“STUDIES AND SIMULATION BASED LIGHTING DESIGN OF APRON AREAS”

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ABSTRACT

Outdoor lighting design is a challenging field for all beginners due to their vast complex city and trial and error approaches. Especially in apron lighting design trial and error approaches can be performed to optimise use of luminaires in simulation design purposes. Many software components mainly like dialux 4.13 use for analysis purpose to obtain photometric parameters (uniformity, horizontal illuminance, vertical illuminance) etc.

In this thesis these photometric parameters (horizontal illuminance, vertical illuminance and uniformity) were obtained. These photometric parameters were varied with their standard values mentioned in "National Lighting Code". Photometric parameters were plotted individually for horizontal illuminance, vertical illuminance and uniformity. These characteristics were shown how much increment or decrement was happened by these photometric parameters (horizontal illuminance, vertical illuminance and uniformity). After that detailed cost calculation has been done and characteristics were plotted.

Keywords: optimization, photometric parameters, dialux 4.13, increment or decrement, cost calculation.

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CHAPTER 1

INTRODUCTION

1. Introduction

The outdoor lighting is one type of lighting where outdoor places like streets, building (outside), roads, seaports, apron bays etc are illuminated to perform visual tasks and provides safety for appropriate environment and also provide visual comfort for pedestrians.
The purpose of outdoor lighting is to increases the efficiency of human activities during the time when it is dark to make production, transportation, construction, city beautifications, maintenance purposes in hangers and seaports for goods loading and unloading in yards, ports, beautification of sculptures in public places like garden, roads, prestigious monuments etc.

Safety is always important but the emphasis given to task performance and the appearance of the outdoor lights will depend on the nature of the outdoor.

Lighting requirements are based on the following lighting engineering criteria:

- Lighting level.
- Luminance distribution.
- Glare restriction.
- Direction of incidence of light and shadow effect.
- Colour appearance and colour rendering.
- Good uniformity value for spreading light in equal areas.
- Visual comfort for pedestrians and workers.

A lighting installation can satisfy the requirements laid down, only if all the quality criteria was complied with; one or other quality criteria may be given priority, depending on the nature and difficulty level of the visual task or area of outdoor lighting.

The main objective of outdoor lighting is to achieve standard illumination level mentioned in national lighting code and to improve the uniformity of that particular area where visual performance happened. Visual performance is a task that can be done by achieving proper arrangement of lighting fixture and required illumination level. Outdoor illumination designed in such a manner that one can perform task like walking, car driving, playing in field, parking etc.

Outdoor lighting requirements can vary in proportion to the function of space, numbers of people and their activities and the periods of their activities. [1]

Fig no. 1 outdoor lighting. [1]

In this project it has compared the standard values giving in "National Lighting Code" with measured lighting values and standard uniformity values with measured uniformity values.

These values can be obtained through the simulation software dialux 4.13.

1.1 Objectives

In this project main objectives were listed below;

- Obtain average horizontal illuminance, average vertical illuminance and uniformity. After that, obtain values are matching with standard value mentioned in "National Lighting Code 2010".

- After matched these values with standard values comparison characteristics were shown for horizontal illuminance, vertical illuminance and uniformity.

- After that detail cost calculation and its analysis took place.

1.2 Scope

In this lighting design first obtain the parametric values (vertical illuminace, horizontal illuminance and uniformity) which are related to the apron lighting design. These obtain values were matched with the standard values which are mentioned in "National Lighting Code". These standard values and obtain values were varied with different pole heights to see the variation between standard values and obtain values. After variation a comparison characteristics is obtain for horizontal illuminance, vertical illuminance and uniformity to show the variation of parameters with respect to their mounting heights of luminaires. After parametric comparison was done, detailed cost calculation is happen. After cost calculation, detailed characteristics were done to show the design cost of the apron for different values of height.

CHAPTER 2

APRON LIGHTING

2.1 Apron lighting

An apron is a fixed area on a land aerodrome which intended to accommodate aircraft for the purpose of loading and unloading passengers, mail or cargo, refuelling, parking or maintenance. Aircrafts would normally be expected to move into these areas under their own power or with the help of the towing car. In apron area sufficient lighting design is necessary to enable these tasks to be performed safely and efficiently at night. The part of the apron containing the aircraft stands requires a relatively high level of illuminance. The size of each aircraft stand is largely defined by the size of the aircraft and the amount of space necessary to occupy for the aircraft safely into and out of this position.

2.1.1 Functions of apron lighting

The primary functions of apron floodlighting are as below:

- To guide pilots in taxiing the aircraft into and out of the final parking position.
- To provide suitable lighting for passengers to onboard and off board of the aircraft and for personnel to load and unload cargo, refuel and perform other apron service functions.
- To maintain airport security.

2.2 Aircraft Taxiing

The pilot mainly depends on apron floodlighting when taxiing on the apron. Uniform illuminance of the pavement, within the aircraft stand and elimination of glare are major requirements. On taxiways adjacent to aircraft stands, a lower illuminance is desirable in order to provide a gradual transition to the higher illuminance on the aircraft stands. []

2.3 Apron Service

These functions require uniform illuminance of the aircraft stand area of a sufficient level to perform most of the tasks. In case of unavoidable shadows, some tasks may require supplementary lighting.

2.4 Airport Security

Airport security is the main issue to solve by proper apron lighting design in apron areas. In apron areas illuminance should be sufficient to detect the presence of unauthorized persons on the apron and to enable identification of personnel on or near aircraft stands.

2.5 Performance Requirements

A variety of light sources are used for airport area floodlighting. The spectral distribution of these light sources will be such that all colours used for aircraft markings connected with routine servicing, and for surface and obstruction markings, can be correctly identified.

Practice has shown that incandescent halogens as well as different high pressure gas discharge lamps are suitable for this purpose. Discharge lamps by the nature of their spectral composition will produce colour shifts which is an advantage for these lamps. Therefore, it is really helpful to check the colours produced by these lamps under daylight as well as artificial light to ensure correct colour identification. Occasionally it may be advisable to adjust the colour scheme used for the surface and obstruction markings. LED lamps also have same spectral composition to produce colour shift and really helpful to performing any task in apron areas.

2.5.1 Illuminance requirement

An average illuminance of not less than 20 Lux is needed for colour perception and is considered the minimum requirement for the tasks to be carried out on the aircraft stands. In order to provide optimum visibility, it is essential that illuminance on the aircraft stand be uniform within a ratio of 4 to 1 (average to minimum). In this connection, the average vertical illuminance at a height of 2 m should not be less than 20 Lux in the relevant directions. To maintain acceptable visibility conditions, the average horizontal illuminance on the apron, except where service functions are taking place should not be less than 50 percent of the average horizontal illuminance of the aircraft stands within a Horizontal uniformity ratio of 4 to 1 (average to minimum) in this area. It is recognized that some visual tasks require additional supplementary lighting, for example, portable lighting. However, the use of vehicle headlights for purposes other than guidance during driving should be avoided. For security reasons additional illuminance greater than that specified above may be required. The areas between aircraft stands and the apron limit (service equipment, parking area, service roads) should be illuminated to an average horizontal illluminance of 10 Lux. If the higher mounted floodlights do not light this adequately, then glare free lighting of the street lighting type could be used. [2]

The vertical illuminance of apron should be maintained in 20 Lux. The horizontal illuminance of the apron should be maintained in 20 Lux. The Horizontal uniformity should be maintained in 0.25.

In Table no-1 the table all requirements parameters are mentioned for apron lighting design.
Table no-1 Standard values of all essential parameters. [3]

Vertical illuminance E_v (Lux)	20
Horizontal illuminance E_h (Lux)	20
Horizontal uniformity U_0	0.25

2.5.2 Glare

Aiming of floodlights should be arranged as far as practicable in the directions away from the control tower or landing aircraft. Direct light above the horizontal plane through a floodlight should be maintained to the minimum as much as possible.

To minimize direct and indirect glare:

- The mounting height of floodlights should be at least two times the maximum eye height of pilots inside the aircraft regularly using the airport.

- The location and height of the masts should be such that inconvenience to ground personnel due to glare is kept to a minimum.

- The aiming of flood-lights should be as far as practicable, in the direction away from the control tower or landing aircraft. Direct light above the horizontal plane through a flood-light should be restricted to the minimum level.

In order to meet these requirements, floodlights will have to be aimed carefully, giving due consideration to their light distribution. Light distribution may be controlled by the use of screens.

Perfect mounting height is an effect to avoid glare. So mounting height of luminaire should be maintained to avoid glare in apron area.

In Fig no. 2 showed the perfect mounting height to avoid glare.

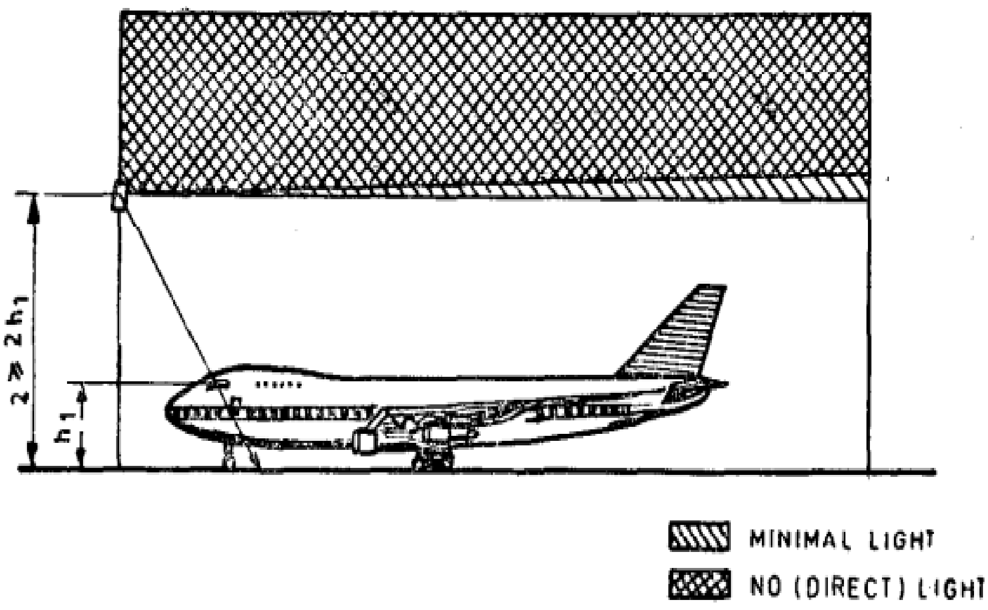

Fig no. 2 mounting height to avoid glare. [2]

Aiming of light source was one of the most valuable criteria to avoid glare in apron area. It should be done in such a way that glare in apron area should be minimizes.

In Fig no. 3 showed the perfect floodlight aiming to avoid glare.

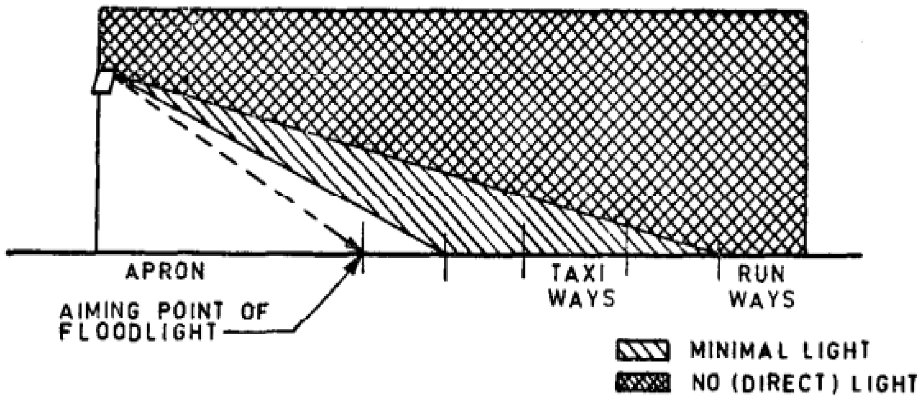

Fig no. 3 aiming to avoid glare. [2]

In apron lighting design various types lighting arrangement were used. In here mainly two types of lighting arrangement were discussed. They were nose in parking lighting system and other one is parallel parking lighting system.

Nose in parking lighting system was one type of lighting system where lighting arrangement were done in one side of apron area.

In Fig no. 4 showed lighting arrangement for nose in parking.

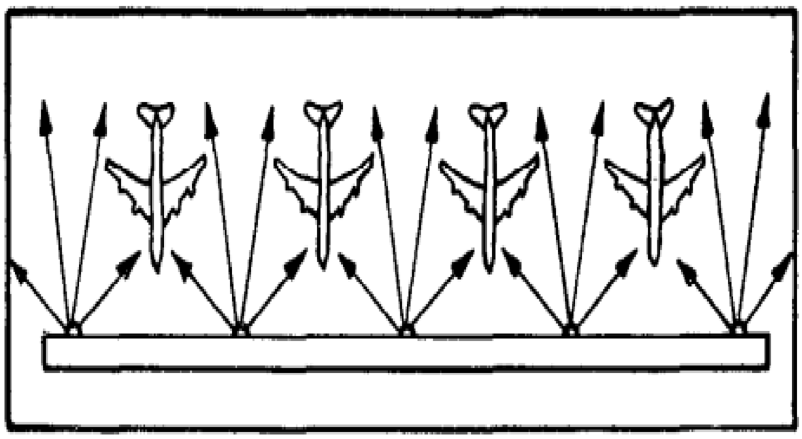

Fig no. 4 arrangement for nose in parking. [2]

Parallel parking lighting system was one type of lighting system where lighting arrangement can be done in both side of apron area.

In Fig no. 5 parallel parking arrangement were shown.

