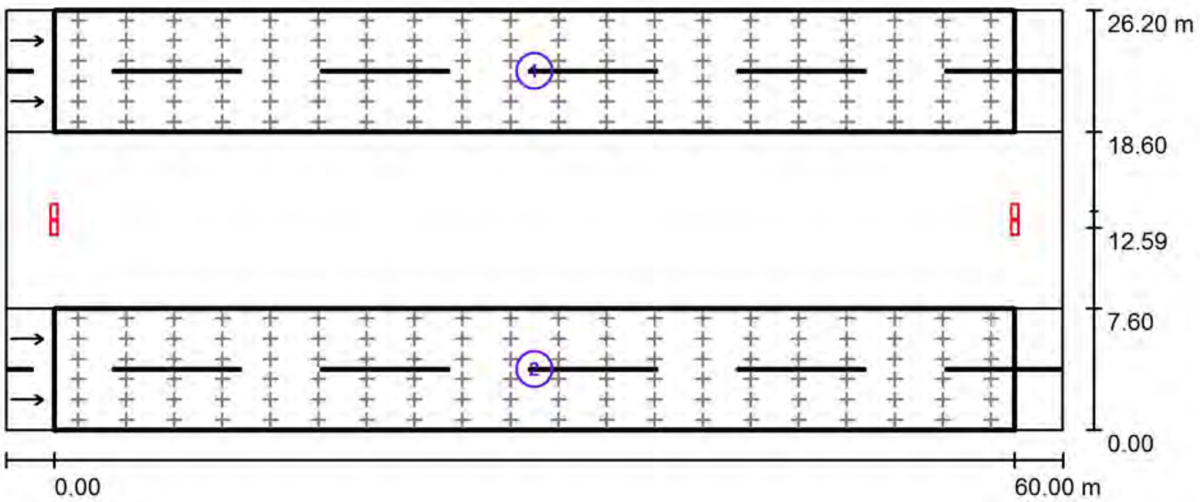




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 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):	16.000 m		
Height:	15.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.05	0.58	0.80	10	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

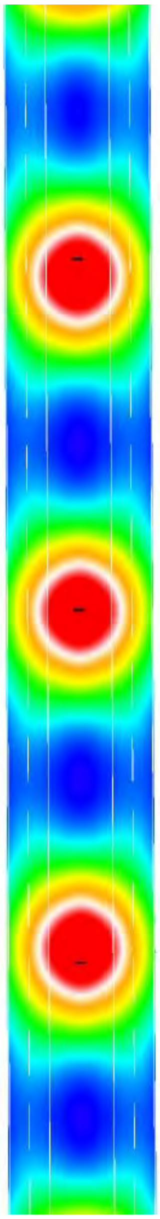
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.58	0.80	10	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

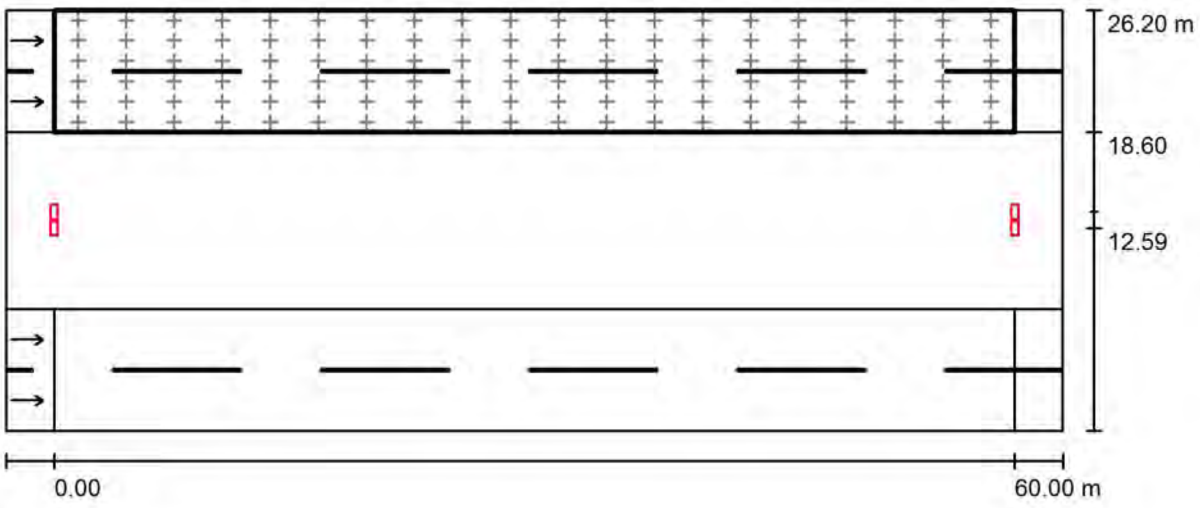
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

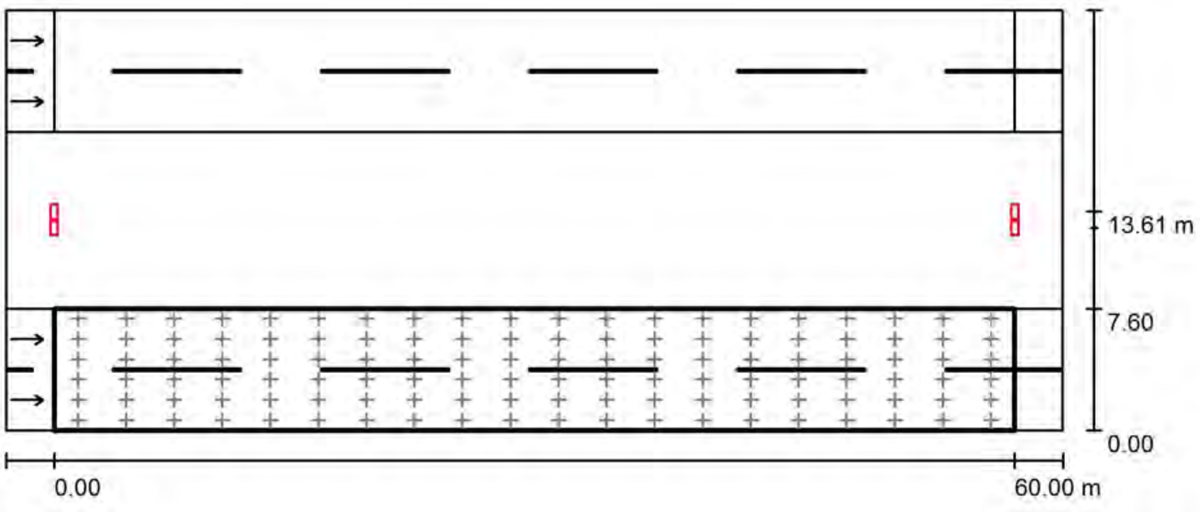
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.58	0.80	10	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.05	0.61	0.90	10
2	Observer 4	(-60.000, 24.300, 1.500)	1.22	0.58	0.80	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.05	0.58	0.80	10	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.22	0.58	0.80	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.05	0.61	0.90	10

2 - 16 - 70

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

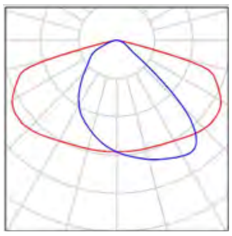
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

2 - 16 - 70 / Luminaire parts list

8 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

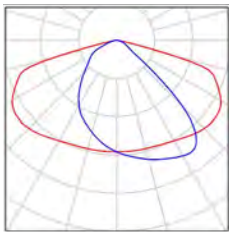
See our luminaire catalog for an image of the luminaire.



2 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

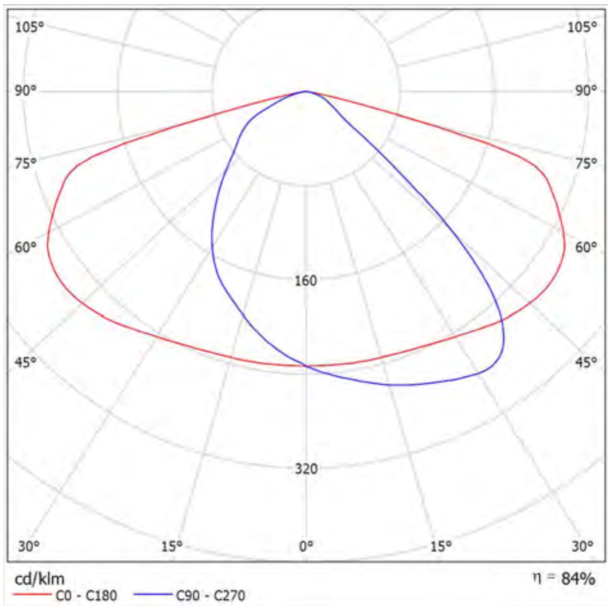


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

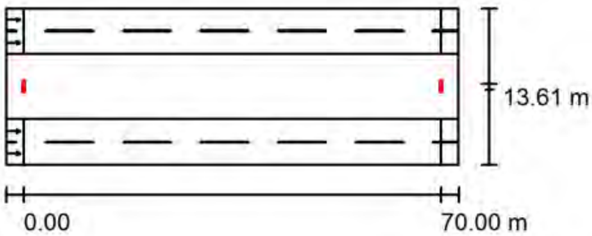
LED 1 / Planning data

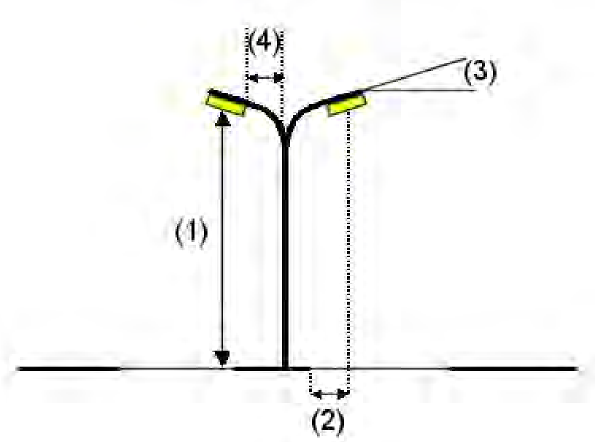
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

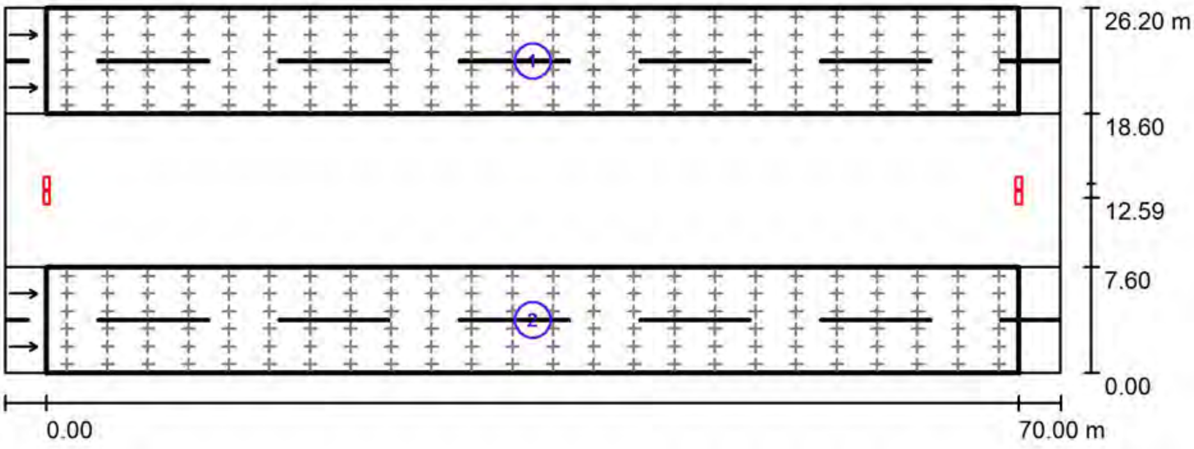




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	586 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	70 cd/klm
Arrangement:	on Median	at 90°:	0.54 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	16.000 m		
Height:	15.865 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G3.	
Boom Angle (3):	2.0 °	Arrangement complies with glare index class D.6.	
Boom Length (4):	0.507 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.90	0.50	0.69	11	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

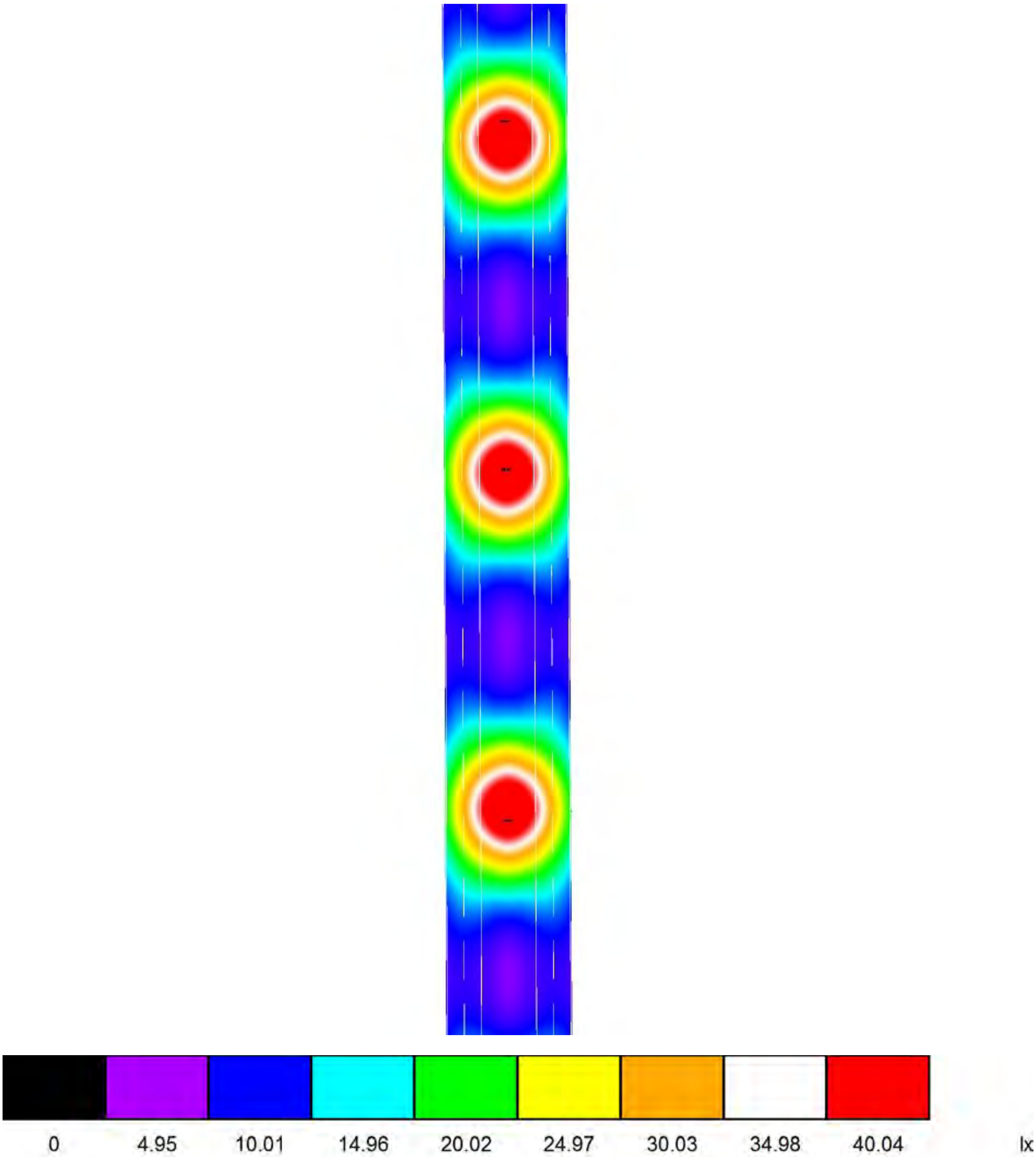
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.90	0.50	0.69	11	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