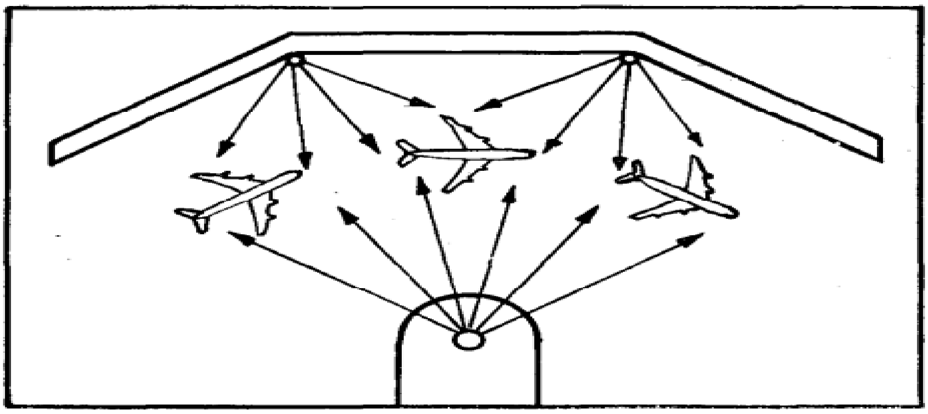

Fig no. 5 Arrangement for parallel parking. [2]

In this Fig no. 6 described that amount of light were distributed on horizontal surface of the apron area. This light distribution was visualized by isolux curve.

In this figure taxiway was a connecting roadway between apron area and runway.

In Fig no. 7 showed typical isolux curve for horizontal illuminance.

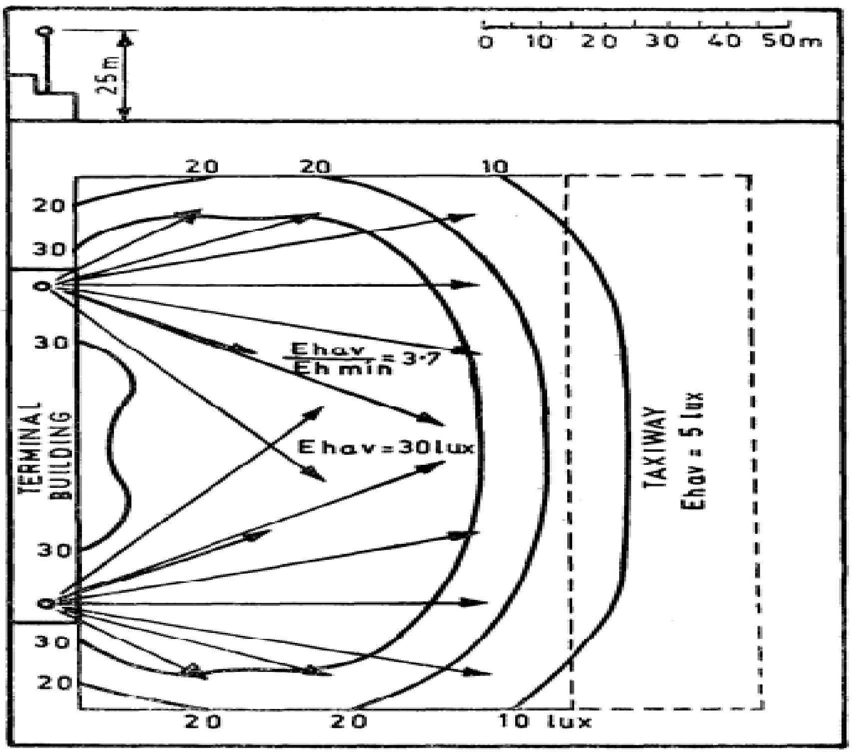

Fig no. 7 typical isolux curve for horizontal illuminance. [2]

In this Fig no. 8 described that amount of light were distributed on vertical surface of the apron area. This light distribution was visualized by isolux curve.

In this figure taxiway was a connecting roadway between apron area and runway.

Vertical illuminance at 2 m. height denoted that viewing height of the object which pilot can be seen.

In Fig no. 8 showed typical isolux curve for horizontal illuminance.

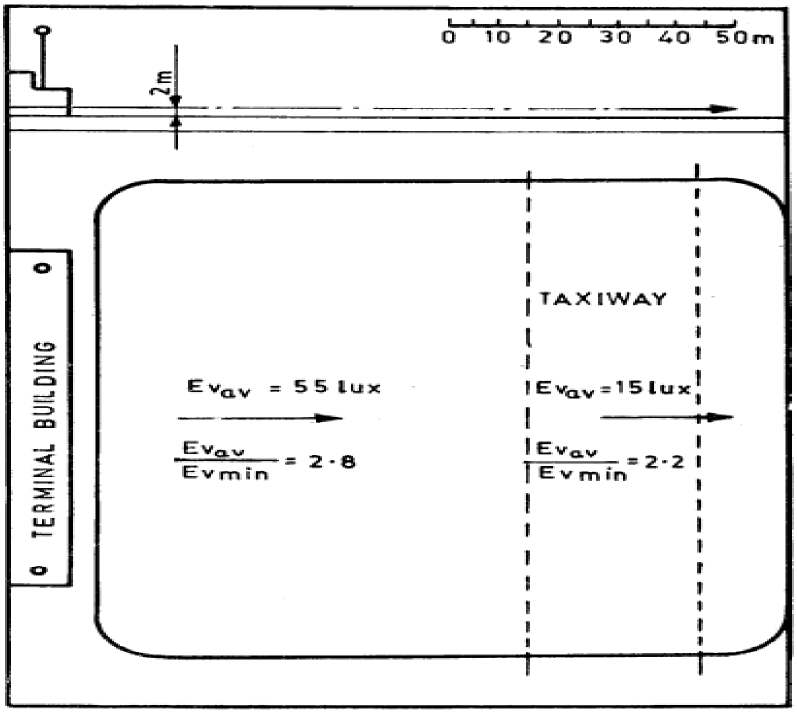

Fig no. 8 typical average vertical illuminance at 2m height. [2]

In this Fig no. 9 described that amount of light were distributed on horizontal surface of the apron area. This light distribution was visualized by isolux curve. Luminaires were mounted on top of the tower.

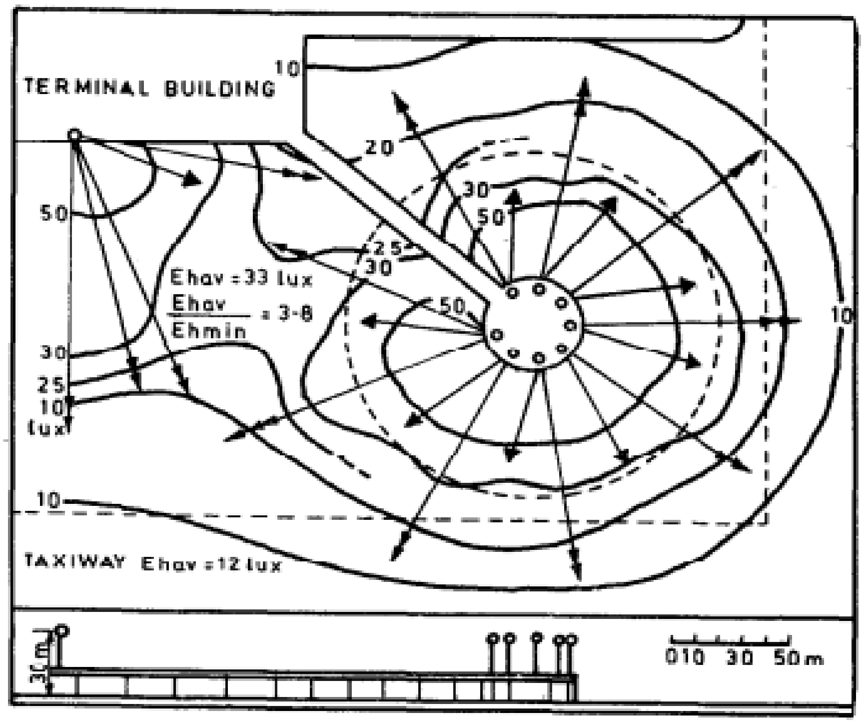

Fig no. 9 typical isolux curves for horizontal illuminance. [7]

In this Fig no. 10 described that amount of light were distributed on vertical surface of the apron area. This light distribution was visualized by isolux curve. Luminaires were mounted on top of the tower.

Vertical illuminance at 2 m. height denoted that viewing height of the object which pilot can be seen.

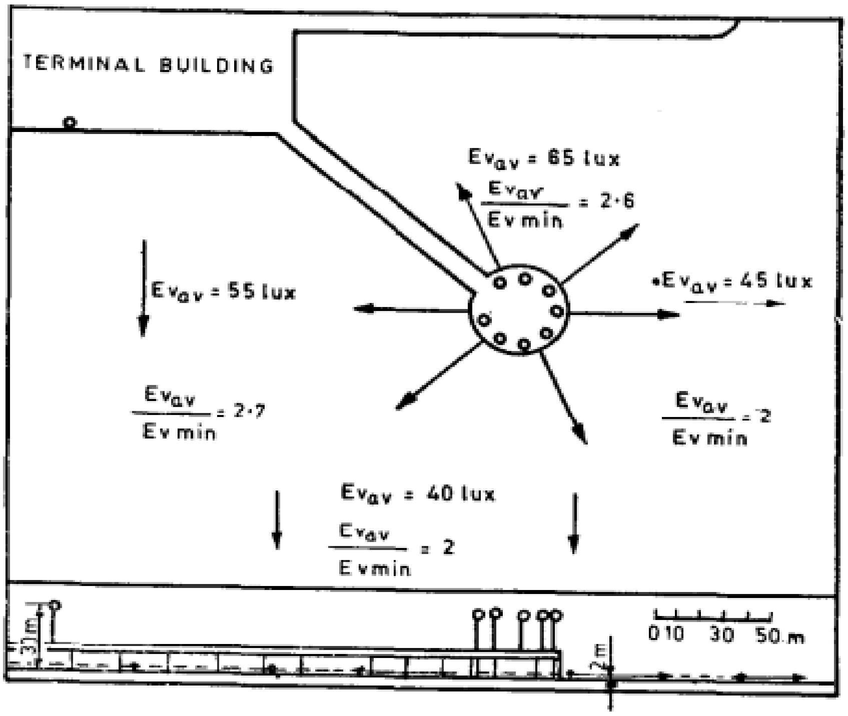

Fig no. 10 typical average vertical illuminance at 2 m. height. [2]

2.6 Emergency Lighting

In the event of a power failure, it is recommended that provision be made for sufficient illumination to ensure passenger safety.

2.7 Obstruction Lights

Each flood-light tower should be provided with sufficient numbers of omni-directional obstruction lights with red prisms. The optical system of each fixture should consist of two specially designed aviation red prismatic glass domes to give a symmetric light distribution. Obstruction light shall have intensity sufficient to ensure conspicuity considering the intensity of the adjacent lights land the general level of illumination against which they would normally be viewed. In no case shall the intensity be less than 10 candelas of red light. The glass domes should have smooth exterior with prisms on the inside surface.

2.8 Design Criteria

2.8.1 Lighting aspects

In addition to the design criteria derived from the performance requirements, the following aspects should be considered in designing an apron floodlighting system.

- The height of the apron floodlighting masts should be in accordance with the relevant obstacle clearance requirements.
- Obstructions to the view of control tower personnel should be avoided. In this respect special attention should be paid to the location and height of the floodlighting towers.
- The arrangement and aiming of floodlights should be such that aircraft stands receive light from different directions to minimize shadows. Better results are obtained by uniform illuminance of the total area than by directing individual floodlights at the aircraft.
- Consider the aircraft wing clearance tolerances for design purposes.

2.8.2 Physical aspects

During the design stage of an airport due consideration should be given to the physical aspects of the apron in order to provide efficient apron floodlighting. The ultimate choice of the location and height of the floodlights relies on:

- Dimension of the apron.
- Arrangement of aircraft stands.
- Taxiway arrangement and traffic scheme.
- Adjacent areas and buildings especially for the control tower.
- Location and status of runways and helicopter landing areas.

2.8.3 Electrical aspects

- If discharge lamps are used, a three phase electrical supply system should be utilized in such a manner that discharge lamps should not encounter any stroboscopic effects.
- If high pressure discharge lamps are used, then emergency lighting fan should be arranged by either halogen incandescent lamps or by special circuitry of some of the high pressure discharge lamps (dedicatedly on UPS).

- If LED lamps are used 3phase supply line should be utilized in such a manner that it did not face any major problems and connection of wire is done as per Indian standard design. Battery backup system should be provided for LED lamps in case any major fault occurs then this backup system will delivered power.

- Lightning arrester protection should be provided at the top of the lighting tower.

2.8.4 Maintenance aspects

The lighting system should be so designed that maintenance expense can be held to a reasonable value. If access to lights is difficult, it is most economical to change lamps on a group replacement basis. Since cost of replacing lamps in high mounted lights can be significant, long life lamps should be used, where possible, the lights should be so placed that they will be easily accessible without using special equipment. Tall poles could be equipped with pole steps or raising and lowering devices for servicing.

2.9 Light Sources

2.9.1 Selection of light source

Some consideration or features has been taken for selection of light sources as below;

- Luminous efficacy of light source.

- Optical control of light source.

- Colour appearances of light source.

- Colour rendering of light source.

2.9.2 Spectral distribution of light source

Spectral distribution of light source should be happened in such a manner that all colour used for aircraft marking connected with routine servicing and surface and obstruction marking can be correctly identified.

From the point of view of energy conservation due consideration should be given in the selection of the lamps.

2.10 Luminaires

The optical system of the luminaires is the most important criteria for apron lighting design. Depending upon location of the luminaires and what area to be covered, symmetrical, asymmetrical or double asymmetrical distribution of flood-lighting system can be selected for the requirement. The flood light again can be divided into wide beam or narrow beam type, which can be used as per requirement.

2.11 Supplementary Lighting

Wherever general illumination is not sufficient but requires higher illumination for a particular task or to improve Horizontal uniformity at desired level or to minimize the shadows, supplementary lighting is provided by using portable telescopic mast.

The lighting system should be designed in such a manner that the maintenance expenses can be minimised to a reasonable value. If access to luminaires is difficult, the light sources would be changed on a group replacement basis. Since the cost of replacing light sources in high mounted luminaires can be significant, long life light sources should be provided to avoid frequent replacements. Where possible the luminaires should be placed in such a manner that they will be easily accessible without using special equipment. Tall poles should be equipped with pole-steps or raising and lowering devices for maintenance purposes.