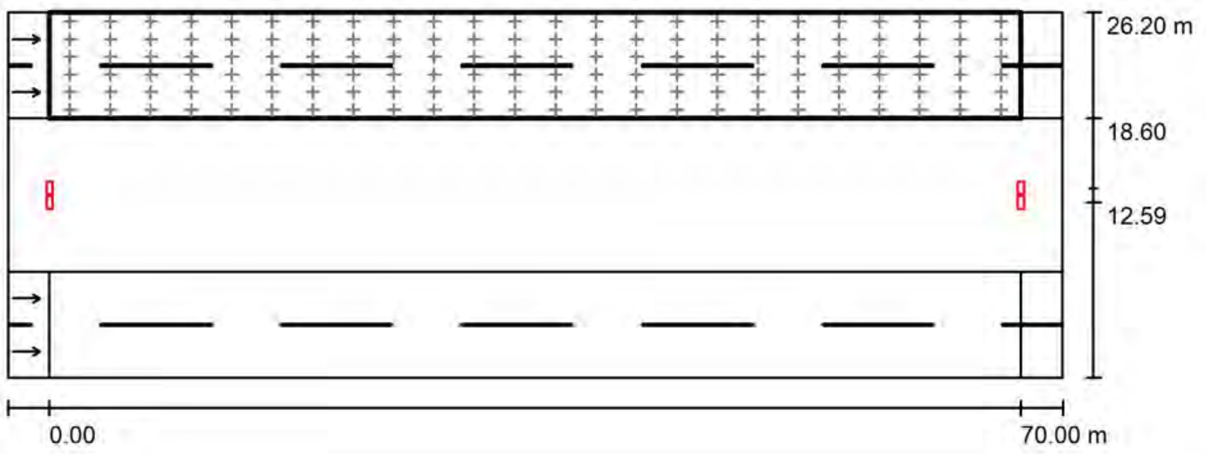
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

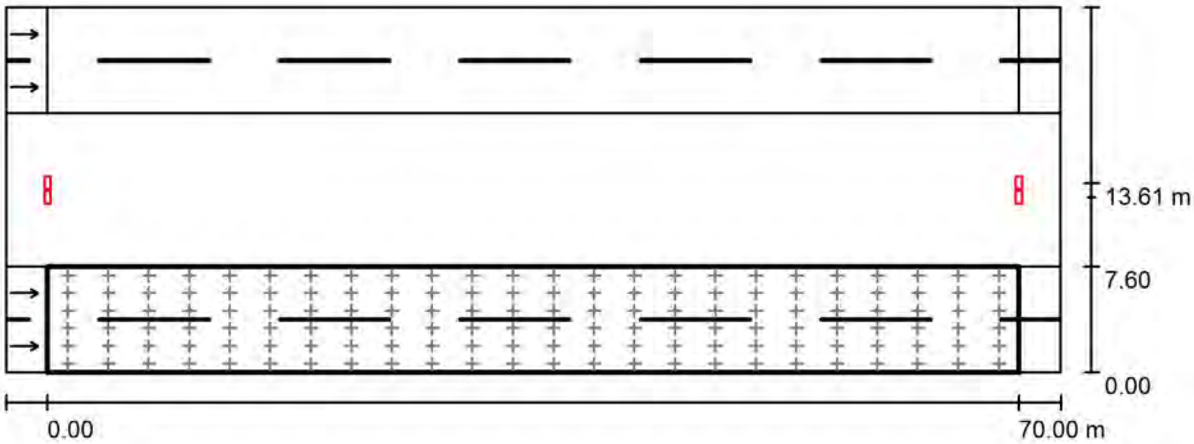
L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.90	0.50	0.69	11	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.90	0.55	0.73	11
2	Observer 4	(-60.000, 24.300, 1.500)	1.04	0.50	0.69	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80 Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.90	0.50	0.69	11	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.04	0.50	0.69	8
2	Observer 2	(-60.000, 5.700, 1.500)	0.90	0.55	0.73	11

Appendix (G)

5 - 12 - 50

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

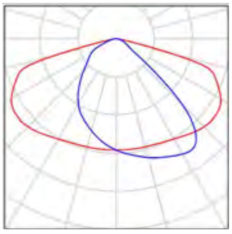
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 12 - 50 / Luminaire parts list

4 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

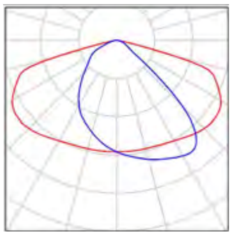
See our luminaire catalog for an image of the luminaire.



6 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

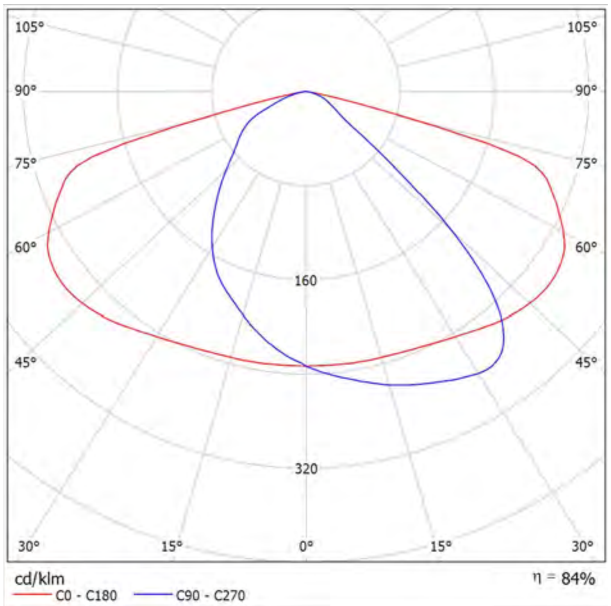
See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

Luminous emittance 1:



See our luminaire catalog for an image of the luminaire.

Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

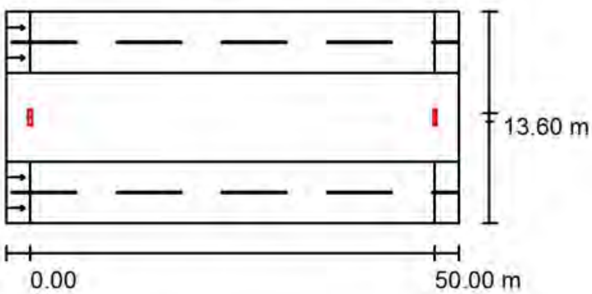
LED 1 / Planning data

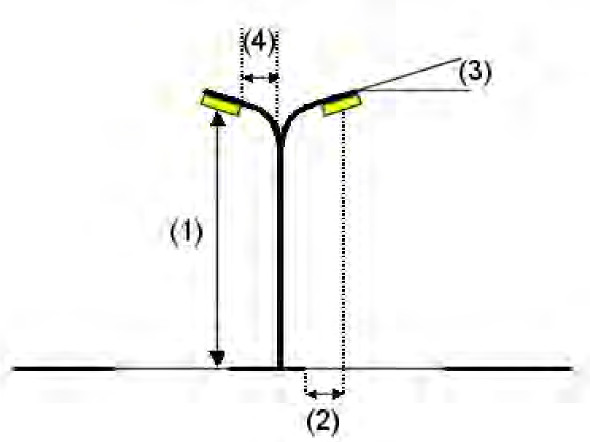
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

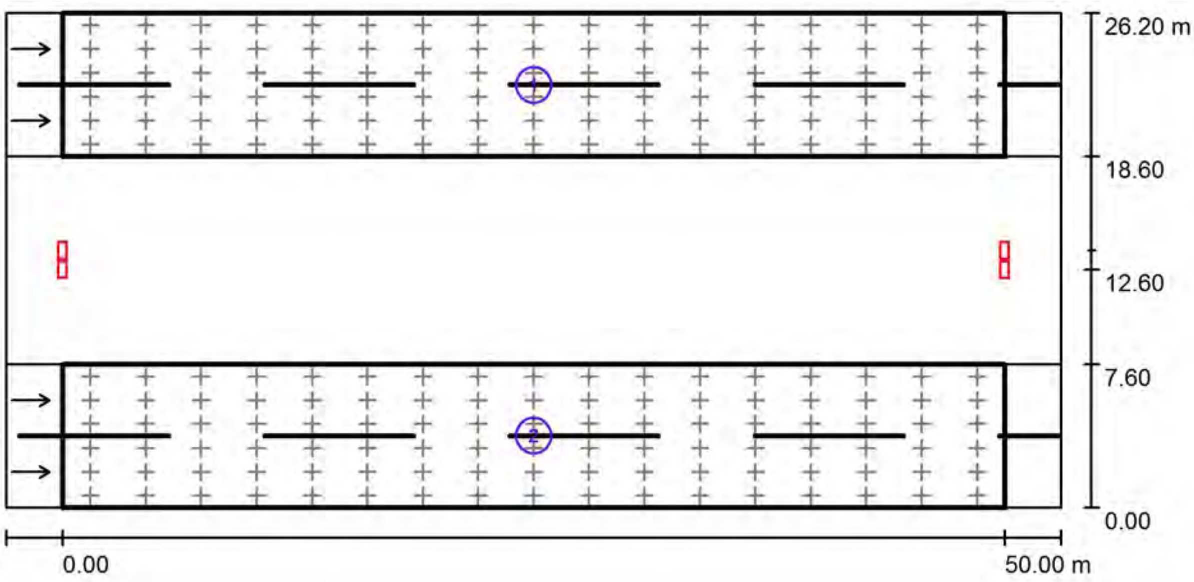




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	12.000 m		
Height:	11.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.26	0.47	0.72	14	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway

Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

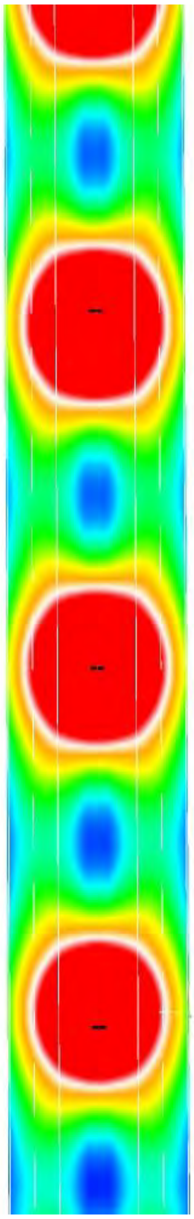
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.26	0.47	0.72	14	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

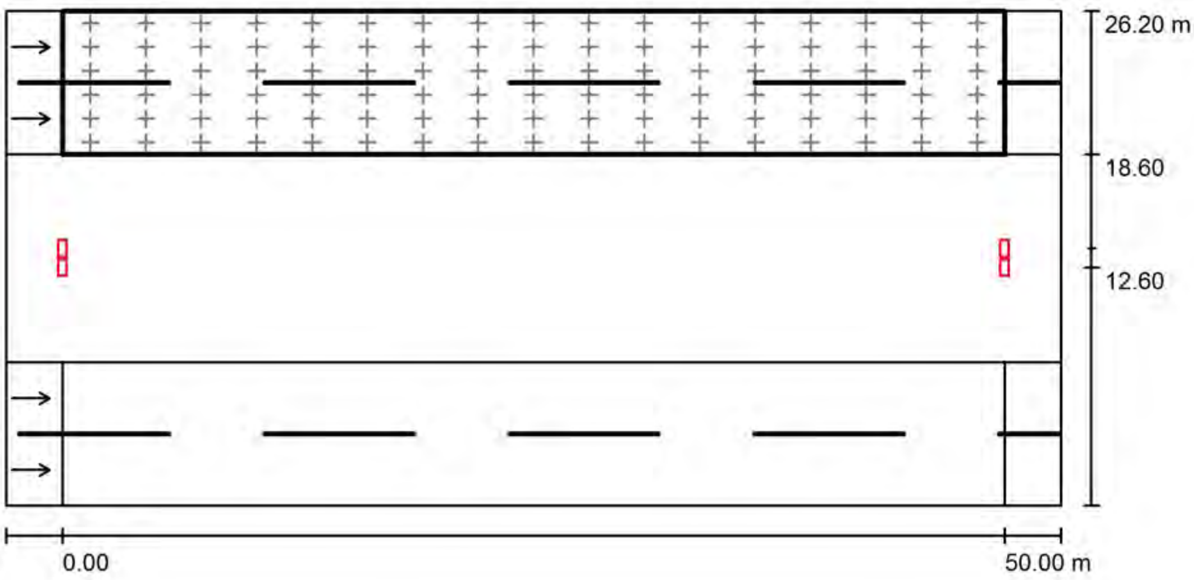
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

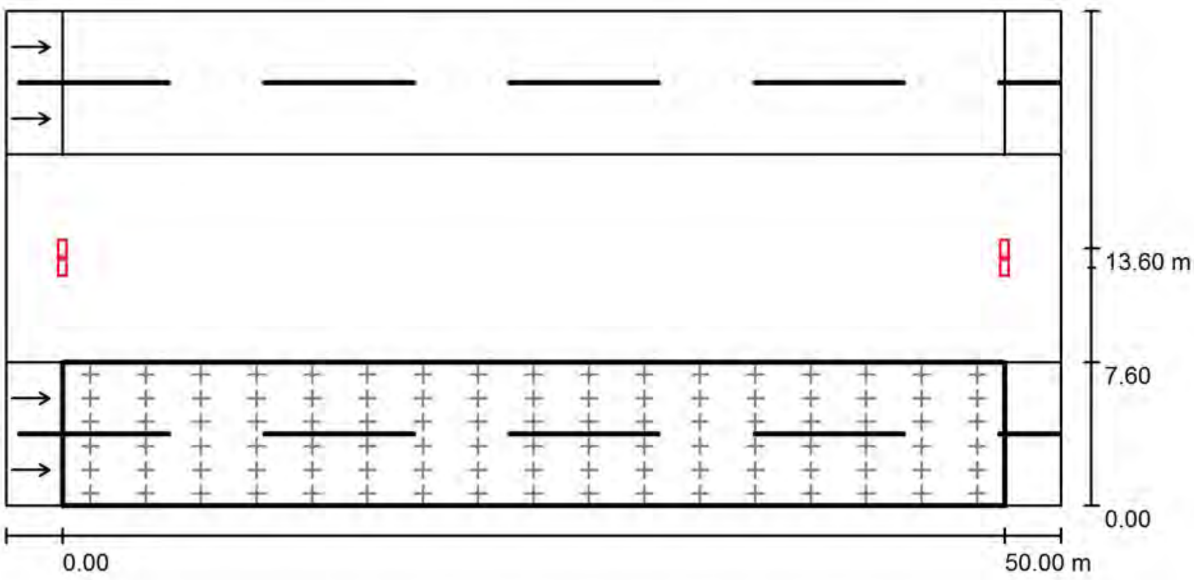
L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.26	0.47	0.72	14	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.26	0.51	0.76	14
2	Observer 4	(-60.000, 24.300, 1.500)	1.45	0.47	0.72	8

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.26	0.47	0.72	14	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.45	0.47	0.72	8
2	Observer 2	(-60.000, 5.700, 1.500)	1.26	0.51	0.76	14

5 - 12 - 60

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

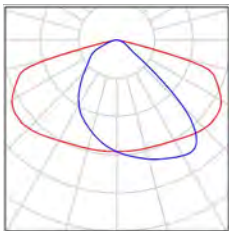
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 12 - 60 / Luminaire parts list

2 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

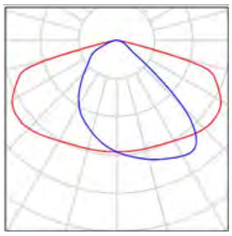
See our luminaire catalog for an image of the luminaire.



6 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

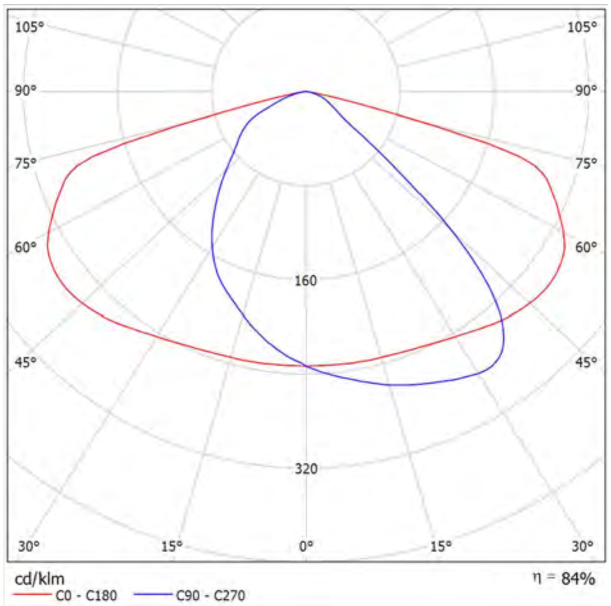


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

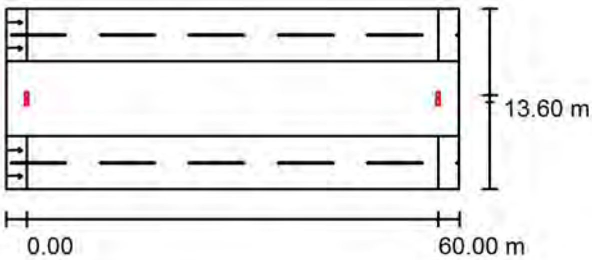
LED 1 / Planning data

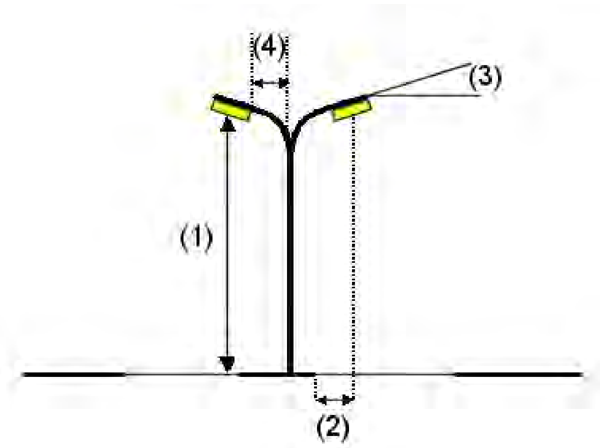
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements

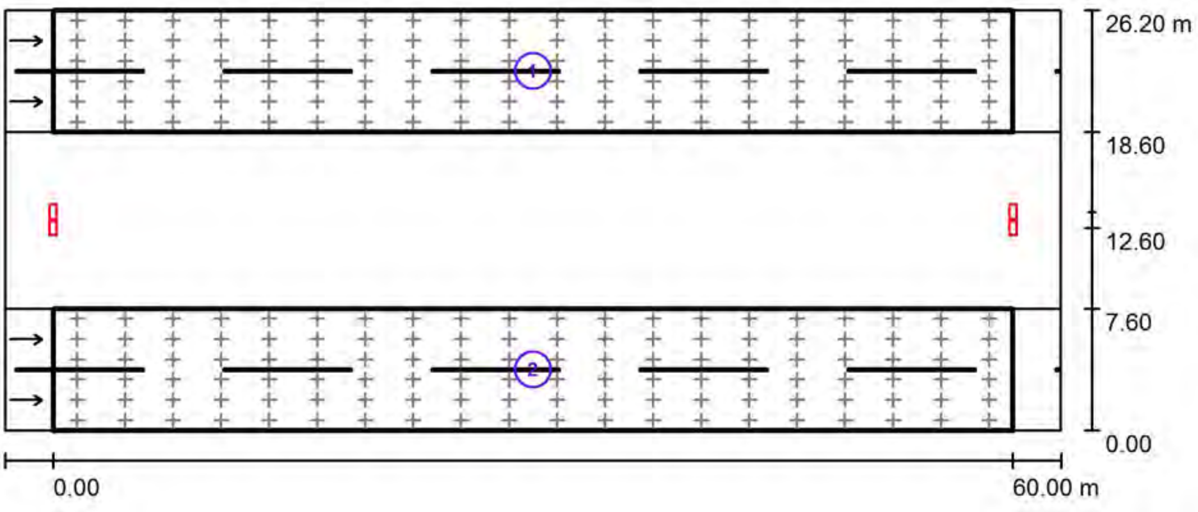




Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 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):	12.000 m		
Height:	11.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.45	0.57	17	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

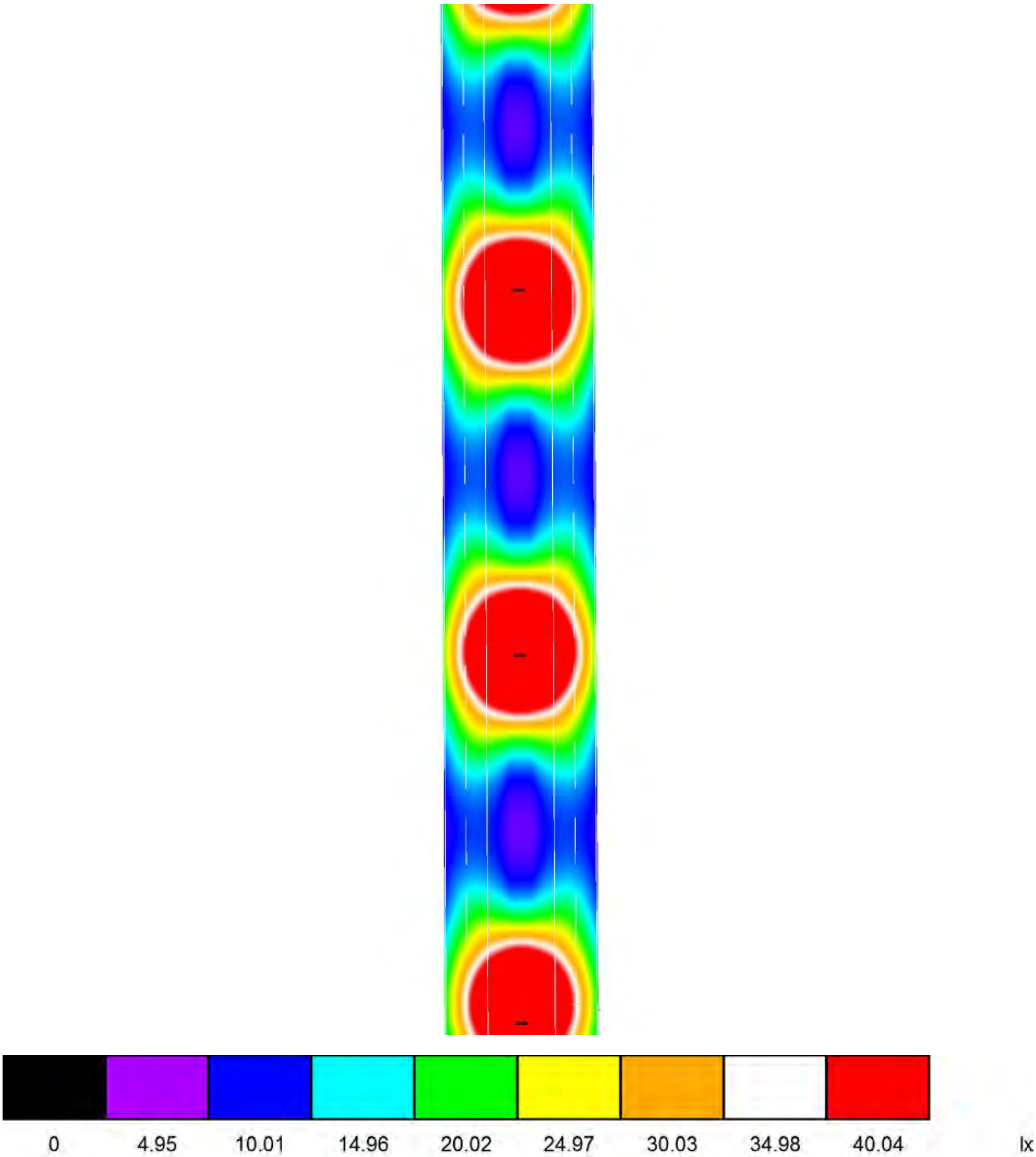
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.45	0.57	17	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

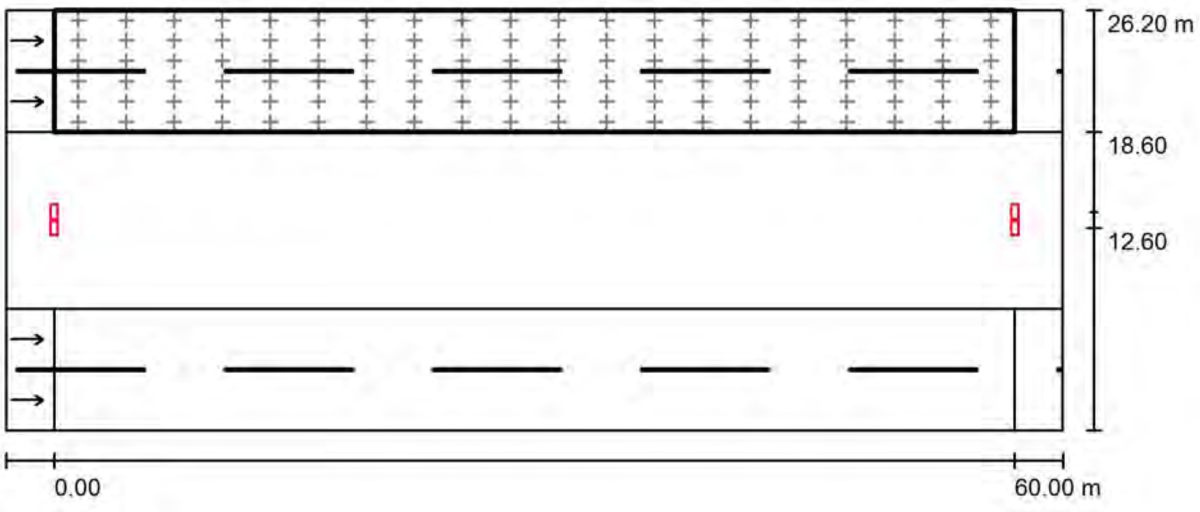
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

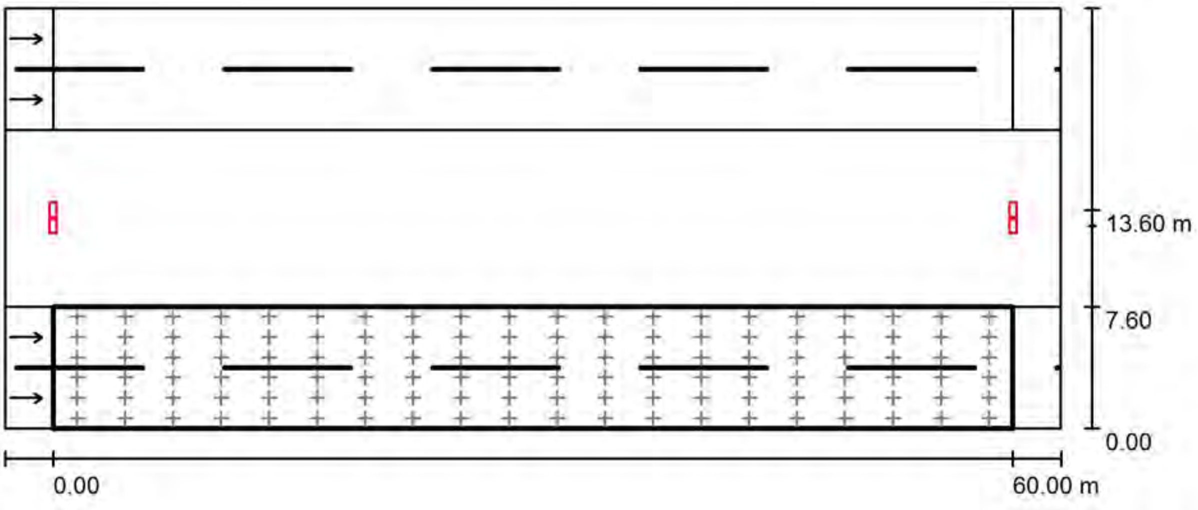
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.45	0.57	17	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.05	0.49	0.57	17
2	Observer 4	(-60.000, 24.300, 1.500)	1.20	0.45	0.63	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.05	0.45	0.57	17	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.20	0.45	0.63	9
2	Observer 2	(-60.000, 5.700, 1.500)	1.05	0.49	0.57	17

5 - 12 - 70

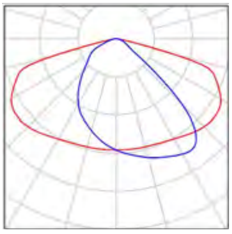
Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 12 - 70 / Luminaire parts list

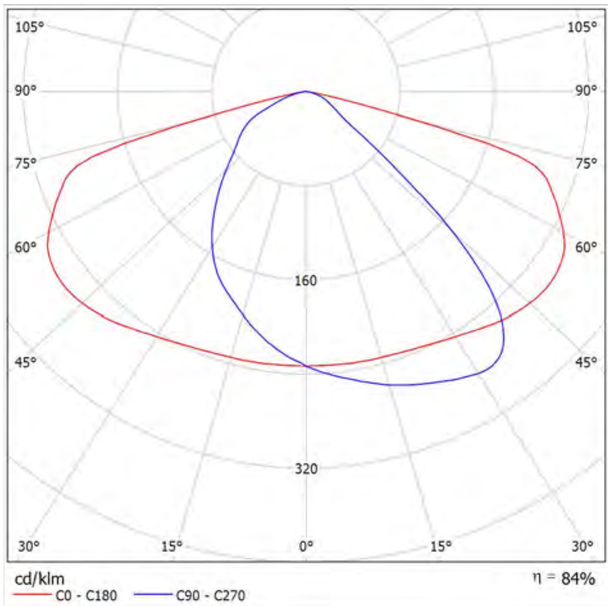
8 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 Article No.: Luminous flux (Luminaire): 30970 lm Luminous flux (Lamps): 36759 lm Luminaire Wattage: 279.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

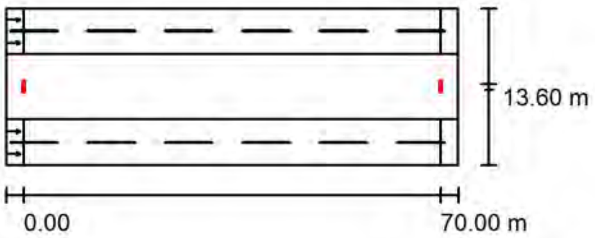
LED 1 / Planning data

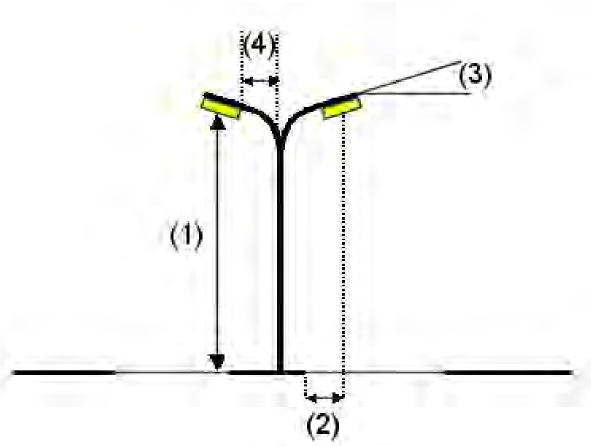
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