2.12 Earthing

All flood-light fittings, obstruction lights and emergency light fittings and their accessories will be earthed with the flood-light tower as per the requirements given in the relevant Indian Standards. [4]

2.13 Testing

Luminaire and other accessories would be tested as per Indian Standard.

CHAPTER 3

APRON LIGHTING DESIGN SIMULATION

3. Apron Lighting Design Simulation

Various types of software were available in the market to design outdoor lighting. The best software used for design the apron lighting was dialux 4.13.

Dialux 4.13 was best software due to user friendly interface, ies files were easily accessible and this software can easily accessible in internet. So this software was used for lighting simulation purposes.

DIALUX is software developed by DIAL GmbH of Germany for the purpose of lighting system planning & design utilizing its standard library of objects. DIALUX enables one to plan the lighting in a room, scene, building or even outdoors. It utilizes the luminaire catalogues of the leading luminaire manufactures of the globe and a designer can avail these with requisite permission from the manufactures to incorporate into lighting design. [5]

For a more realistic rendition, the programme can use various textures and outdoor equipment and it also uses an integrated ray-tracing module. To calculate illuminance for different user selected surfaces called as calculation surfaces and even seen in a 3-D view.

In this thesis, dialux 4.13 was used for lighting simulation.

3.1 Procedure for opening Dialux 4.13 to simulate exterior lighting

First step open dialux window in computer. After that, clicked new exterior project where exterior lighting can be drawn. In Fig no. 11 initial window for dialux was showed.

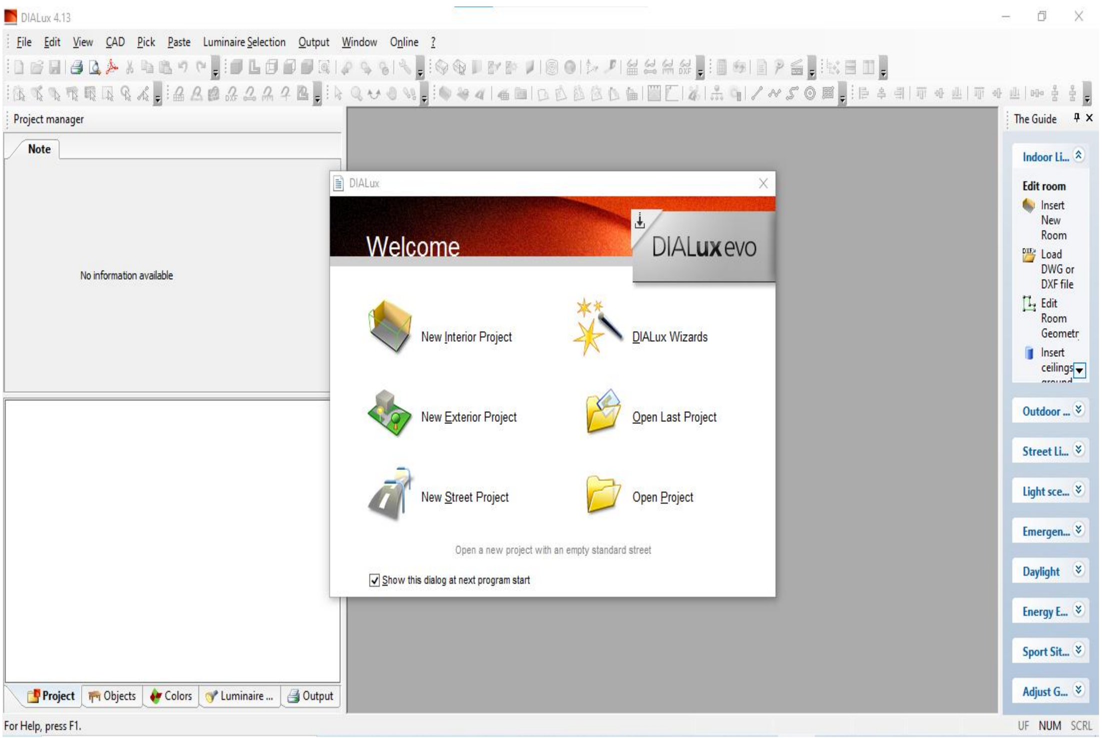

Fig no. 11 initial window for dialux 4.13.

Then open new exterior project where apron will be drawn. After opening new exterior project dialux window will appear like that in Fig no. 12. In two dimensional view inserted apron length and breadth to construct the required apron area. In beginning light loss factor set as per type of luminaire used in the thesis. In this thesis LED luminaires were used.

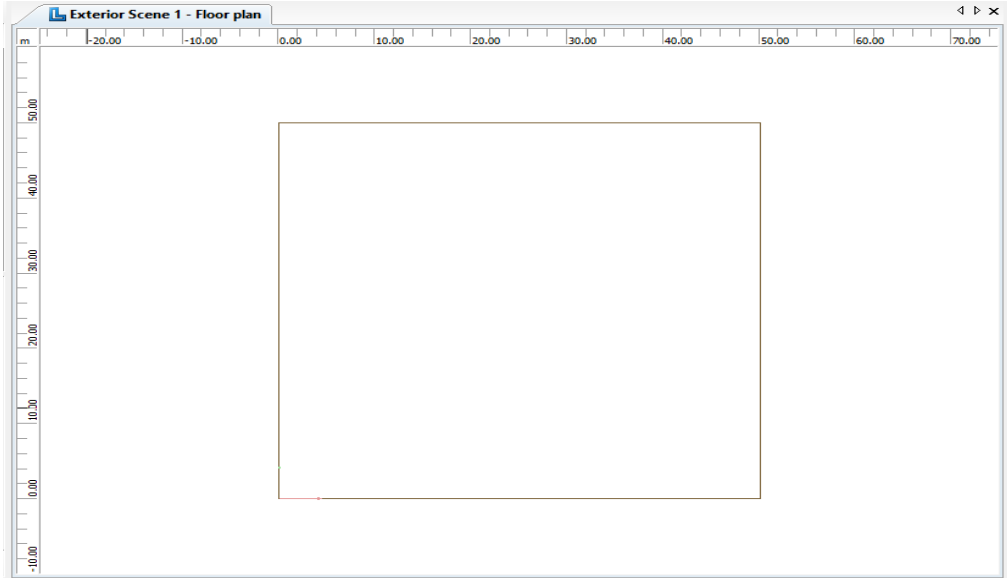

Fig no. 12 picture of exterior window.

After that select exterior ground elements and further designing process will proceed as per recomandatations.

In Fig no. 13 selection of exterior ground elements for outdoor lighting was shown.

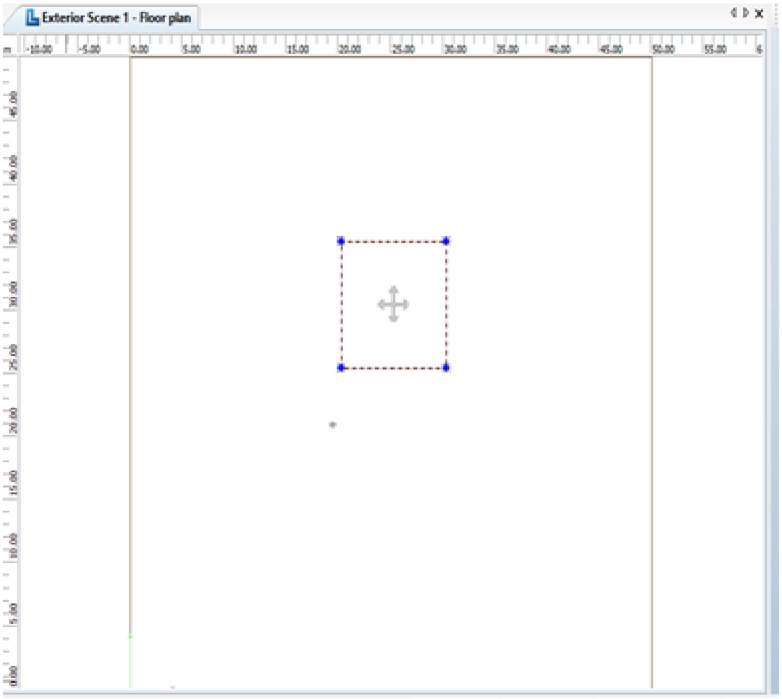

Fig no. 13 selections of ground elements for outdoor lighting design.

After design the apron insert Flood light luminaires in exterior scene for simulation purposes.

After that result will occurred in result section.

In given Fig no. 14 inserting the luminaires in given apron area.

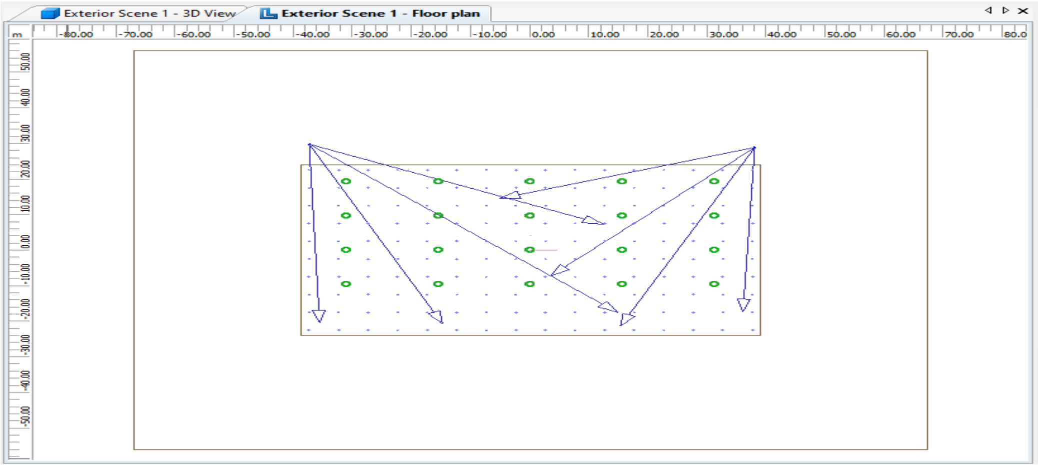

Fig no. 14 inserted of luminaires in given apron area

CHAPTER 4

SIMULATION RESULTS AND ANALYSIS

4.1 Simulation Results

In the apron lighting design for three specific apron areas like A_1 and A_2 were used in this thesis. In this thesis, it had been obtained three parameters; they are horizontal illuminance (E_{av}, H), vertical illuminance (E_{av}, V) and Horizontal uniformity (U_0, H). These parameters can be matched with same standard parameters, mentioned in "National Lighting Code 2010".

In this design phase we set the maintenance factor value as 0.8 for LED luminairs which are mentioned in "National Lighting Code 2010". In designing phase, asymmetrical luminairs used in the apron lighting design for better illumination.

According to "National Lighting Code 2010", mentioned standard parametric values of horizontal illuminance (E_{av}, H), vertical illuminance (E_{av}, V) and Horizontal uniformity (U_0, H) are used as a reference values. These reference values are used for comparative study between standard values and obtain values.

Standard values which are mentioned in "National Lighting Code 2010" as mentioned below; [21]

1. Horizontal Illuminance ($E_{av,}$ H) value is 20 Lux.

2. Vertical illuminance ($E_{av,}$ V) value is 20 Lux with 2m height.

3. Horizontal uniformity ($U_{0,}$ H) value is 0.25.

In the designing stage first we consider three apron areas (previously mentioned) which are denoted as A_1 and A_2. Numeric values of these areas were mentioned below;

1. A_1= (L_1 * B_1) = (77.816 * 48.034) m^2.

2. A_2= (L_2 * B_2) = (255 * 88.5) m^2.

Where;

A_1 and A_2 are two apron areas which were used in this thesis.

L_1 and L_2 are the length of the apron which was used in this thesis.

B_1 and B_2 are the breadth of the apron which was used in this thesis.

In this thesis 400 watt, 440 watt LED luminaires ies files were used.

In this thesis Calculation point has been taken (5.000 m*5.000 m).

The justification for choosing 400 watt and 440 watt instead of higher wattages were due to cost effective solution, less energy consumptions of luminaires and others issues encountered in lower wattages etc.

Tabular format of 400 watt luminaire detailed specifications i.e. luminaire name (which was used in simulation design), Luminous flux for luminaire (The lamp and the gear is mounted in the fixture and the luminous intensity distribution of the fixture was measured), Luminous flux for lamp (luminous flux of the bare lamp is measured) and Wattage of the Lamp were mentioned.

The 400 watt Luminaire details tabulation format shown in Table-2;

Table-2 Luminaire technical specifications

SL. NO	Type of Luminaire Used in The Thesis	Luminous Flux for Luminaire (Lumen)	Luminous Flux for Lamp (Lumen)	Wattage of Lamp (Watt)
1	Flood Light LED Luminaire	50000	50000	400

LDC Polar Plot

LDC Polar Plot represented the luminous intensity distribution of the flood light luminaire in polar diagram. LDC Polar plot shows beam angle of light source used in design i.e. narrow beam. In this polar plot lumen profile can be obtained from it.

In below Figure the LDC Polar Plot of 400 watt was shown in Fig no. 15;

LDC Linear Plot

LDC Linear Plot is one type of plot where luminous intensity distribution of light was shown. In this plot light intensity changes with small angular area increased.

The LDC Linear Plot of 400 watt Luminaire was shown in Fig no. 16;

Tabular format of 440 watt luminaire detailed specifications i.e. luminaire name (which was used in simulation design), Luminous flux for luminaire (The lamp and the gear is mounted in the fixture and the luminous intensity distribution of the fixture was measured), Luminous flux for lamp (luminous flux of the bare lamp is measured) and Wattage of the Lamp were mentioned.