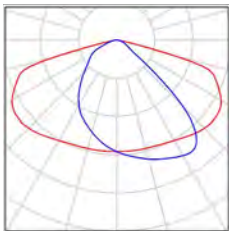
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	589 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	12.000 m		
Height:	11.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

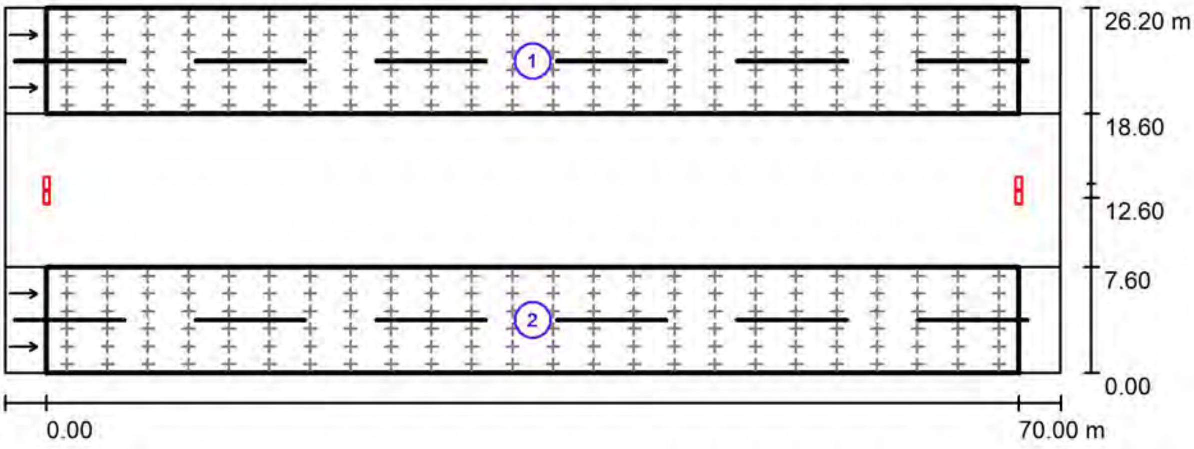
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.00	0.44	0.43	19	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

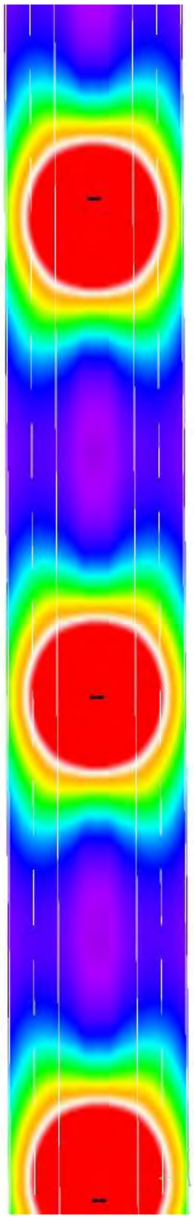
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.00	0.44	0.43	19	0.92

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

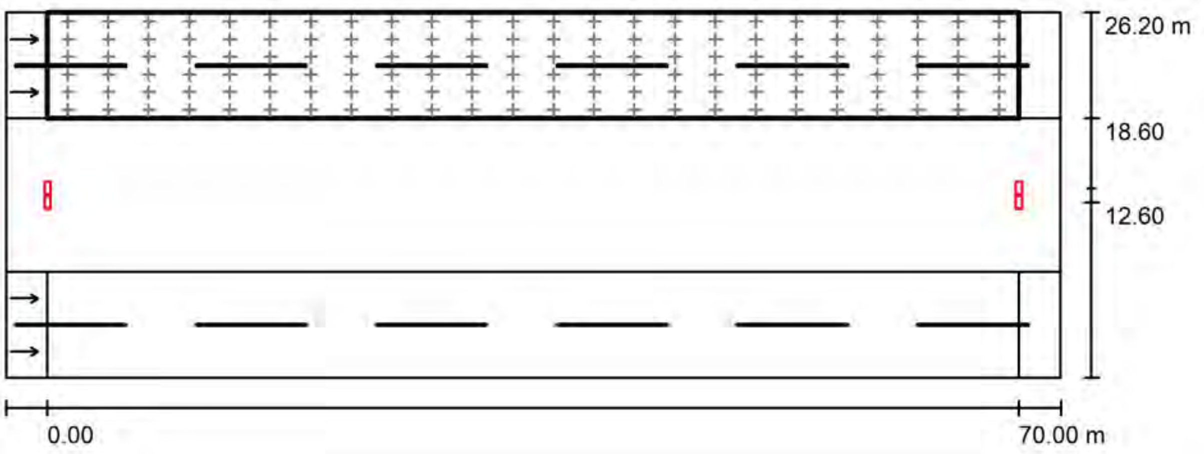
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

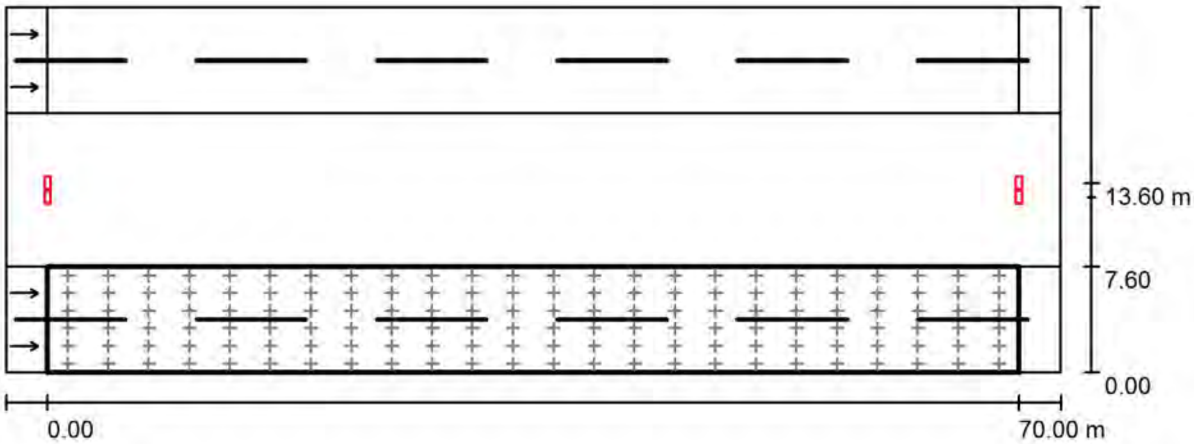
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.00	0.44	0.43	19	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.00	0.46	0.43	19
2	Observer 4	(-60.000, 24.300, 1.500)	1.12	0.44	0.54	11

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.00	0.44	0.43	19	0.92

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.12	0.44	0.54	11
2	Observer 2	(-60.000, 5.700, 1.500)	1.00	0.46	0.43	19

5 - 14 - 50

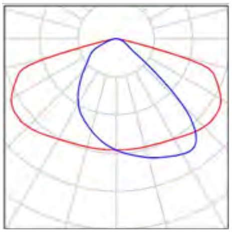
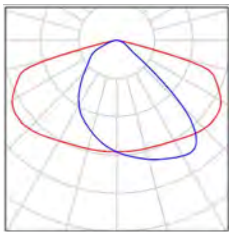
Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 14 - 50 / Luminaire parts list

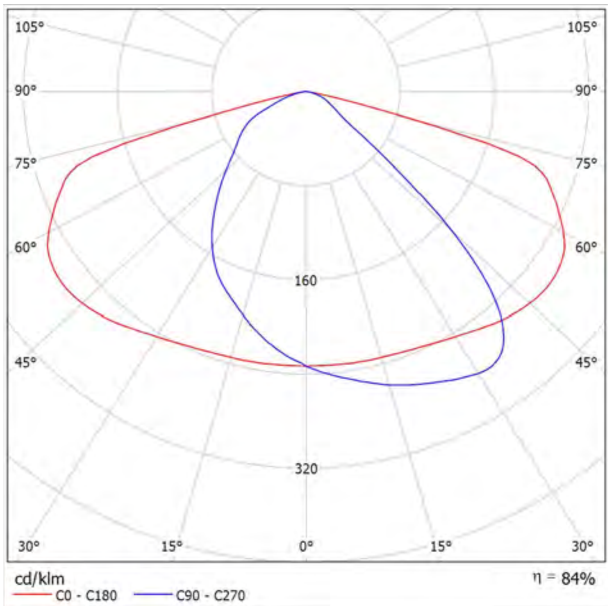
2 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1) Article No.: Luminous flux (Luminaire): 27927 lm Luminous flux (Lamps): 33147 lm Luminaire Wattage: 240.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	
10 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 Article No.: Luminous flux (Luminaire): 30970 lm Luminous flux (Lamps): 36759 lm Luminaire Wattage: 279.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

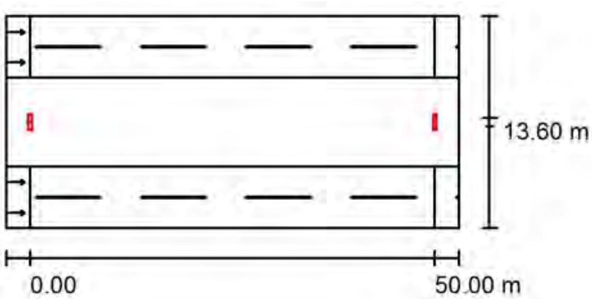
LED 1 / Planning data

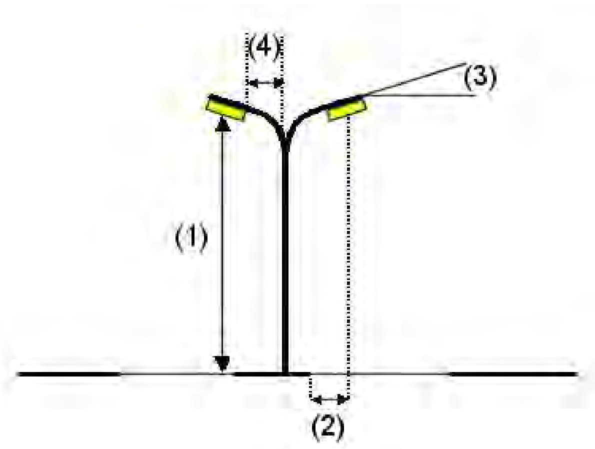
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





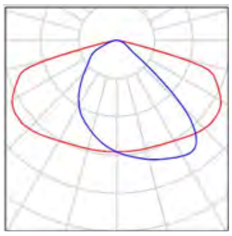
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

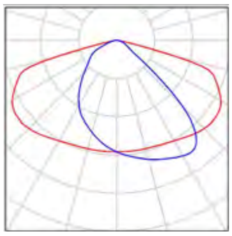
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



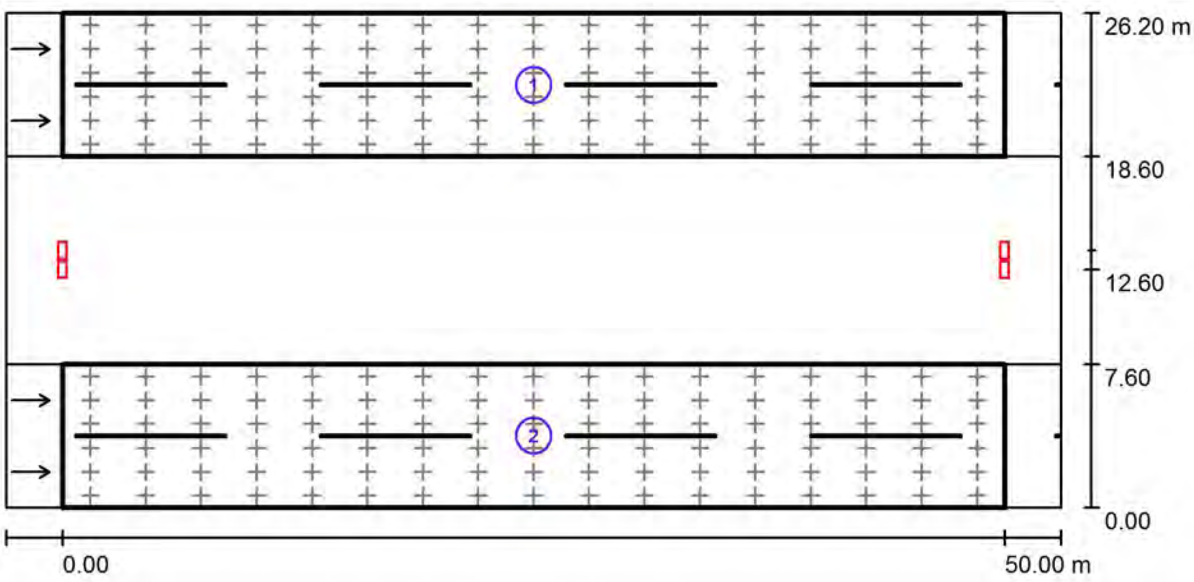
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80 Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.25	0.55	0.84	11	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

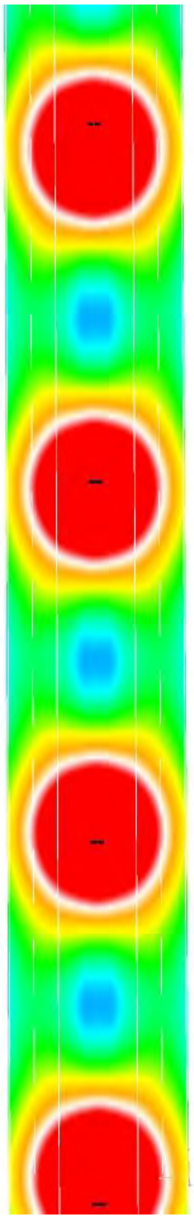
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.25	0.55	0.84	11	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

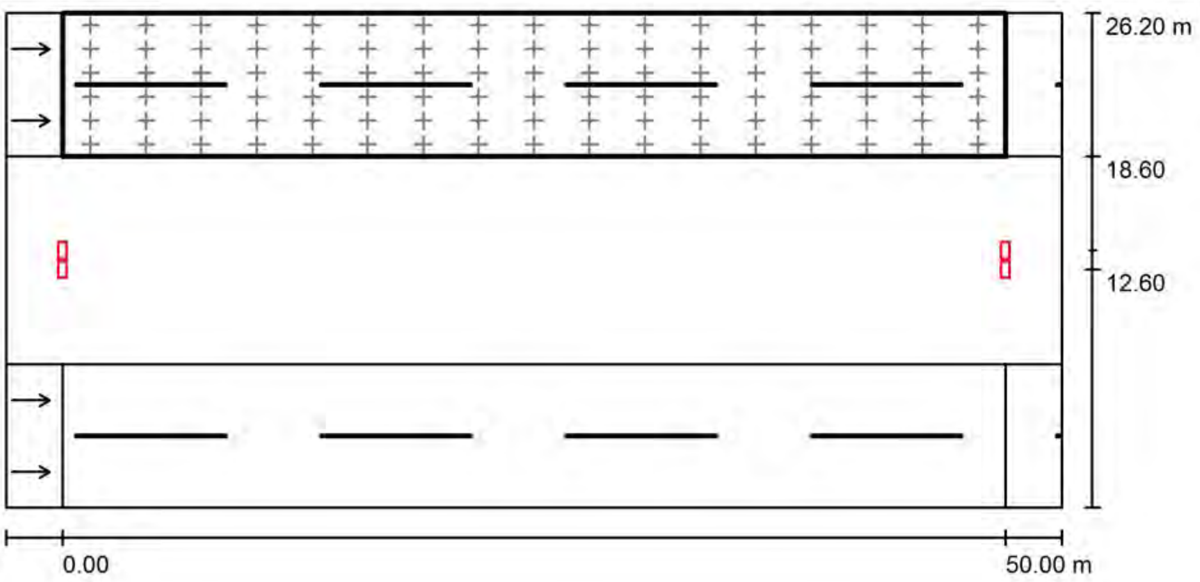
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

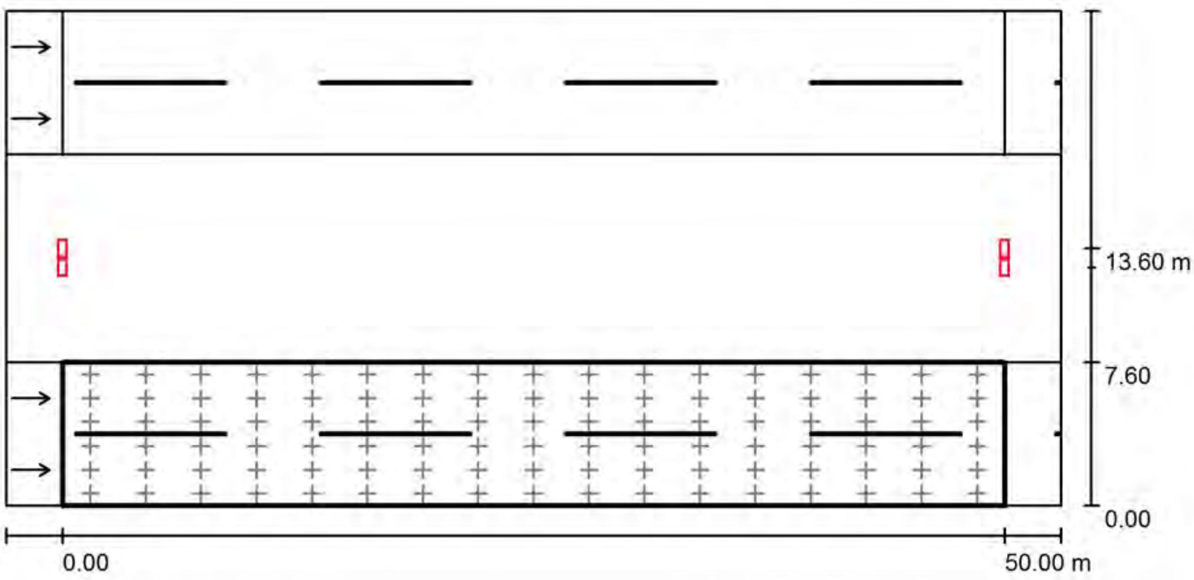
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.25	0.55	0.84	11	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.25	0.59	0.90	11
2	Observer 4	(-60.000, 24.300, 1.500)	1.45	0.55	0.84	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80 Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.25	0.55	0.84	11	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.45	0.55	0.84	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.25	0.59	0.90	11

5 - 14 - 60

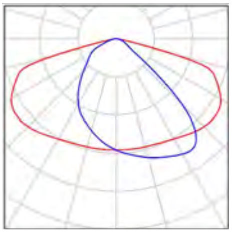
Date: 28.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 14 - 60 / Luminaire parts list

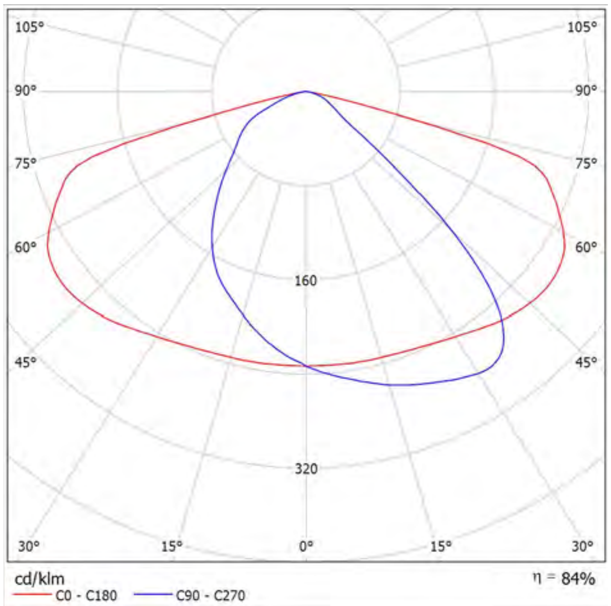
10 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 Article No.: Luminous flux (Luminaire): 30970 lm Luminous flux (Lamps): 36759 lm Luminaire Wattage: 279.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

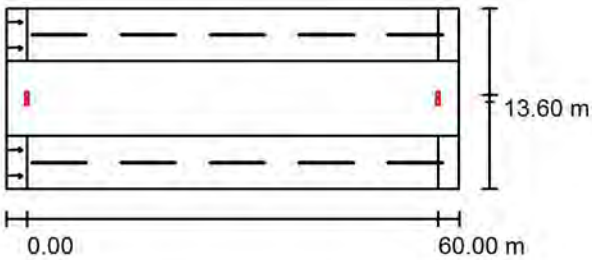
LED 1 / Planning data

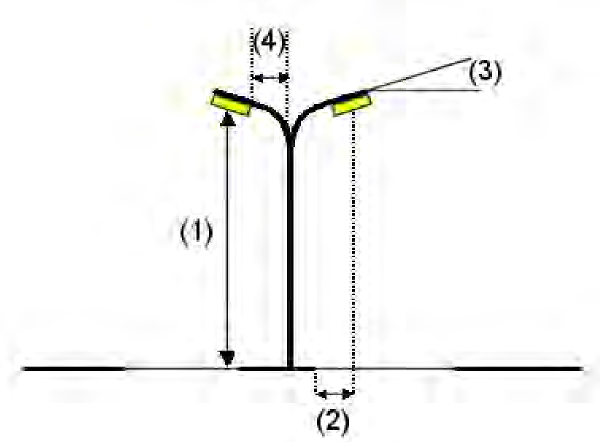
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





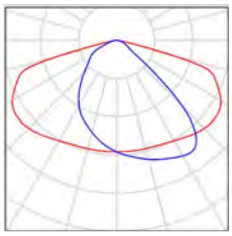
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	589 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 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):	14.000 m		
Height:	13.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

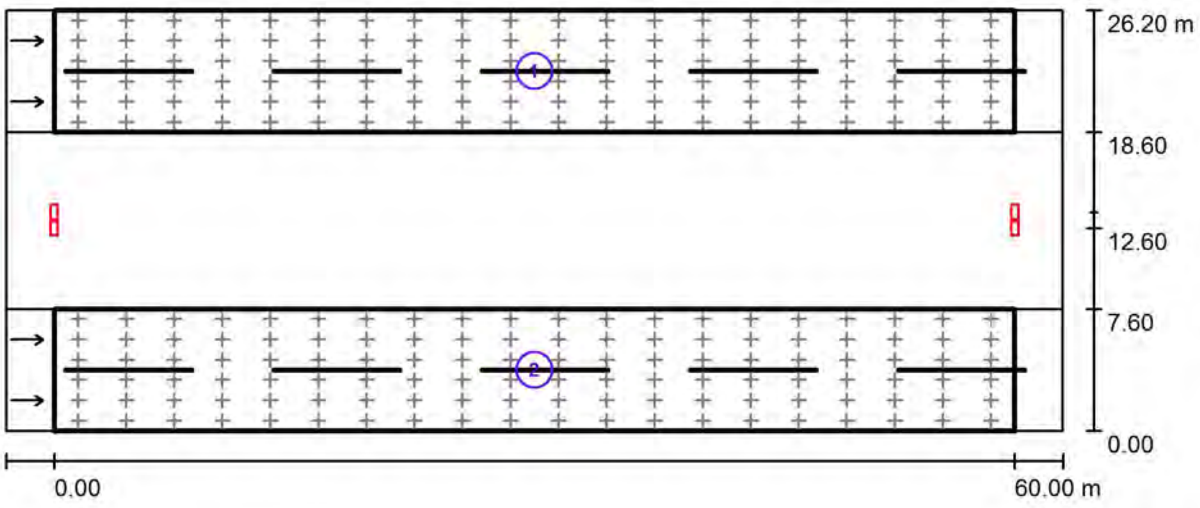
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.16	0.52	0.71	13	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

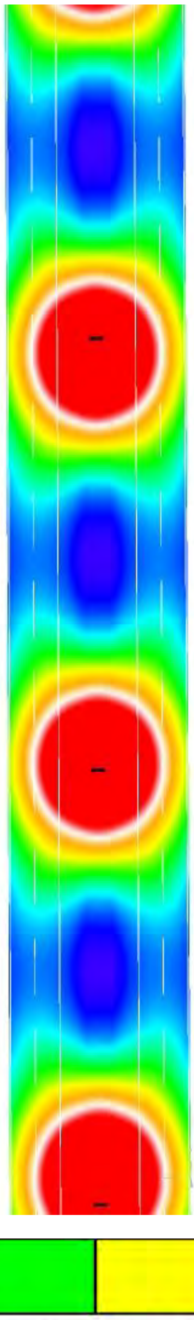
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.16	0.52	0.71	13	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

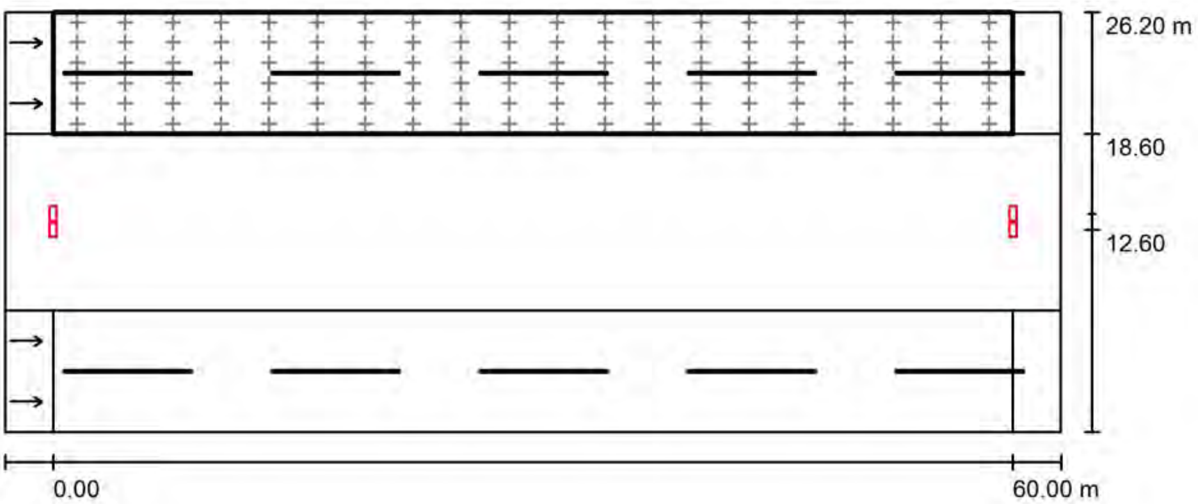
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

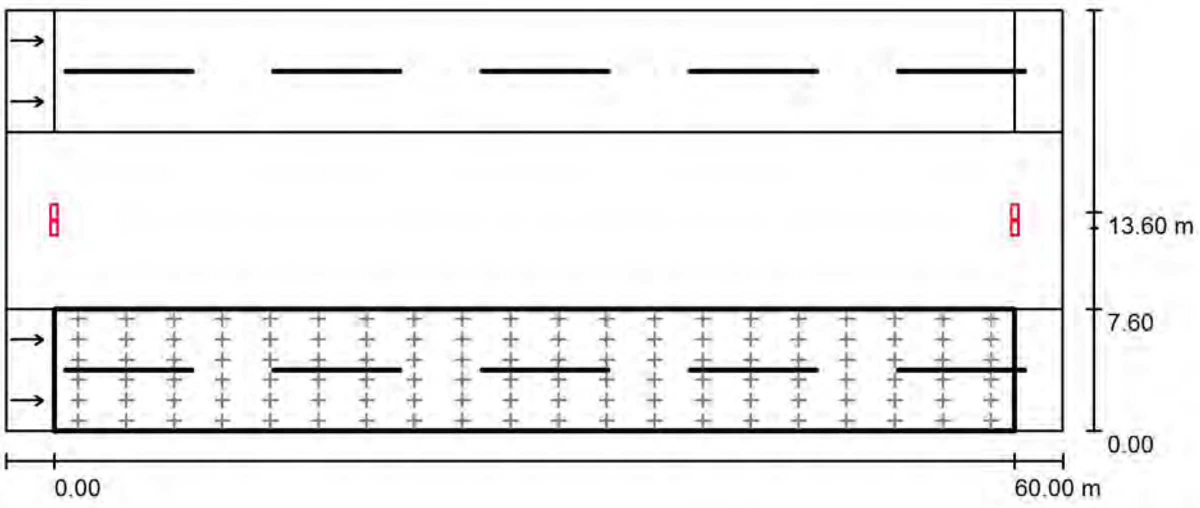
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.16	0.52	0.71	13	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.16	0.56	0.79	13
2	Observer 4	(-60.000, 24.300, 1.500)	1.34	0.52	0.71	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.16	0.52	0.71	13	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.34	0.52	0.71	9
2	Observer 2	(-60.000, 5.700, 1.500)	1.16	0.56	0.79	13

5 - 14 - 70

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

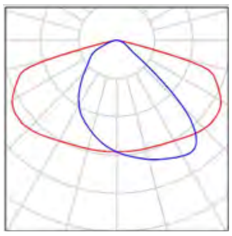
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 14 - 70 / Luminaire parts list

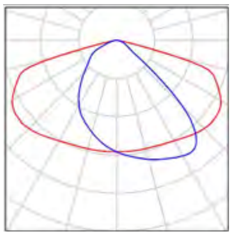
2 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