The details tabulation format of 440 watt luminaire shown in Table-3;

Table-3 Luminaire technical specification

SL. NO	Type of Luminaire Used in The Thesis	Luminous Flux For Luminaire (Lumen)	Luminous Flux for Lamp (Lumen)	Luminaire Wattage (Watt)
1	Flood Light LED Luminaire	53096	52790	440.0

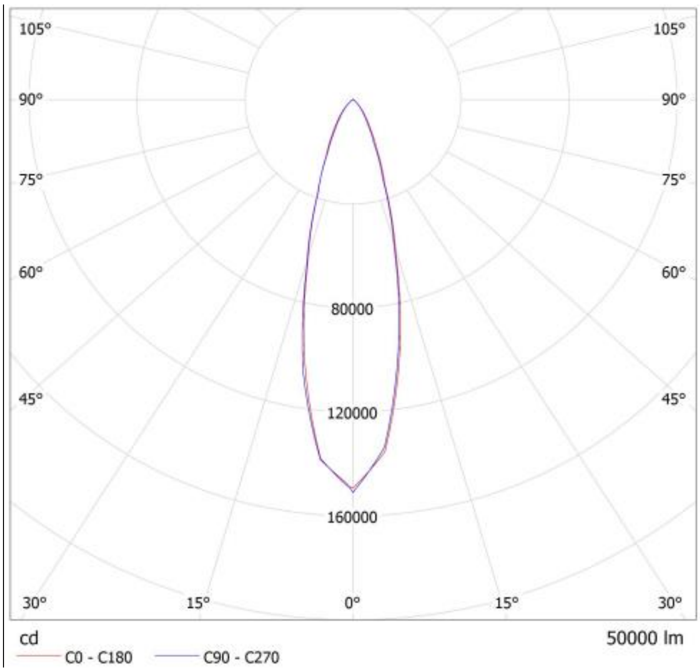

Fig no. 15 LDC polar plot of 400 watt luminaire.

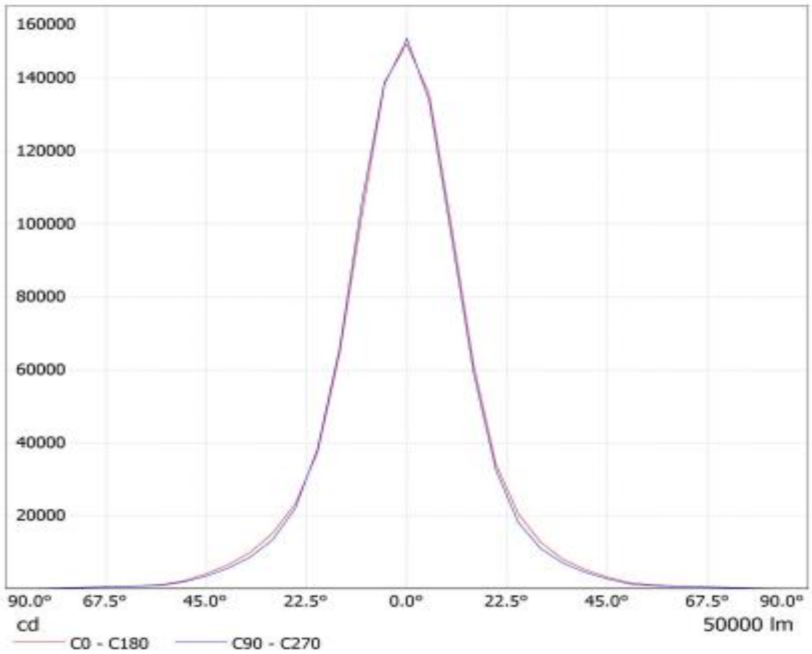

Fig no. 16 LDC Linear Plot of 400 watt luminaire.

LDC Polar Plot

LDC Polar Plot represented the luminous intensity distribution of the flood light luminaire in polar diagram. LDC Polar plot could provide us what types of light were used in design i.e. narrow beam. In this polar plot lumen profile can be obtained from it.

In below Figure the LDC Polar Plot of 440 watt luminaire was shown Fig no. 17;

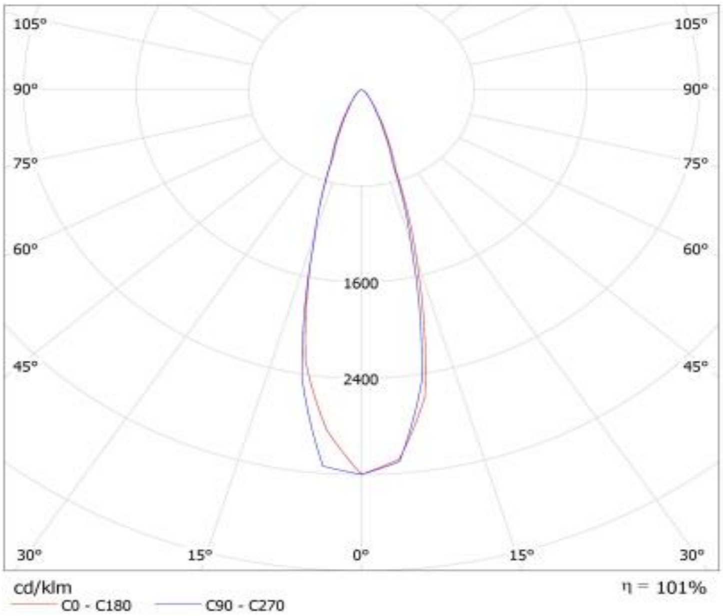

Fig no. 17 LDC polar plot of 440 watt luminaire.

LDC Linear Plot

LDC Linear Plot is one type of plot where luminous intensity distribution of light was shown. In this plot light intensity changes with small angular area increased.

The LDC Linear Plot of 440 watt Luminaire was shown Fig no. 18;

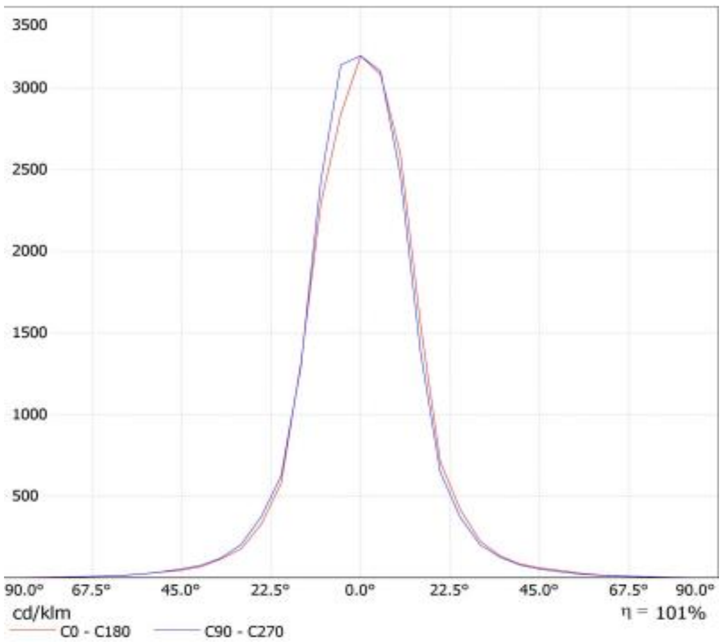

Fig no. 18 LDC Linear Plot of 440 watt luminaire.

4.1.1 Case-1a for apron area A_1 using 400 watt LED luminaires

In the 1a case apron lighting design let considering the apron Length is 77.816 m and Breadth is 48.034 m.

Calculation point in the apron area will be fixed in between (5.000 m*5.000 m) for achieving good result and good Horizontal uniformity in apron area.

In two dimensional view planned apron area can be shown and after that detailed analysis were done.

In Fig no. 19 planned apron area was shown.

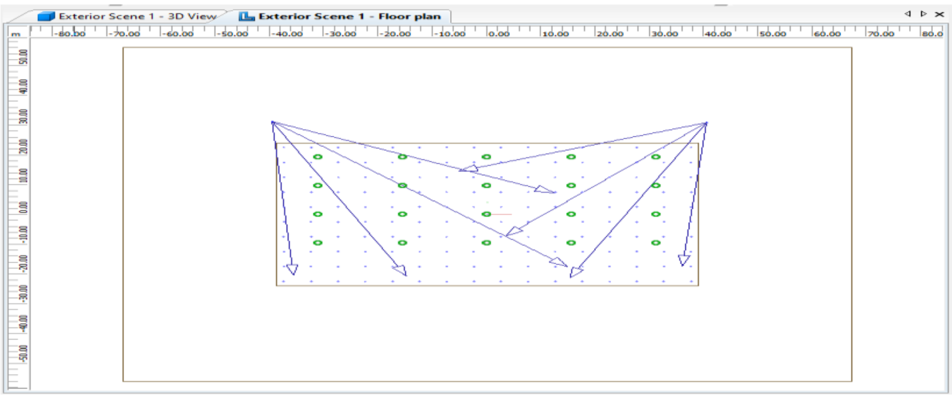

Fig no. 19 apron area A_1 in two dimensional view (for 400 watt luminaires).

Inserting 400 watt luminaires which specification details were tabulated in Table-4. In Table-4, it contained what type of luminaire used in design, no of luminaire used in design, Luminous Flux for Luminaire (The lamp and the gear is mounted in the fixture and the luminous intensity distribution of the fixture was measured), Luminous flux for lamp (luminous flux of the bare lamp is measured) and what type of Wattage of the Lamp was used were mentioned.

The Luminaires specifications details were given in Table-4;

Table-4 Luminaire Specifications

SL. NO	Type of Luminaire Used in The Thesis	No of luminaire used	Luminous Flux for Luminaire (Lumen)	Luminous Flux for Lamp (Lumen)	Luminaire Wattage (Watt)
1	Flood Light LED Luminaire	8	50000	50000	400

In Table-5 contained no of luminaire in each pole were used in apron design, total no of luminaire used in apron design, no of poles were used in apron design, light source wattage and its maintenance factor were mentioned.

The Luminaires Technical Specifications details were given in Table-5;

Table-5 Luminaires other Technical Specifications

No of luminaire in each pole	Total luminaire used in apron lighting	No of pole used in lighting design	Light source wattage Watt	Maintenance factor/Light loss factor
4	8	2	400	0.8

In Table-6, the main three parameters i.e. average illuminance horizontal (E_{av}, H), average illuminance vertical (E_{av}, V), Horizontal uniformity (U_0, H), and pole heights are mentioned. The comparison was done between standard value to obtain value for average vertical illuminance, average horizontal illuminance and Horizontal uniformity factor.

In Table-6, luminaire other parameter specifications were given.

Table-6 Luminaires Other Parameters Specifications

SL. NO	AVARAGE ILLUMINANCE HORIZONTAL (Eav, H) Lux		AVARAGE ILLUMINANCE VERTICAL (Eav, V) Lux		HORIZONTAL UNIFORMITY (U0, H)		POLE HEIGHTS (M)
	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	
1	20	39	20	37	0.25	0.39	16
2	20	40	20	34	0.25	0.33	18
3	20	40	20	32	0.25	0.30	20
4	20	40	20	30	0.25	0.28	22

Horizontal illuminance is the amount of light falling on horizontal activity plane. [6]

Vertical illuminance is the amount of light fall onto the vertical surface. [7]

Horizontal uniformity factor is the ratio between minimum lighting levels to average lighting level. [8]

Isolux diagram is a special type of diagram where it perceived the light distribution characteristics of luminaire. [9]

While changing the mounting height at 16 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 20.

Respective isolux diagram (horizontal illuminance) for 16 m height was given in Fig no. 20;

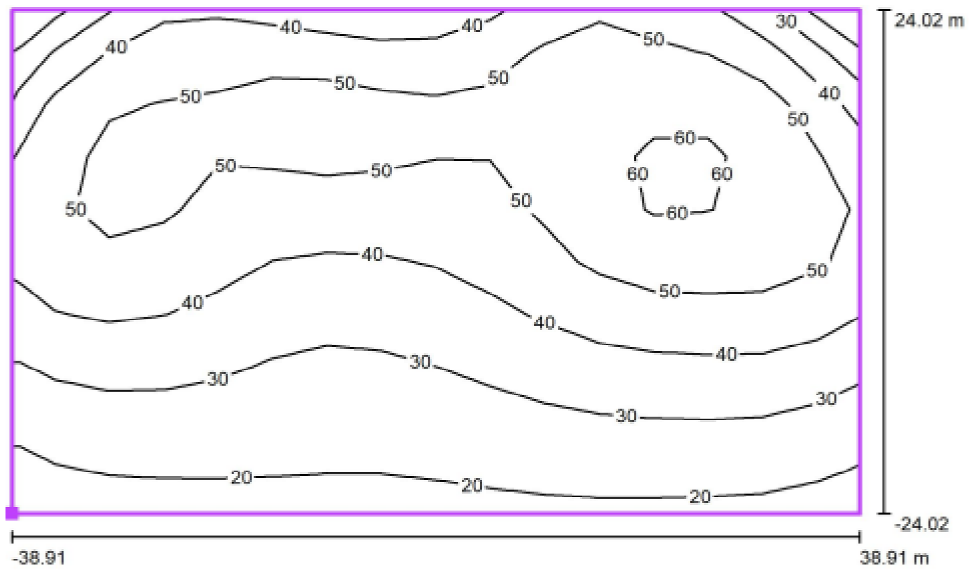

Fig no. 20 isolux diagram (horizontal illuminance) for 16 m pole height.

While changing the mounting height at 16 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 21.

Respective isolux diagram (vertical illuminance) for 16 m height was given in Fig no. 21;

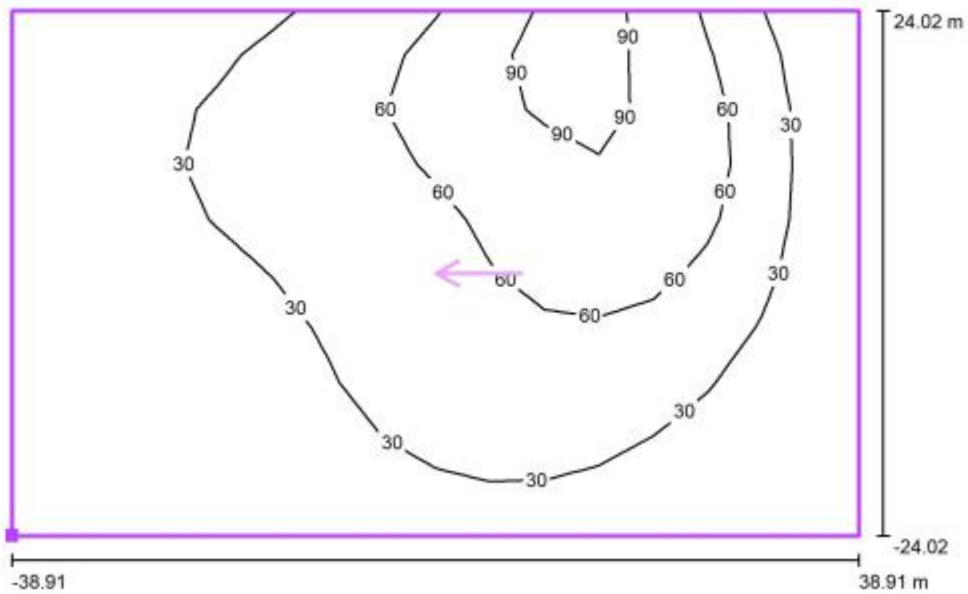

Fig no. 21 isolux diagram (vertical illuminance) for 16 m pole heights.

While changing the mounting height at 18 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 22.

Respective isolux diagram (horizontal illuminance) for 18 m height was given in Fig no. 22;

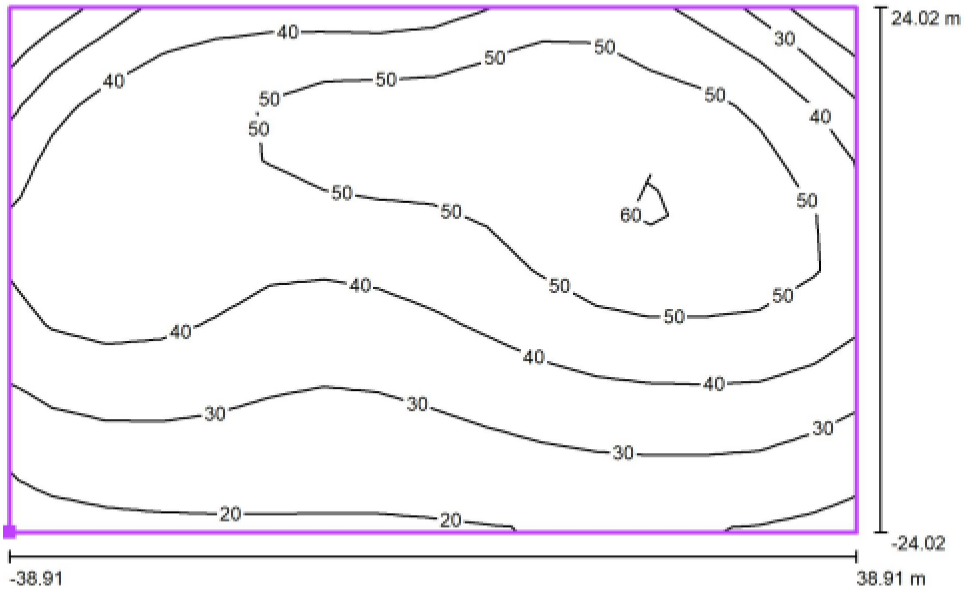

Fig no. 22 isolux diagram (horizontal illuminance) for 18 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 23.

Respective isolux diagram (vertical illuminance) for 18 m height was given in Fig no. 23;

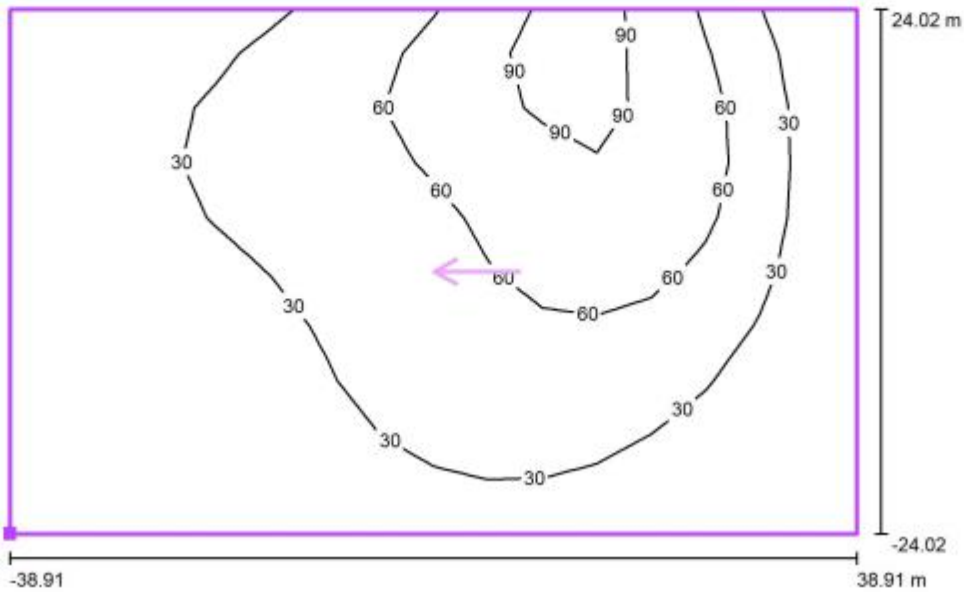

Fig no. 23 isolux diagram (vertical illuminance) for 18 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 24.

Respective isolux diagram (horizontal illuminance) for 20 m height was given in Fig no. 24;

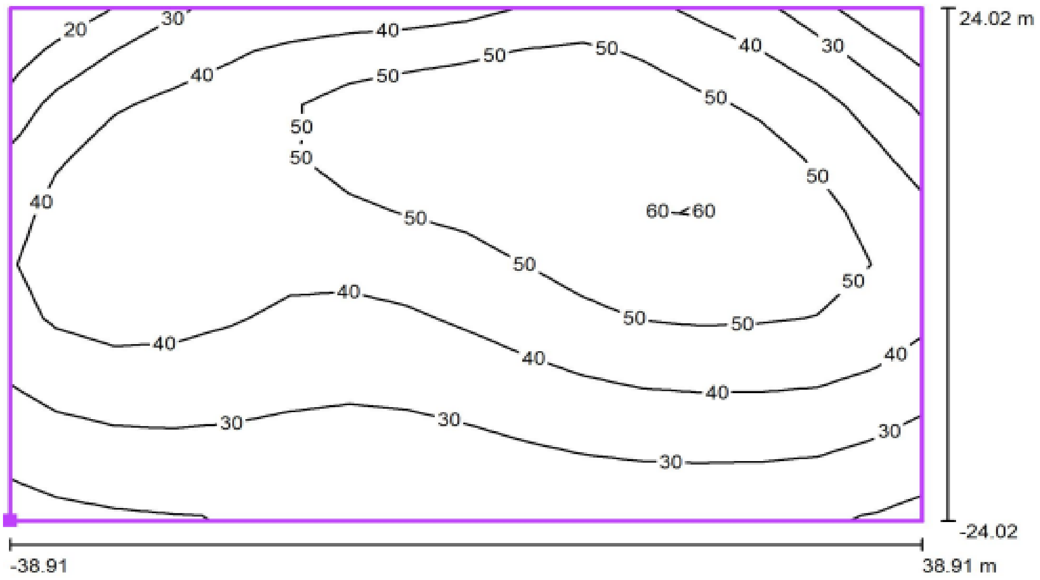

Fig no. 24 isolux diagram (horizontal illuminance) for 20 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 25.

Respective isolux diagram (vertical illuminance) for 20 m height was given in Fig no. 25;

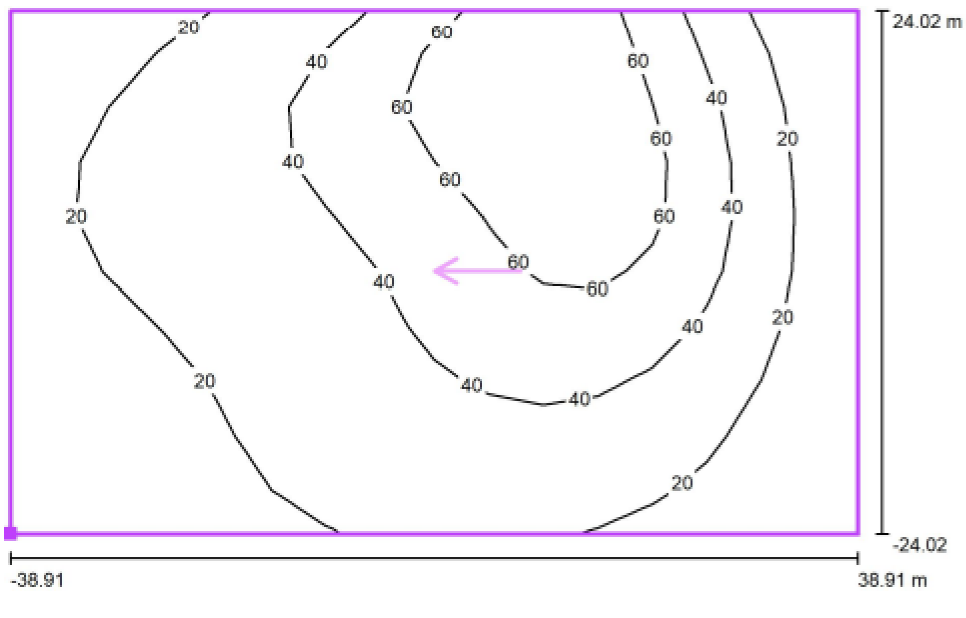

Fig no. 25 isolux diagram (vertical illuminance) for 20 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 24.

Respective isolux diagram (horizontal illuminance) for 22 m height was given in Fig no. 24;

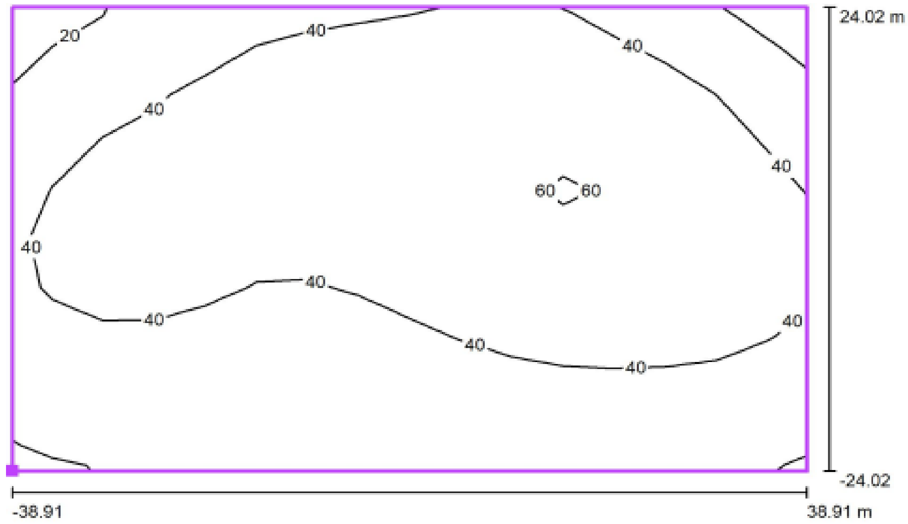

Fig no. 24 isolux diagram (horizontal illuminnce) for 22 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 25.

Respective isolux diagram (vertical illuminance) for 22 m height was given in Fig no. 25;

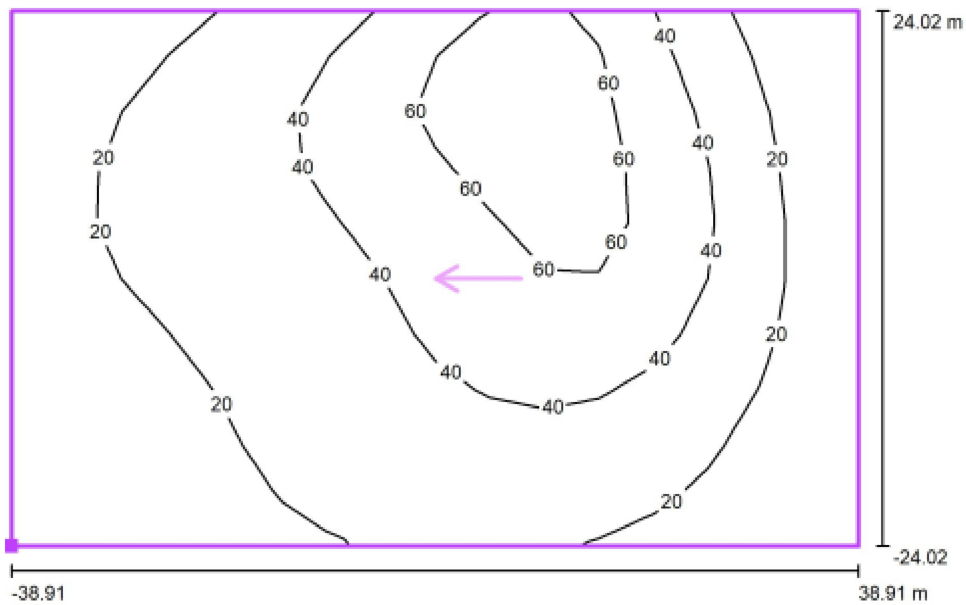

Fig no. 25 isolux diagram (vertical illuminance) for 22 m pole height.

Now in case of horizontal illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of horizontal illuminance was occurred.