6 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

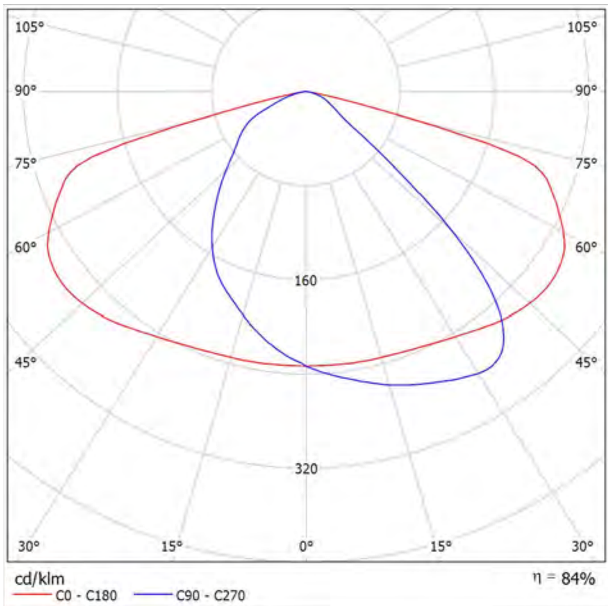


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

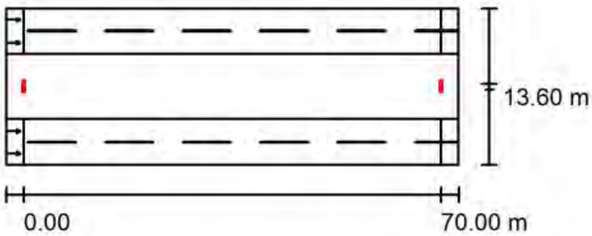
LED 1 / Planning data

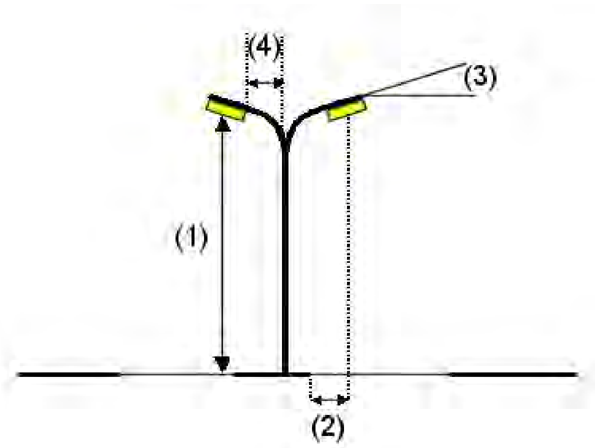
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





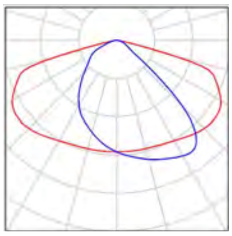
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	14.000 m		
Height:	13.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

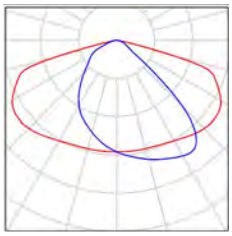
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



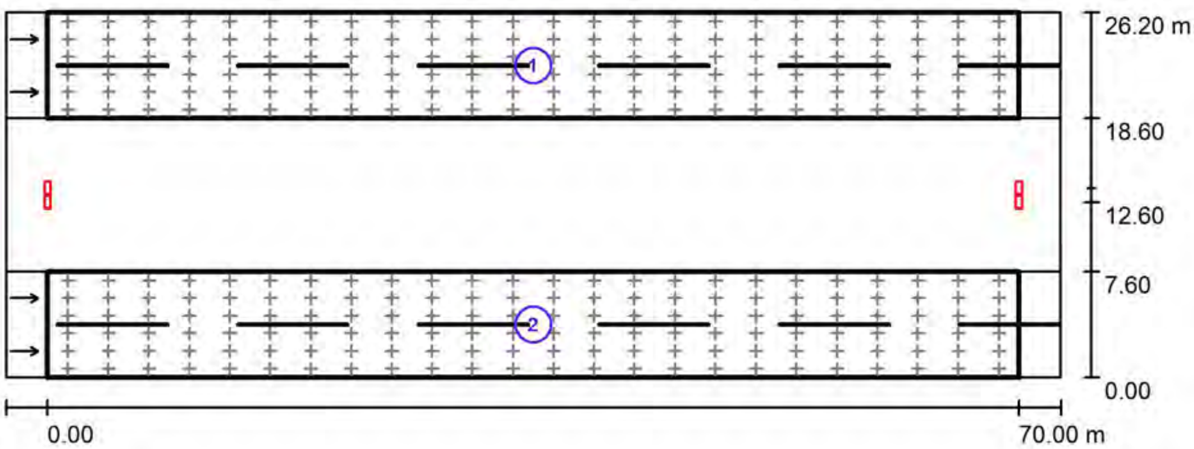
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.90	0.47	0.55	14	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

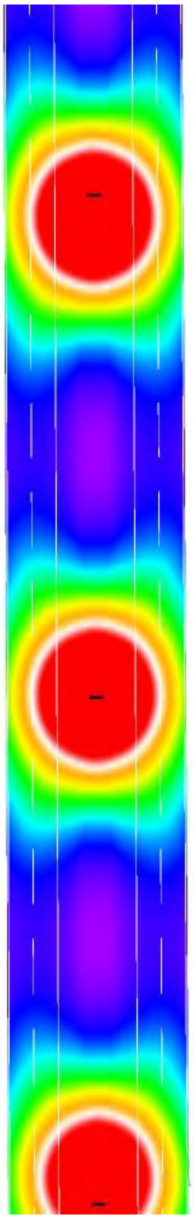
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.90	0.47	0.55	14	0.93

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

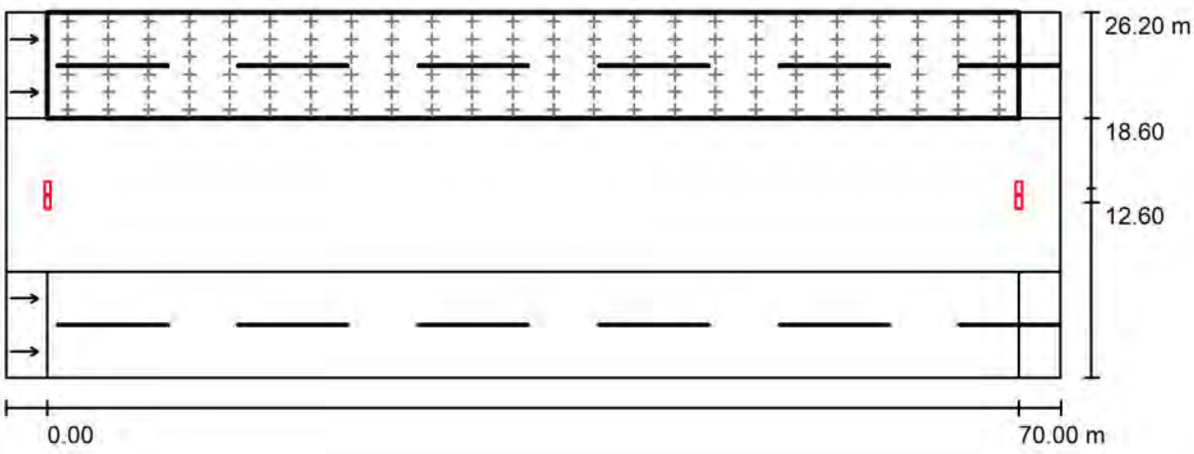
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

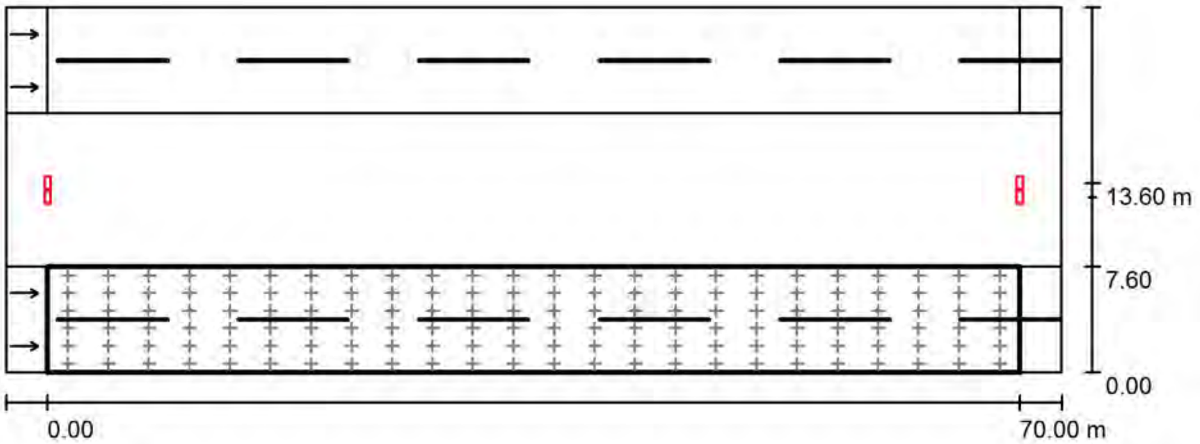
L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.90	0.47	0.55	14	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.90	0.52	0.55	14
2	Observer 4	(-60.000, 24.300, 1.500)	1.02	0.47	0.62	10

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.90	0.47	0.55	14	0.93

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.02	0.47	0.62	10
2	Observer 2	(-60.000, 5.700, 1.500)	0.90	0.52	0.55	14

5 - 16 - 50

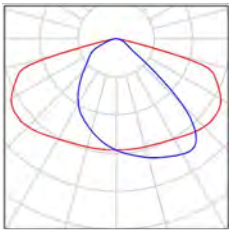
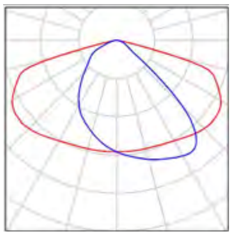
Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 16 - 50 / Luminaire parts list

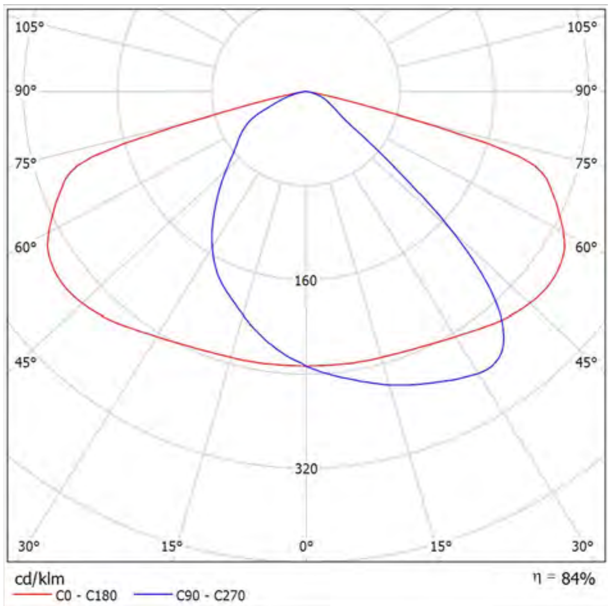
2 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1) Article No.: Luminous flux (Luminaire): 27927 lm Luminous flux (Lamps): 33147 lm Luminaire Wattage: 240.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	
10 Pieces	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 Article No.: Luminous flux (Luminaire): 30970 lm Luminous flux (Lamps): 36759 lm Luminaire Wattage: 279.0 W Luminaire classification according to CIE: 100 CIE flux code: 43 78 97 100 84 Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

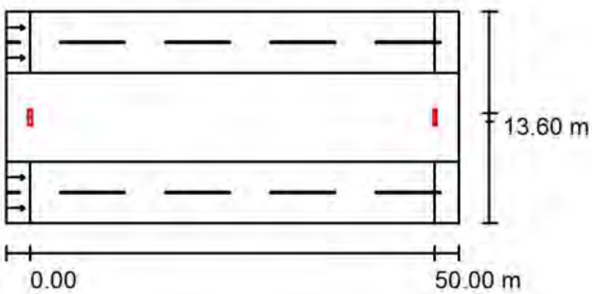
LED 1 / Planning data

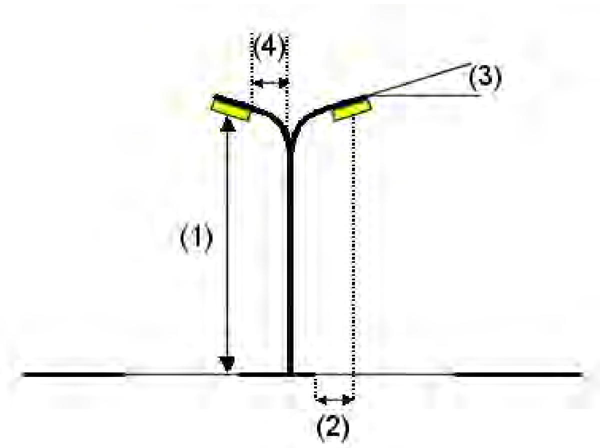
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





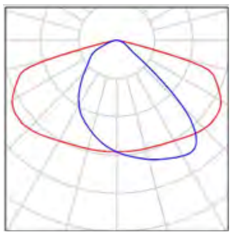
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 cd/klm
Pole Distance:	50.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	16.000 m		
Height:	15.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

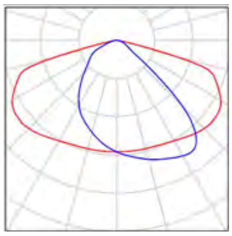
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



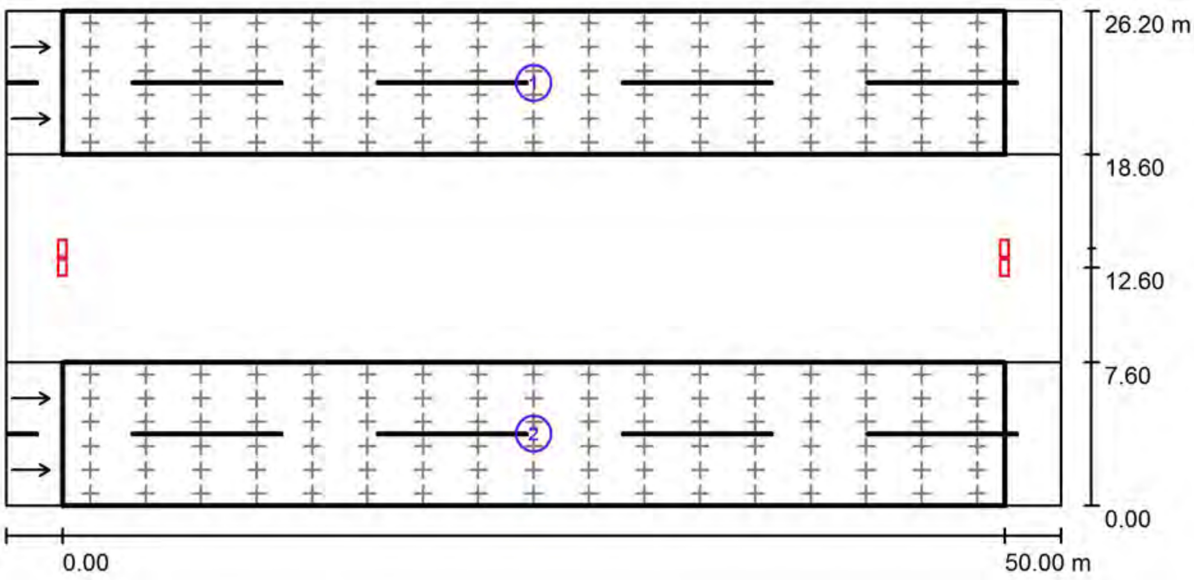
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:401

Calculation Field List

1 Valuation Field 2x3.8m carriageway

Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.22	0.60	0.86	8	0.94

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 50.000 m, Width: 7.600 m
Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

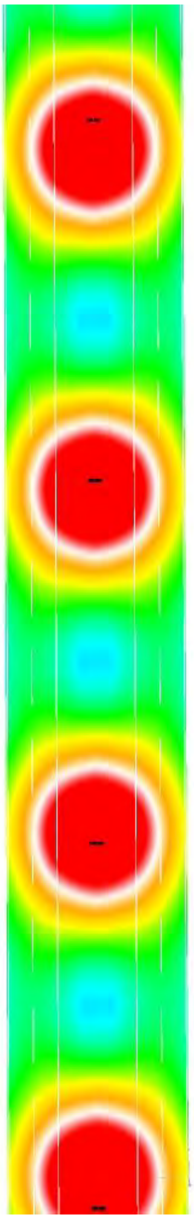
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.22	0.60	0.86	8	0.94