In Fig no. 26 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

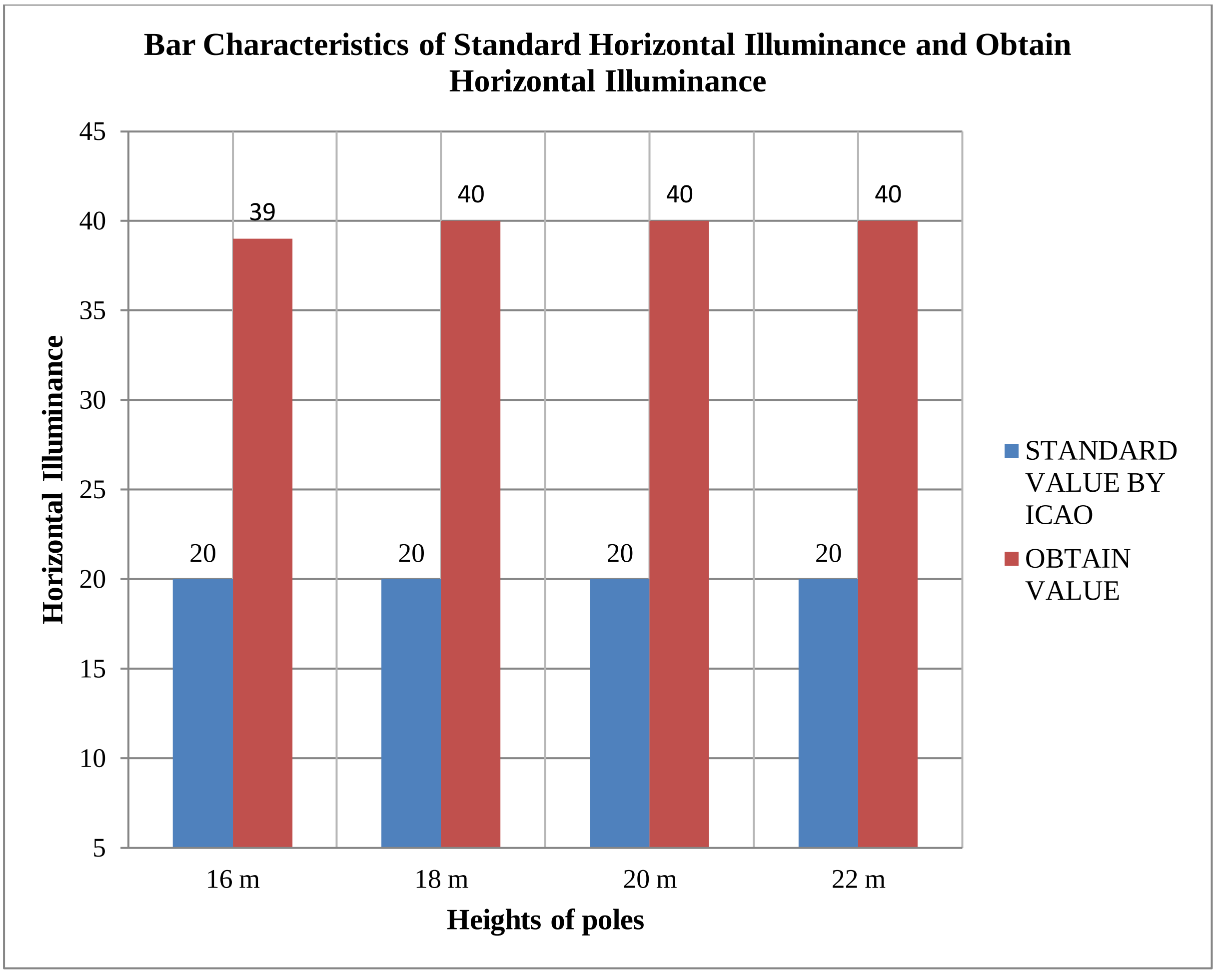

Fig no. 26 comparison plot between standard values and obtain values in case of horizontal illuminance.

Now in case of vertical illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Vertical illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In case of vertical illuminance, values were decreased when heights were increased.

In Fig no. 27 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

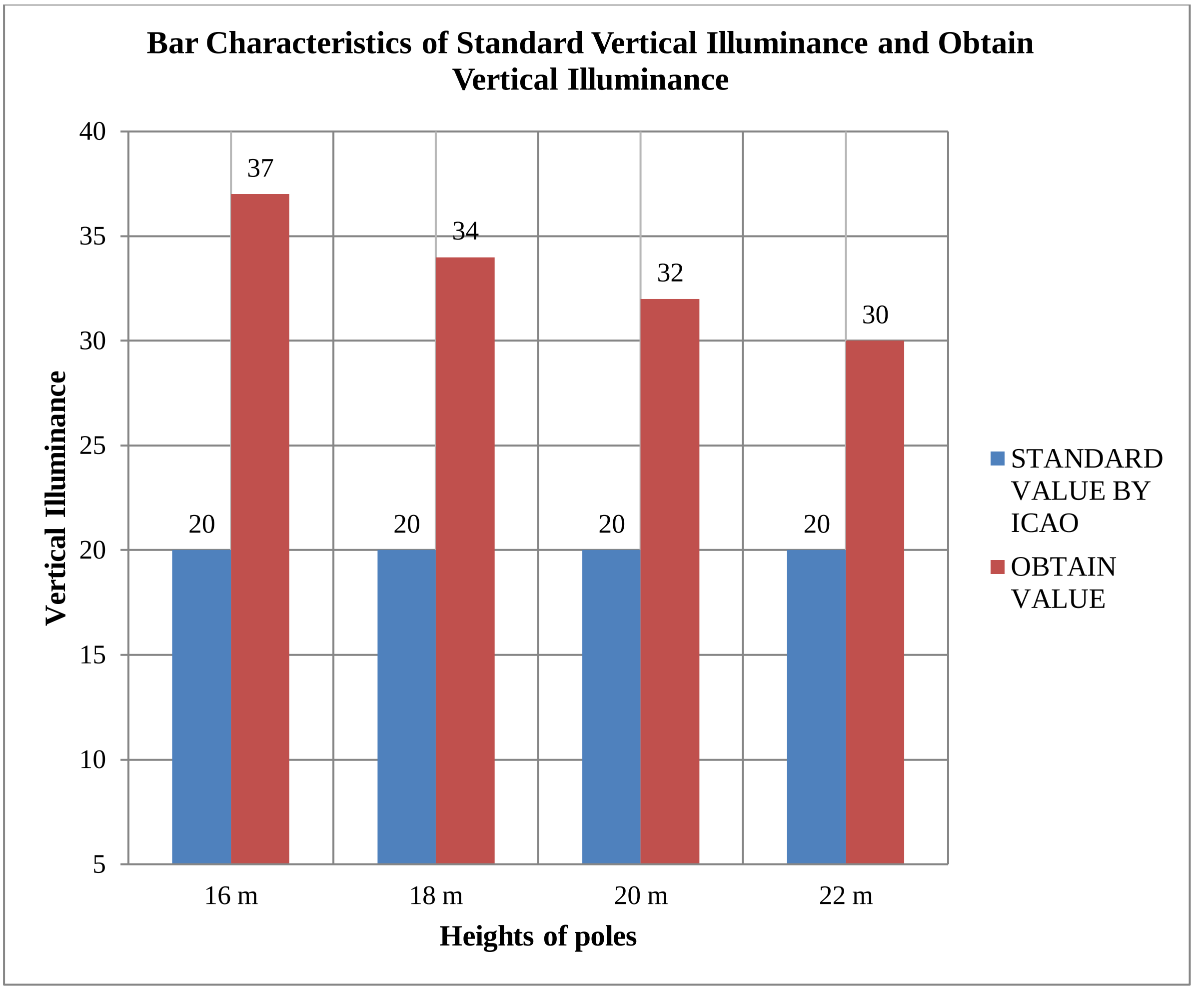

Fig no. 27 comparison plot between standard values and obtain values in case of vertical illuminance.

Now in case of Horizontal uniformity factor comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal uniformity factor can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In case of Horizontal uniformity, values were decreased when heights were increased.

In Fig no. 28 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

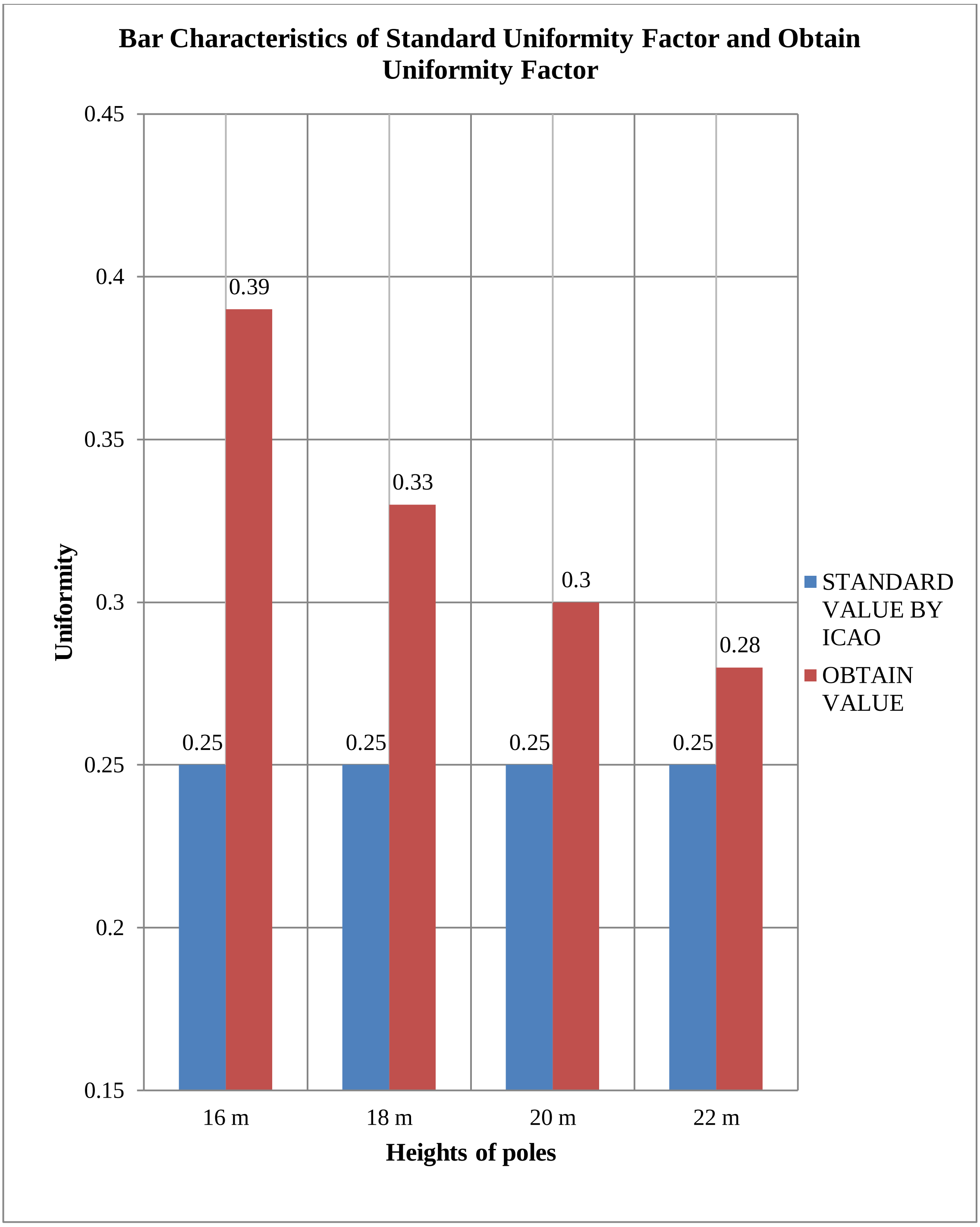

Fig no. 28 comparison plot between standard values and obtain values in case of Horizontal uniformity.

4.1.2 Case-1b for apron area A_1 using 440 watt LED luminaires

In the 1b case apron lighting design let considering the apron Length is 77.816 m and Breadth is 48.034 m.

Calculation point in the apron area will be fixed in between (5.000 m*5.000 m) for achieving good result and good Horizontal Uniformity in apron area.

In two dimensional view planned apron area can be shown and after that detailed analysis were done.

In Fig no. 29 planned apron area was shown.

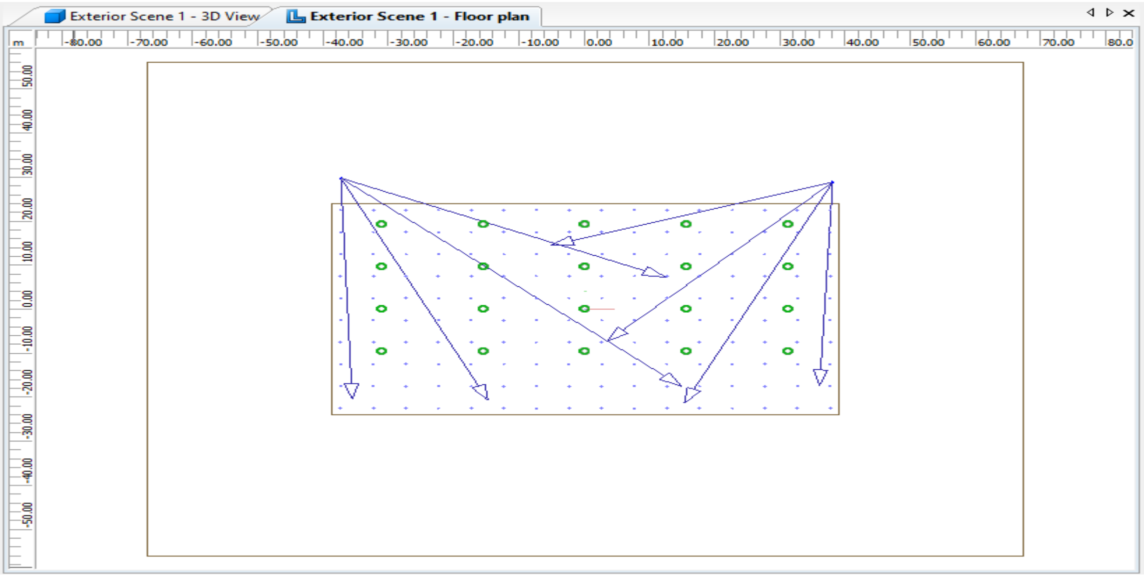

Fig no. 29 apron area A_1 in two dimensional view (for 440 watt luminaires).

Inserting 440 watt luminaires which specification details were tabulated below. In below tabular format, it contained what type of luminaire used in design, no of luminaire used in design, Luminous Flux for Luminaire (The lamp and the gear is mounted in the fixture and the luminous intensity distribution of the fixture was measured), Luminous flux for lamp (luminous flux of the bare lamp is measured) and what type of Wattage of the Lamp was used were mentioned.

The Luminaires specifications details were given in Table-7

Table-7 Luminaires Specifications

SL. NO	Type of Luminaire Used in The Thesis	No of luminaire used	Luminous Flux For Luminaire (Lumen)	Luminous Flux for Lamp (Lumen)	Luminaire Wattage (Watt)
1	Flood Light LED Luminaire	8	53096	52790	440.0

In below tabular format contained no of luminaire in each pole were used in apron design, total no of luminaire used in apron design, no of poles were used in apron design, light source wattage and its maintenance factor were mentioned.

The Luminaire Technical Specifications details were given in Table-8;

Table-8 Luminaires Technical Specifications

No of luminaire in each pole	Total luminaire used in apron lighting	No of pole used in lighting design	Light source wattage Watt	Maintenance factor/Light loss factor
4	8	2	440.0	0.8

In below tabular format the main three parameters i.e. average illuminance horizontal (E_{av}, H), average illuminance vertical (E_{av}, V), Horizontal uniformity (U_0, H), and pole heights are mentioned. The comparison was done between standard value to obtain value for average vertical illuminance, average horizontal illuminance and Horizontal uniformity factor.

In Table-9 luminaires other parameter specifications were given.

Table-9 Luminaires Other Parameters Specifications

SL. NO	AVARAGE ILLUMINANCE HORIZONTAL (Eav H) Lux		AVARAGE ILLUMINANCE VERTICAL (Eav V) Lux		HORIZONTAL UNIFORMITY U0 (H)		POLE HEIGHTS (M)
	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	
1	20	39	20	41	0.25	0.43	16
2	20	39	20	38	0.25	0.37	18
3	20	40	20	36	0.25	0.32	20
4	20	40	20	34	0.25	0.29	22

Horizontal illuminance is the amount of light falling on horizontal activity plane.

Vertical illuminance is the amount of light fall onto the vertical surface.

Horizontal uniformity factor is the ratio between minimum lighting levels to average lighting level.

Isolux diagram is a special type of diagram where it perceived the light distribution characteristics of luminaire.

While changing the mounting height at 16 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 30.

Respective isolux diagram (horizontal illuminance) for 16 m height was given in Fig no. 30;

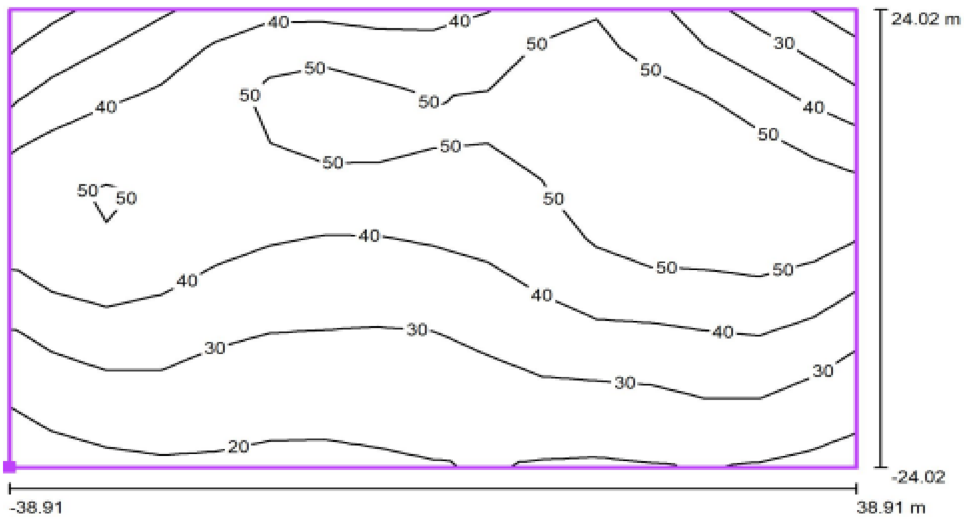

Fig no. 30 isolux diagram (horizontal illuminance) for 16 m pole height.

While changing the mounting height at 16 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 31.

Respective isolux diagram (vertical illuminance) for 16 m height was given in Fig no. 31;

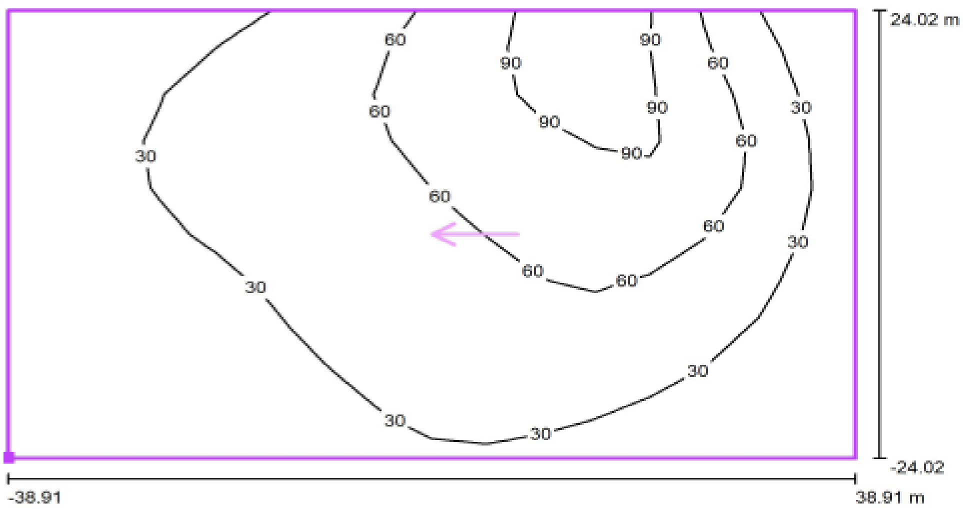

Fig no. 31 isolux diagram (vertical illuminance) for 16 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 32.

Respective isolux diagram (horizontal illuminance) for 18 m height was given in Fig no. 32;

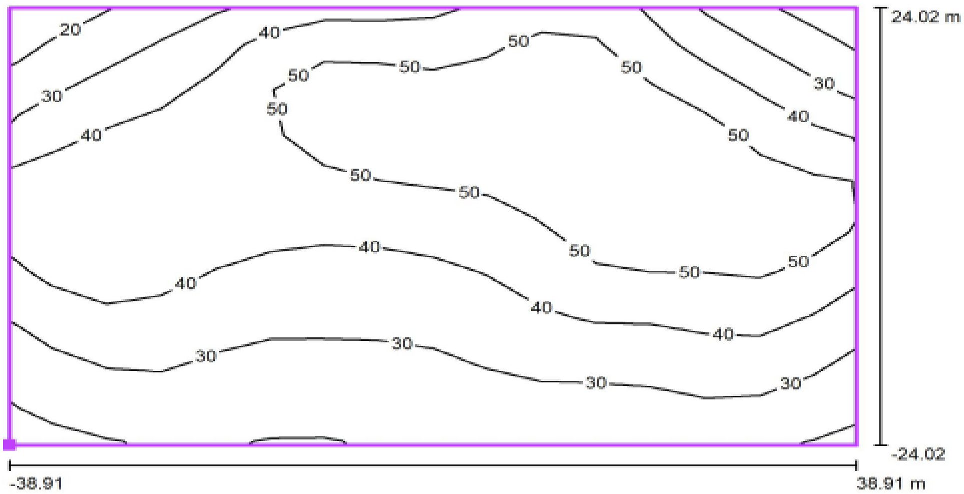

Fig no. 32 isolux diagram (horizontal illuminance) for 18 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 33.

Respective isolux diagram (vertical illuminance) for 18 m height was given in Fig no. 33;

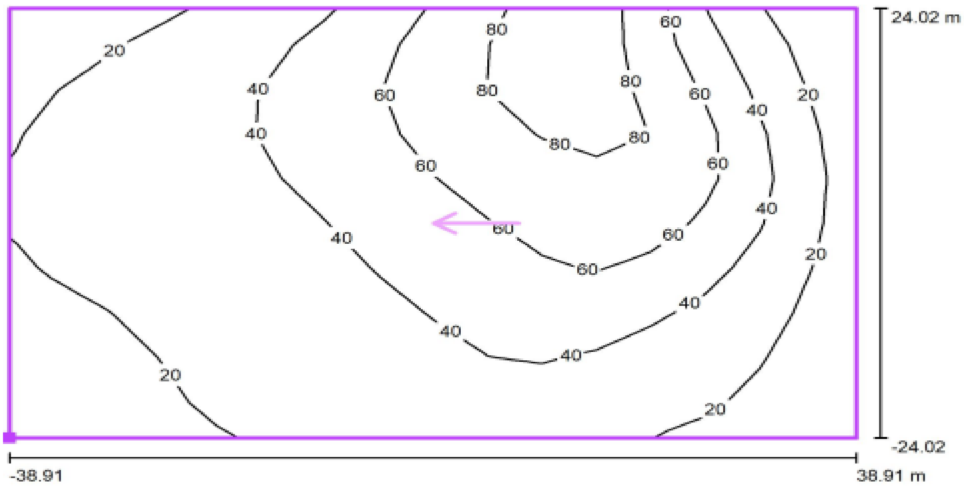

Fig no. 33 isolux diagram (vertical illuminance) for 18 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 34.

Respective isolux diagram (horizontal illuminance) for 20 m height was given in Fig no. 34;

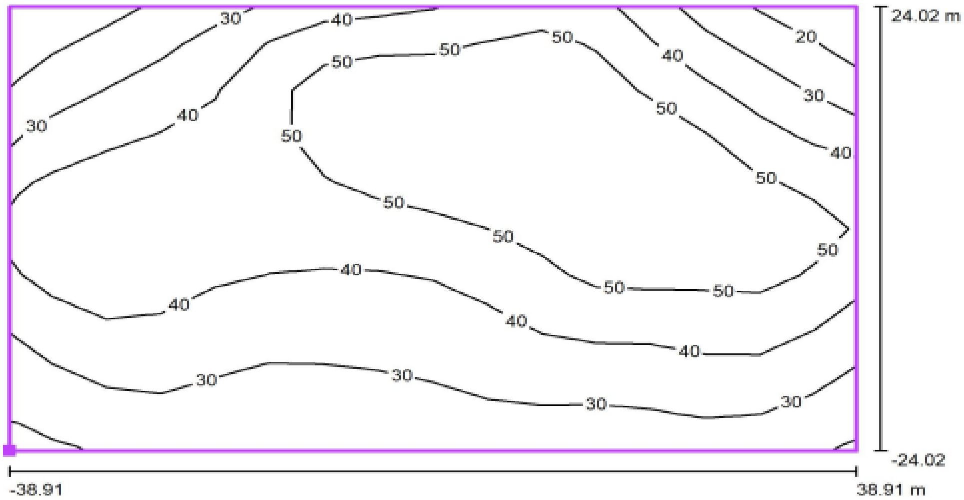

Fig no. 34 isolux diagram (horizontal illuminance) for 20 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 35.

Respective isolux diagram (vertical illuminance) for 20 m height was given in Fig no. 35;

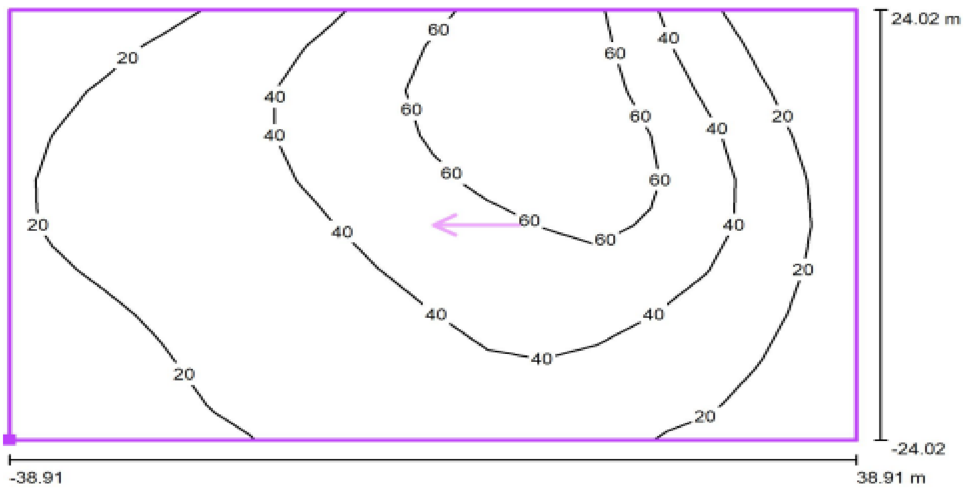

Fig no. 35 isolux diagram (vertical illuminance) for 20 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 36.

Respective isolux diagram (horizontal illuminance) for 22 m height was given in Fig no. 36;

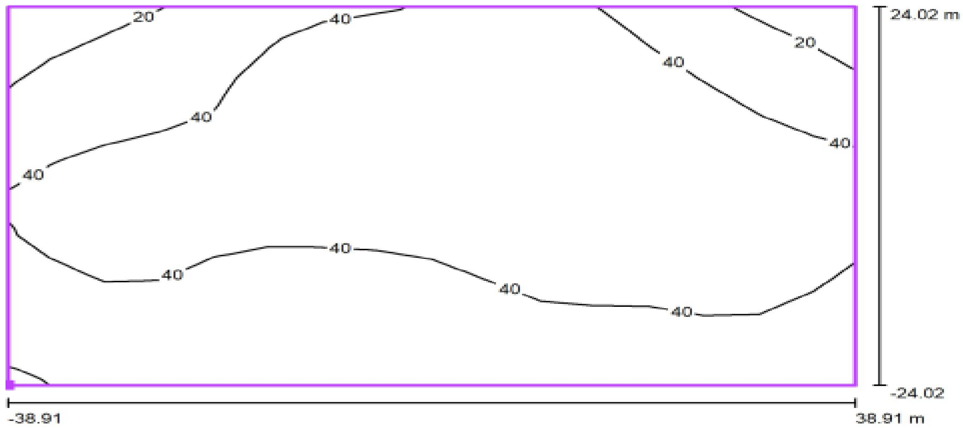

Fig no. 36 isolux diagram (horizontal illuminance) for 22 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 37.