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

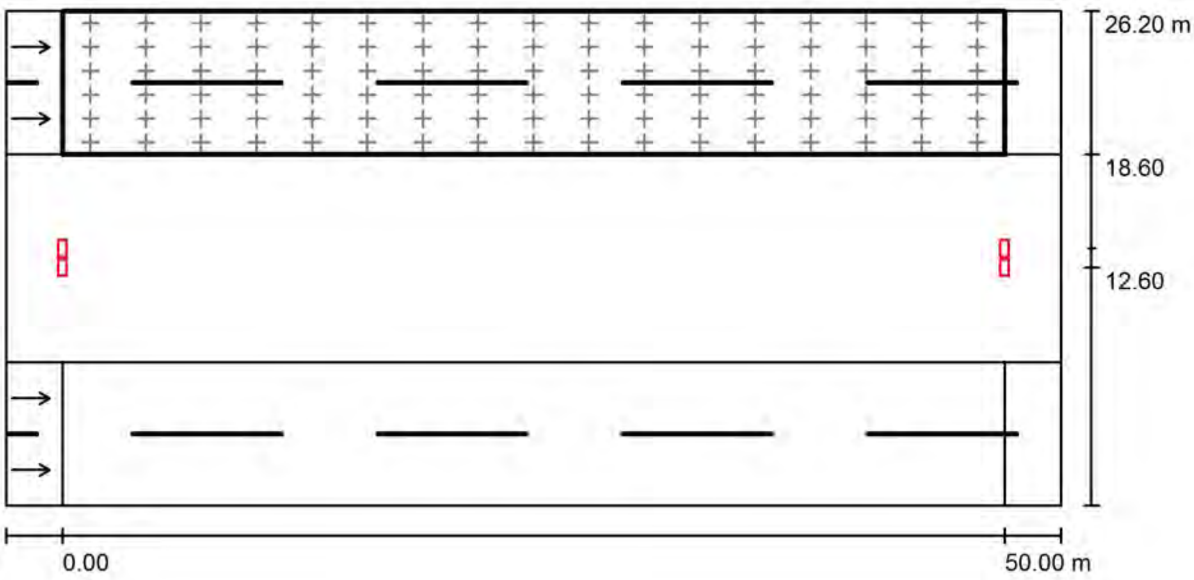
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

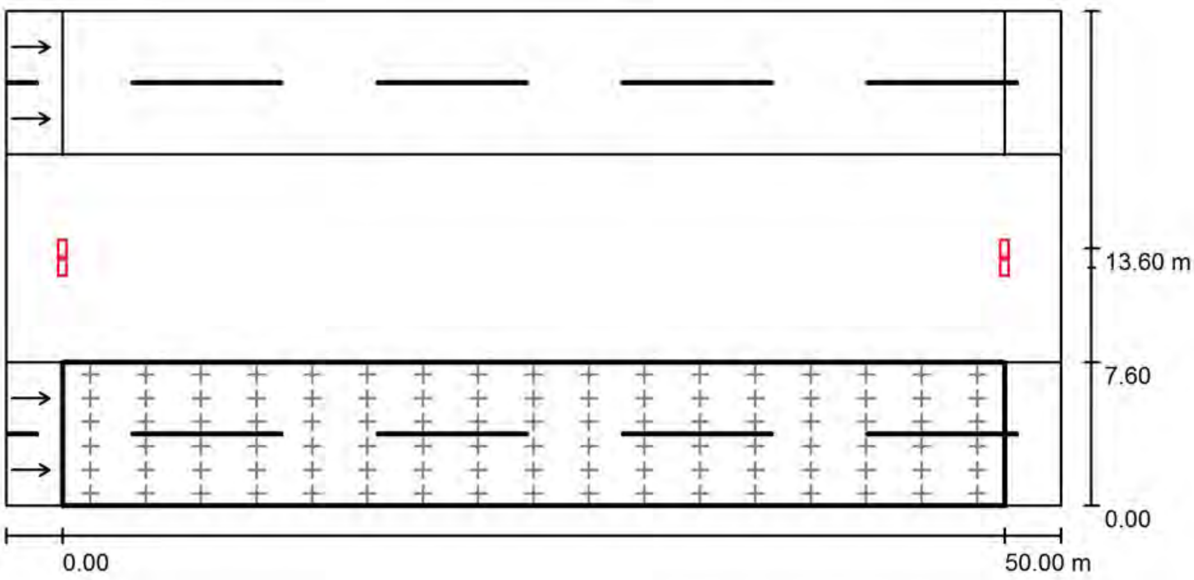
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.22	0.60	0.86	8	0.94

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.22	0.67	0.86	8
2	Observer 4	(-60.000, 24.300, 1.500)	1.41	0.60	0.92	6

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:401

Grid: 17 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.22	0.60	0.86	8	0.94

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.41	0.60	0.92	6
2	Observer 2	(-60.000, 5.700, 1.500)	1.22	0.67	0.86	8

5 - 16 - 60

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

Table of contents

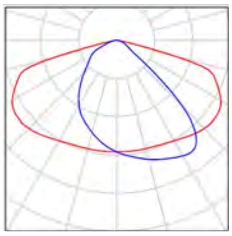
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 16 - 60 / Luminaire parts list

2 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

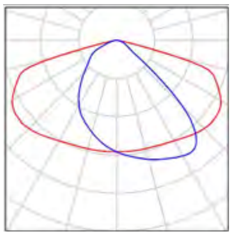
See our luminaire catalog for an image of the luminaire.



10 Pieces

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

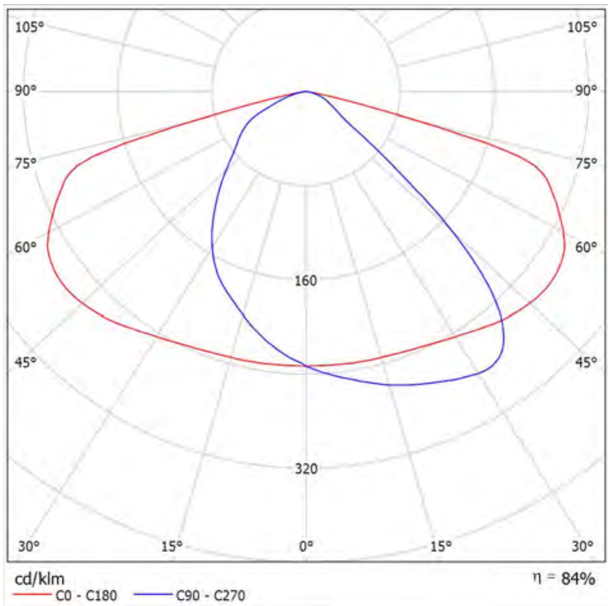


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

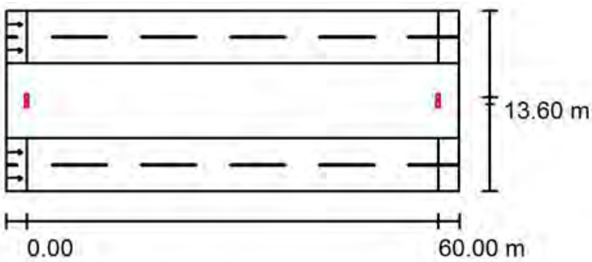
LED 1 / Planning data

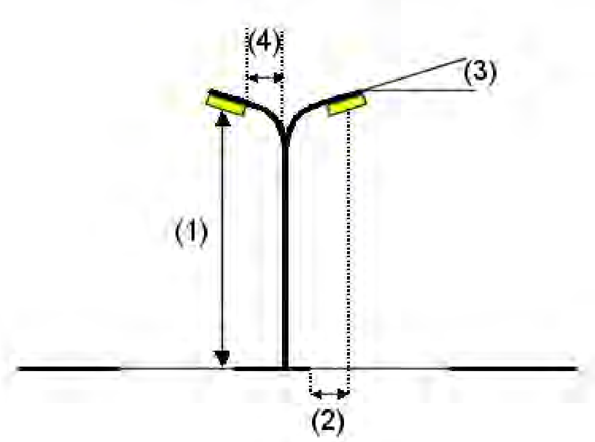
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





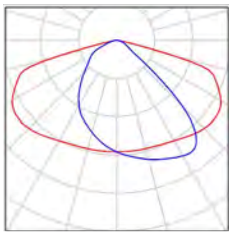
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	27927 lm	Maximum luminous intensities	
Luminous flux (Lamps):	33147 lm	at 70°:	589 cd/klm
Luminaire Wattage:	240.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 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):	16.000 m		
Height:	15.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

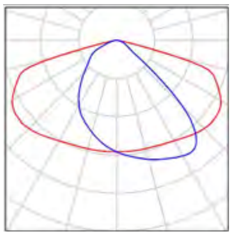
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 (Type 1)
Article No.:
Luminous flux (Luminaire): 27927 lm
Luminous flux (Lamps): 33147 lm
Luminaire Wattage: 240.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



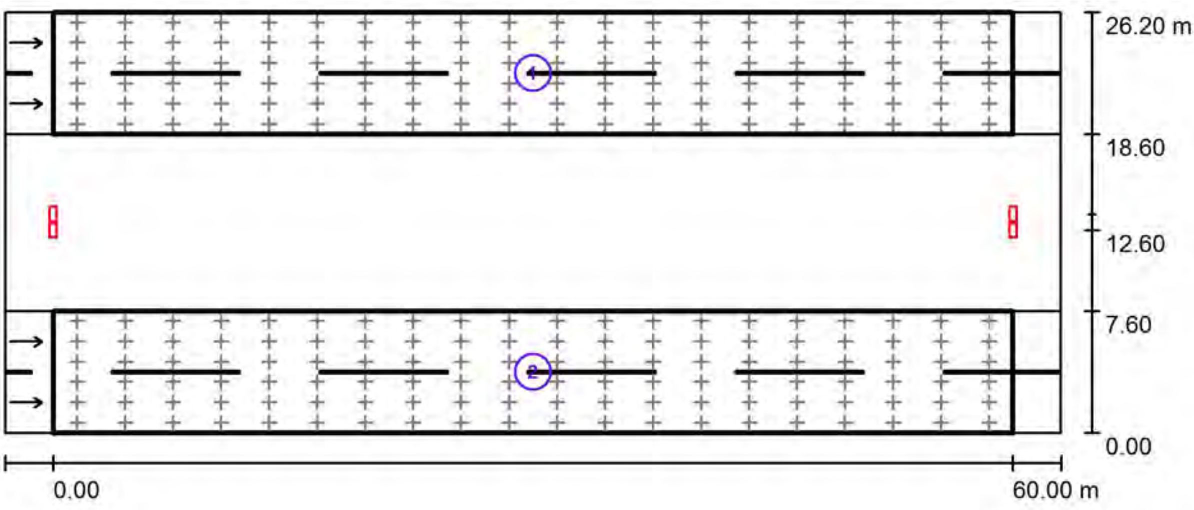
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:472

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
1.01	0.60	0.81	10	0.94

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway

Length: 60.000 m, Width: 7.600 m
Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

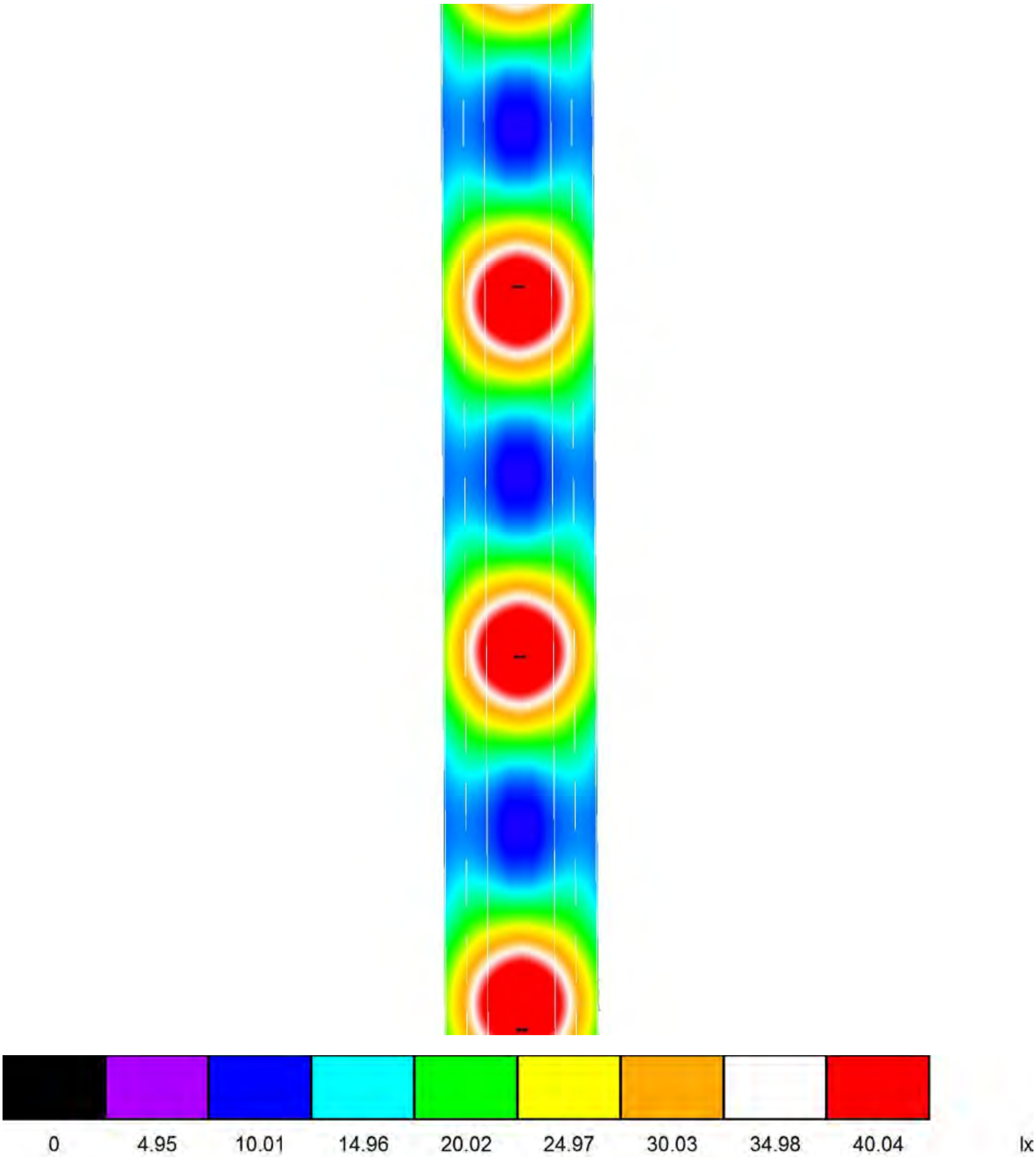
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.01	0.60	0.81	10	0.94

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

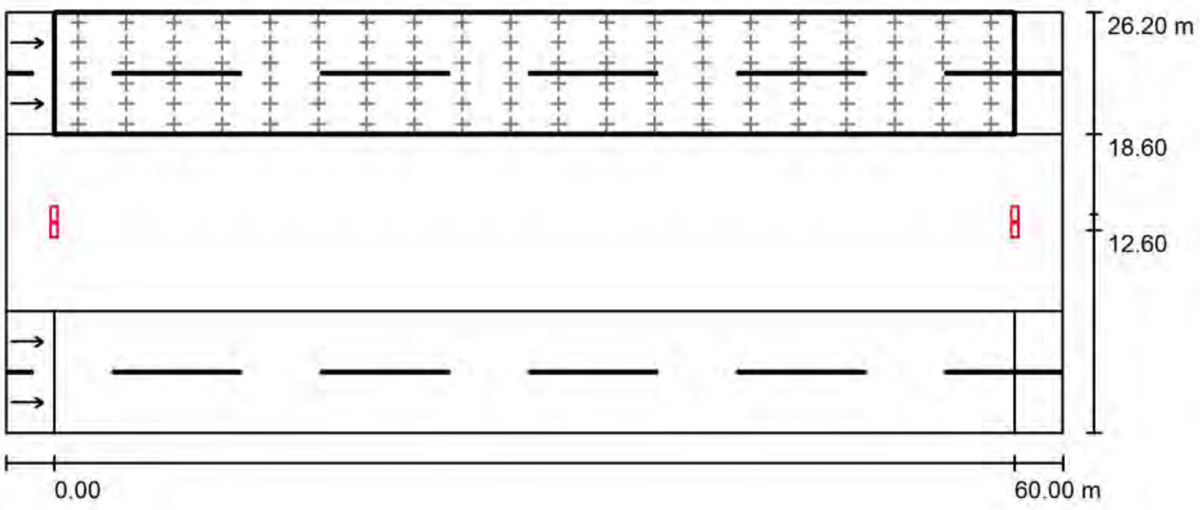
Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / False Color Rendering



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

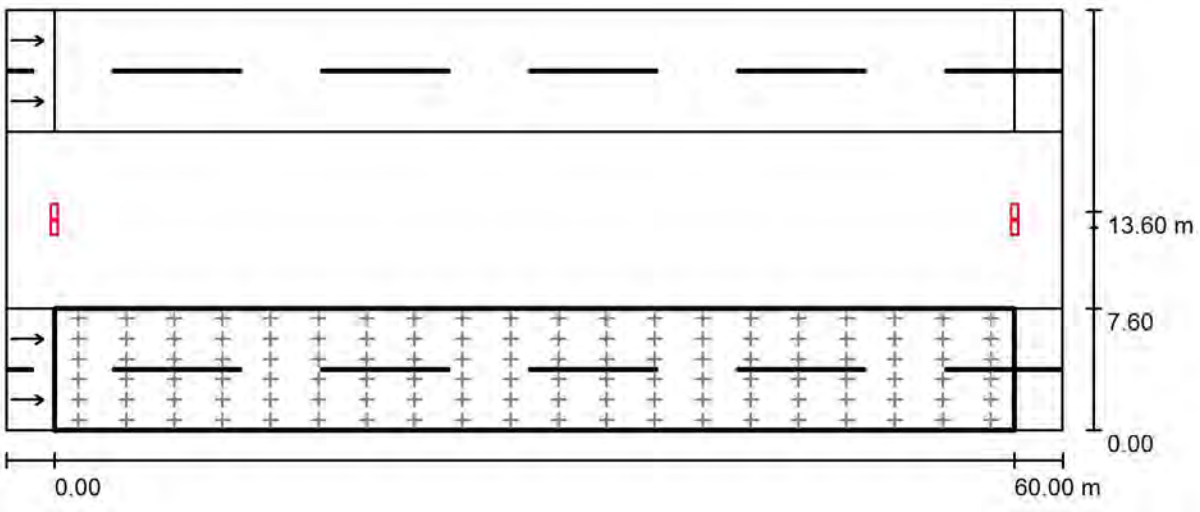
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.01	0.60	0.81	10	0.94

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	1.01	0.63	0.91	10
2	Observer 4	(-60.000, 24.300, 1.500)	1.18	0.60	0.81	7

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:472

Grid: 20 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
1.01	0.60	0.81	10	0.94

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.18	0.60	0.81	7
2	Observer 2	(-60.000, 5.700, 1.500)	1.01	0.63	0.91	10

5 - 16 - 70

Date: 27.02.2018
Operator: Aisha Al Shehhi

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

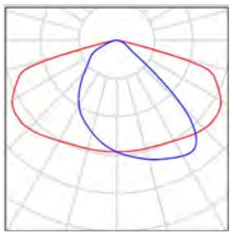
Table of contents

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

5 - 16 - 70 / Luminaire parts list

10 Pieces SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

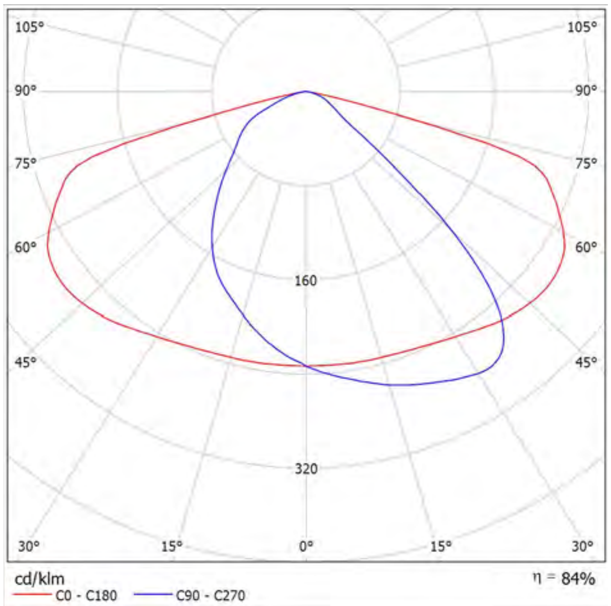


Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84

Due to missing symmetry properties, no UGR table can be displayed for this luminaire.

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

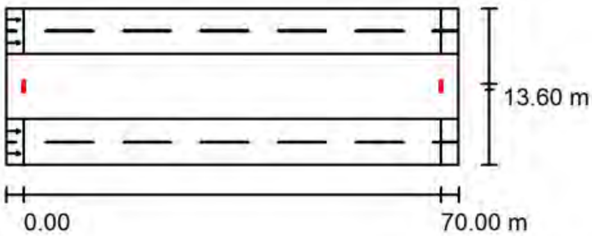
LED 1 / Planning data

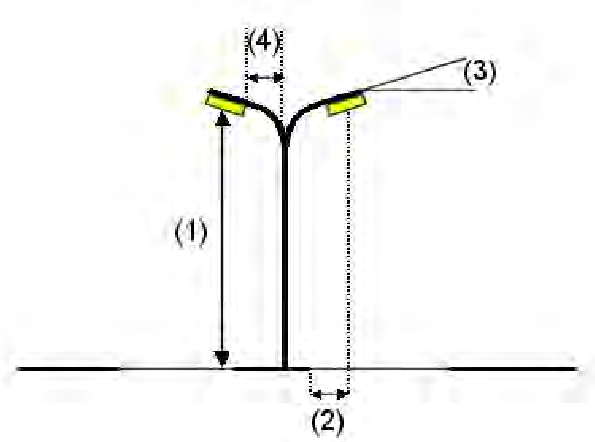
Street Profile

2x3.8m carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)
Median	(Width: 11.000 m, Height: 0.000 m)
2x3.8m Carriageway	(Width: 7.600 m, Number of lanes: 2, tarmac: R4, q0: 0.080)

Light loss factor: 0.80

Luminaire Arrangements





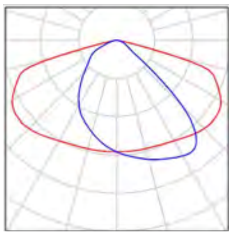
Luminaire:	SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172		
Luminous flux (Luminaire):	30970 lm	Maximum luminous intensities	
Luminous flux (Lamps):	36759 lm	at 70°:	589 cd/klm
Luminaire Wattage:	279.0 W	at 80°:	115 cd/klm
Arrangement:	on Median	at 90°:	0.75 cd/klm
Pole Distance:	70.000 m	Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.	
Mounting Height (1):	16.000 m		
Height:	15.866 m	No luminous intensities above 95°.	
Overhang (2):	-4.988 m	Arrangement complies with luminous intensity class G2.	
Boom Angle (3):	5.0 °	Arrangement complies with glare index class D.4.	
Boom Length (4):	0.500 m		

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Luminaire parts list

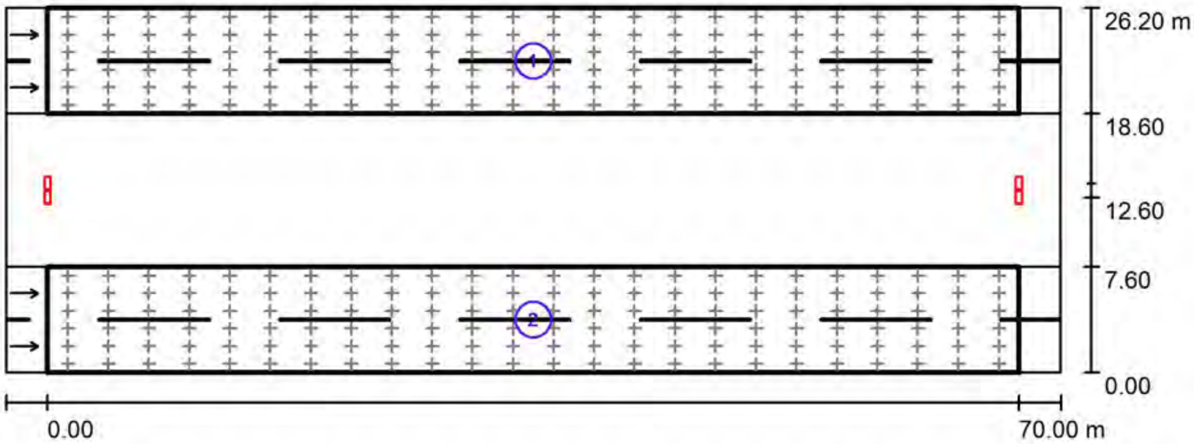
SCHREDER AMPERA MAXI 5138 - 128 Cree XP-G2 700mA NW 230V Flat, Glass Extra Clear, Smooth 357172
Article No.:
Luminous flux (Luminaire): 30970 lm
Luminous flux (Lamps): 36759 lm
Luminaire Wattage: 279.0 W
Luminaire classification according to CIE: 100
CIE flux code: 43 78 97 100 84
Fitting: 1 x 128 Cree XP-G2 (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results



Light loss factor: 0.80

Scale 1:544

Calculation Field List

1 Valuation Field 2x3.8m carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.97	0.51	0.70	11	0.94

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Photometric Results

Calculation Field List

2 Valuation Field 2x3.8m Carriageway
Length: 70.000 m, Width: 7.600 m
Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

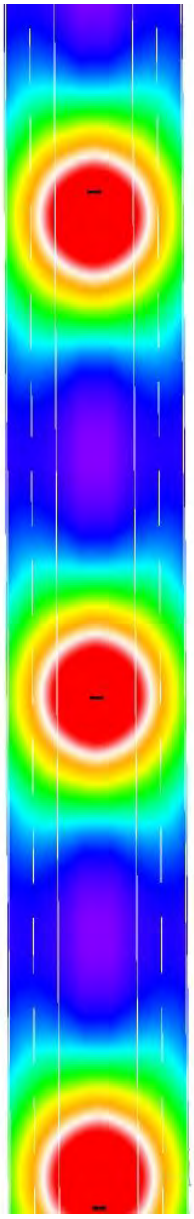
L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.97	0.51	0.70	11	0.94

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / 3D Rendering

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

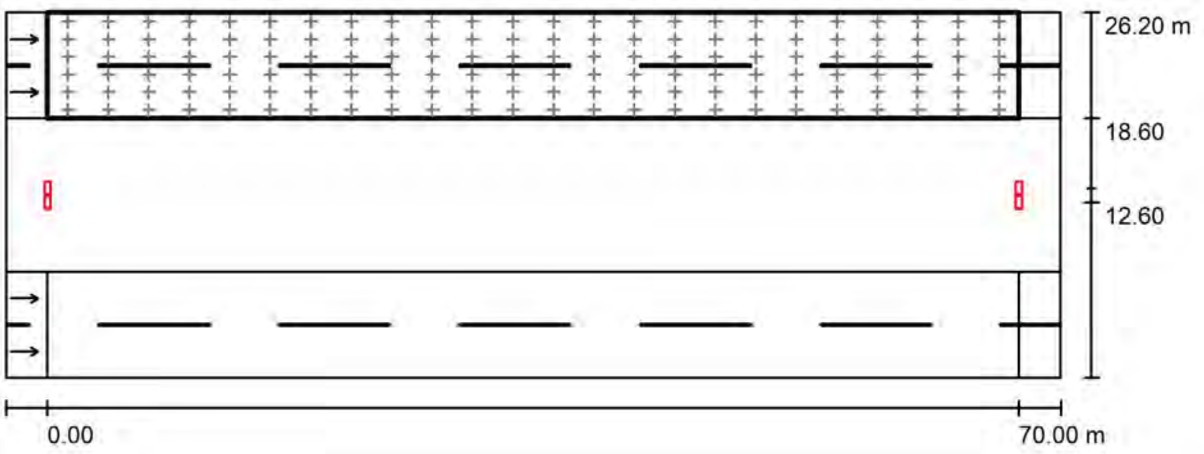
LED 1 / False Color Rendering



0	4.95	10.01	14.96	20.02	24.97	30.03	34.98	40.04	lx

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m carriageway / Results overview



Light loss factor: 0.80 Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

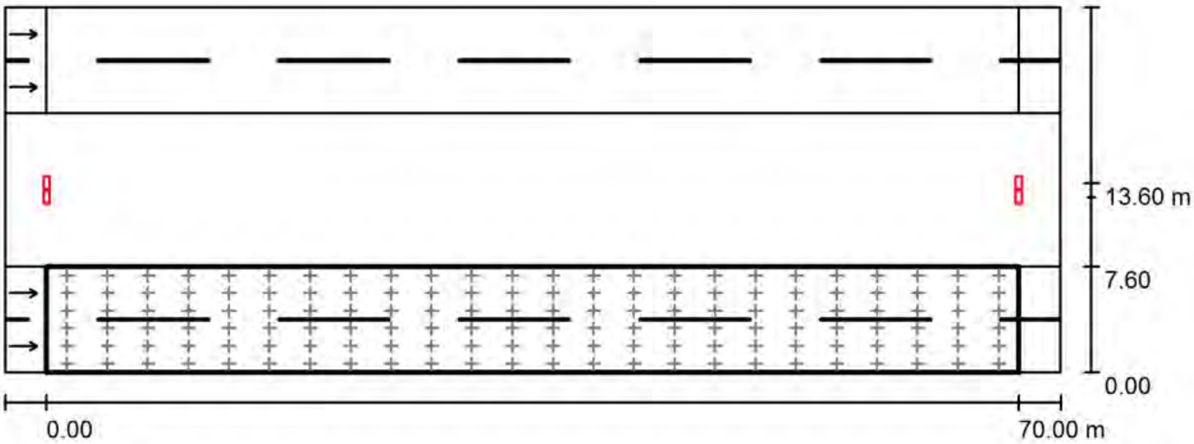
L_{av} [cd/m²]	U0	Ul	TI [%]	SR
0.97	0.51	0.70	11	0.94

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Observer 3	(-60.000, 20.500, 1.500)	0.97	0.57	0.74	11
2	Observer 4	(-60.000, 24.300, 1.500)	1.11	0.51	0.70	9

Operator Aisha Al Shehhi
Telephone
Fax
e-Mail

LED 1 / Valuation Field 2x3.8m Carriageway / Results overview



Light loss factor: 0.80

Scale 1:544

Grid: 24 x 6 Points
Accompanying Street Elements: 2x3.8m Carriageway.
tarmac: R4, q0: 0.080
Selected Lighting Class: ME3b

L_{av} [cd/m²]	U0	UI	TI [%]	SR
0.97	0.51	0.70	11	0.94

Assigned observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	UI	TI [%]
1	Observer 1	(-60.000, 1.900, 1.500)	1.11	0.51	0.70	9
2	Observer 2	(-60.000, 5.700, 1.500)	0.97	0.57	0.74	11