Respective isolux diagram (vertical illuminance) for 22 m height was given in Fig no. 37;

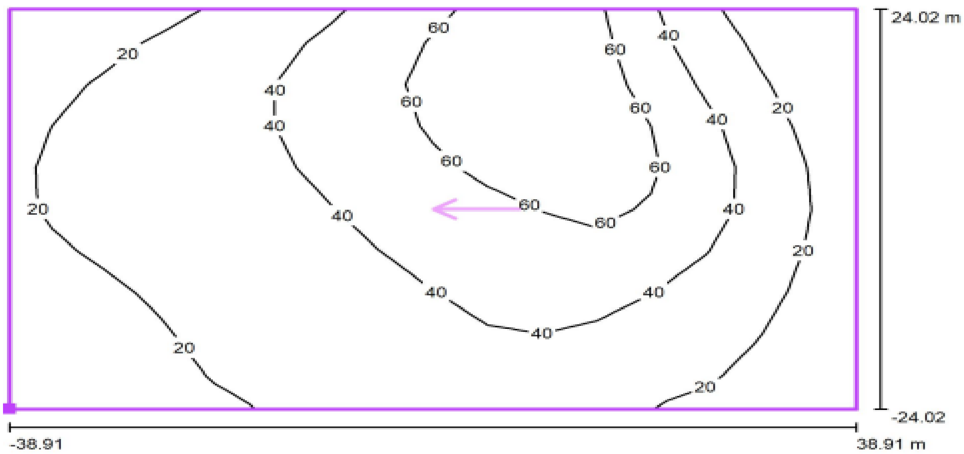

Fig no. 37 isolux diagram (vertical illuminance) for 22 m pole height.

Now in case of horizontal illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variations of horizontal illuminance was observed.

In Fig no. 38 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

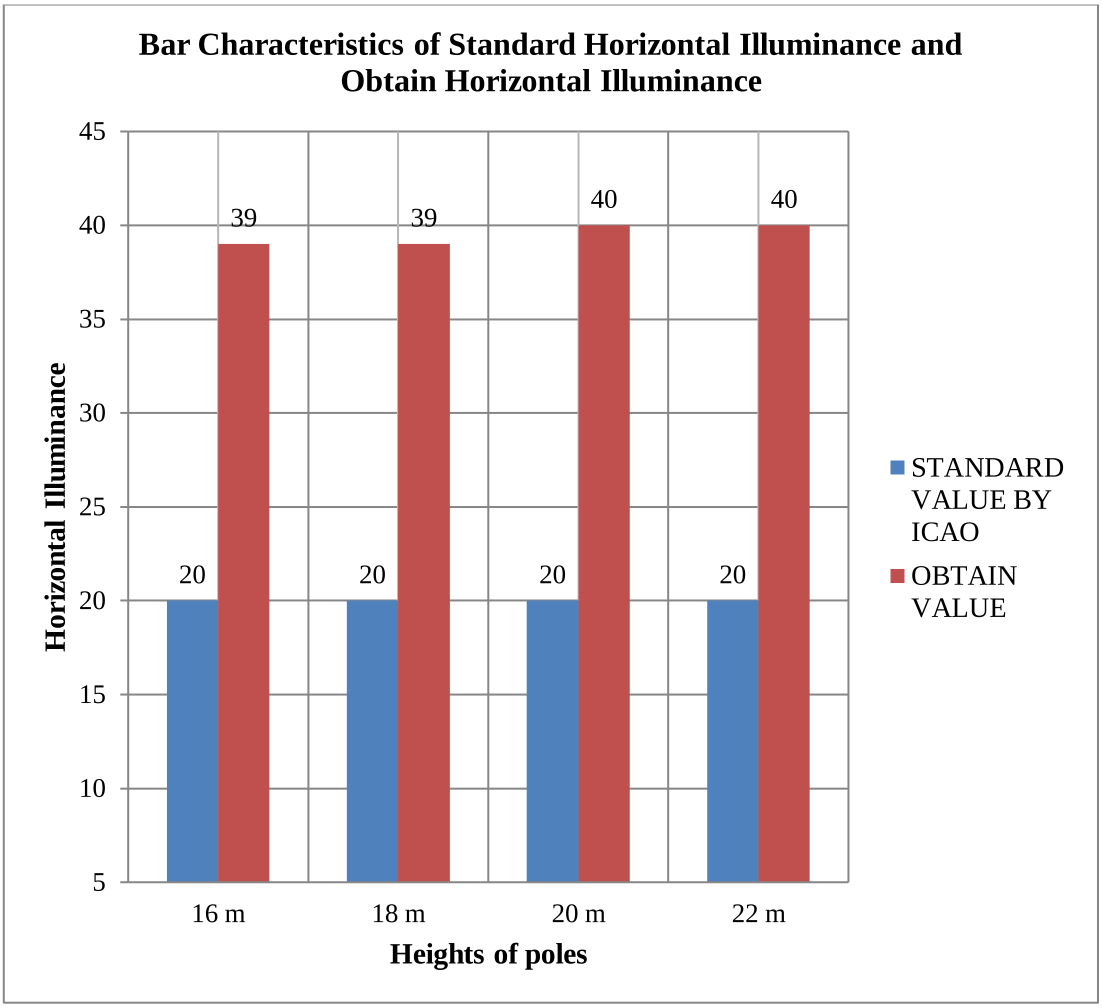

Fig no. 38 comparison plot between standard values and obtain values in case of horizontal illuminance.

Now in case of vertical illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Vertical illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of vertical illuminance can be shown with respect to their heights.

In Fig no. 39 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

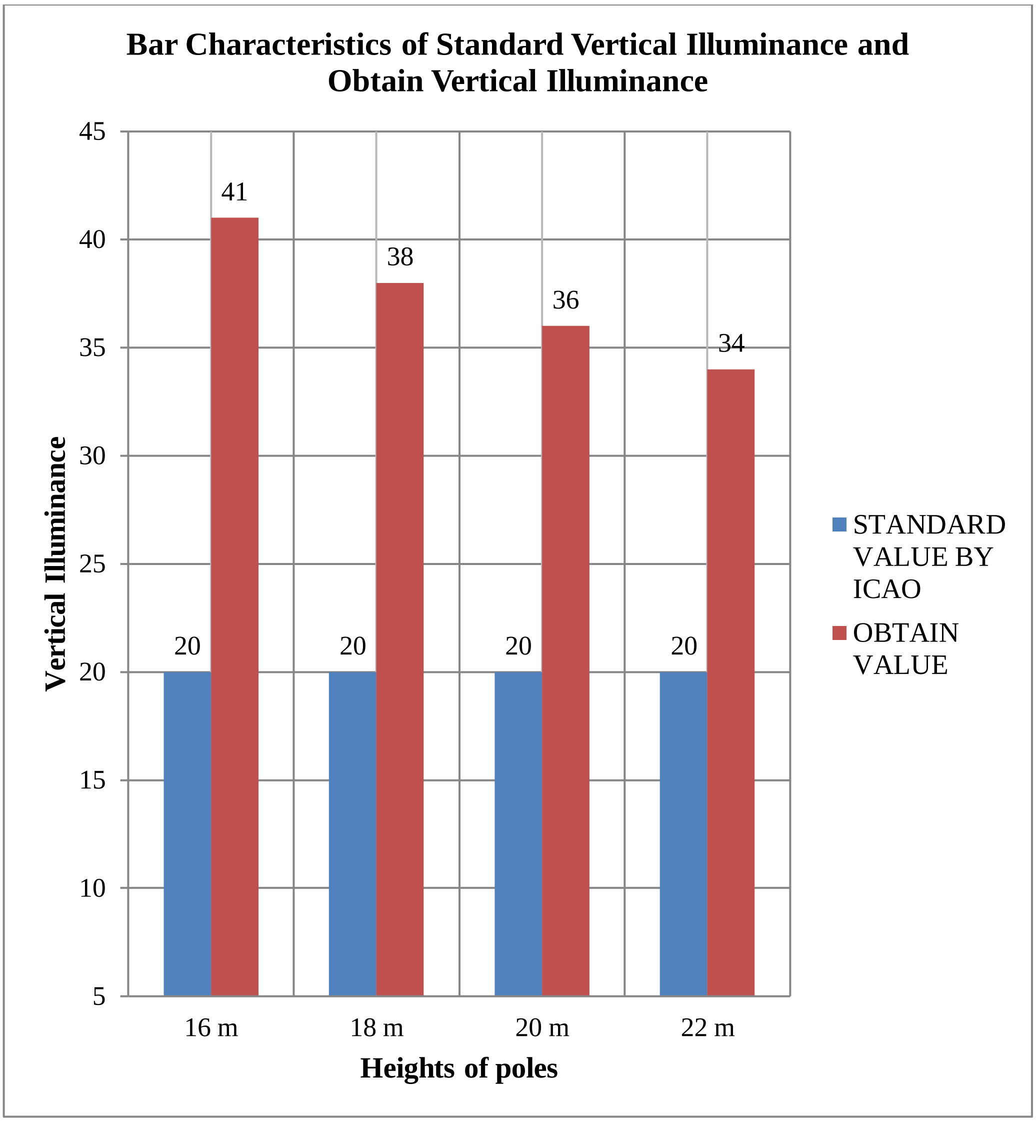

Fig no. 39 comparison plot between standard values and obtain values in case of vertical illuminance.

Now in case of Horizontal uniformity factor comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal uniformity factor can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics Horizontal uniformity variation was observed with respect to their heights.

In Fig no. 40 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

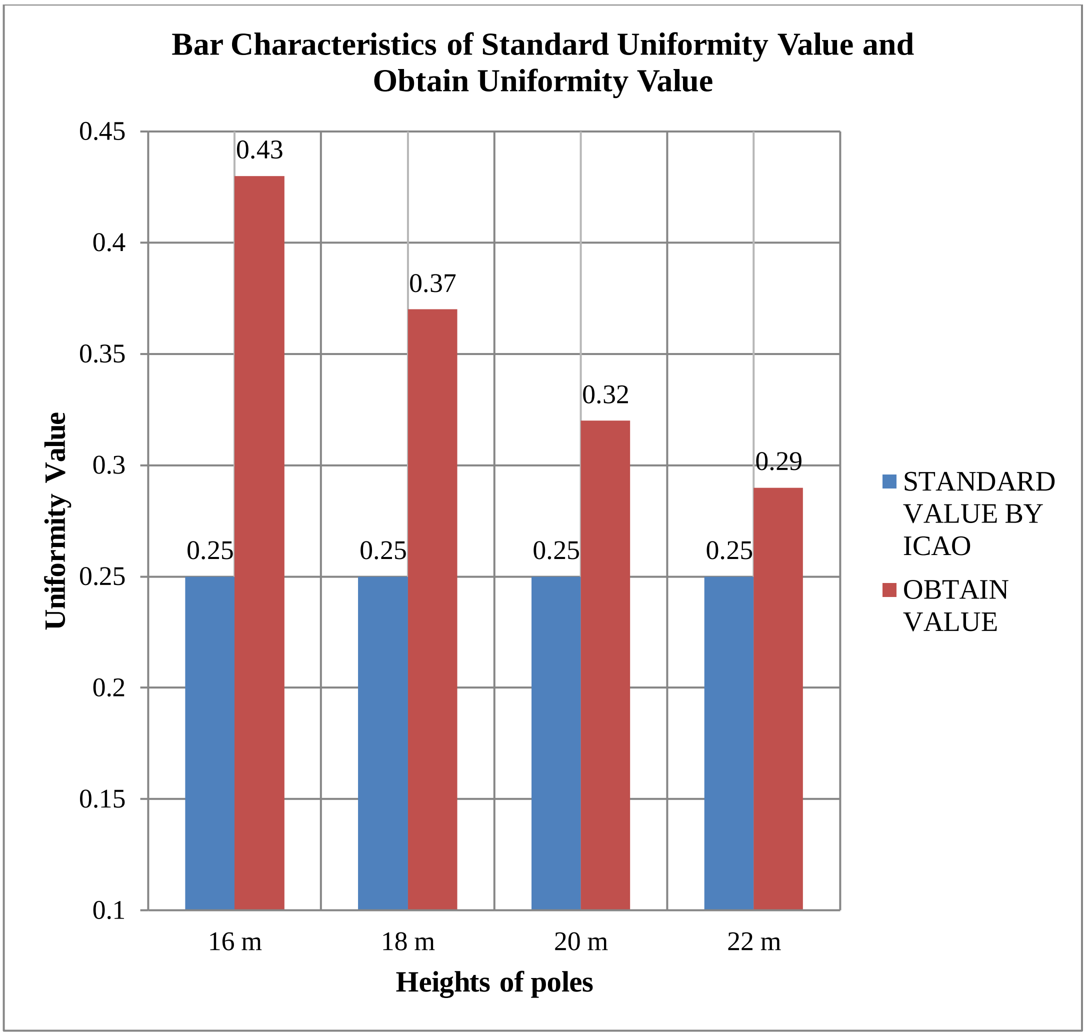

Fig no. 40 comparison plot between standard values and obtain values in case of Horizontal uniformity.

4.1.3 Case -2a for apron area A_2 using 400 watt LED luminaires

In the 2a case apron lighting design let considering the apron Length is 255 m and Breadth is 88.5 m.

Calculation point in the apron area will be fixed in between (5.000 m*5.000 m) for achieving good result and good Horizontal uniformity in apron area.

In two dimensional view planned apron area can be shown and after that detailed analysis were done.

In Fig no. 41 planned apron area was shown;

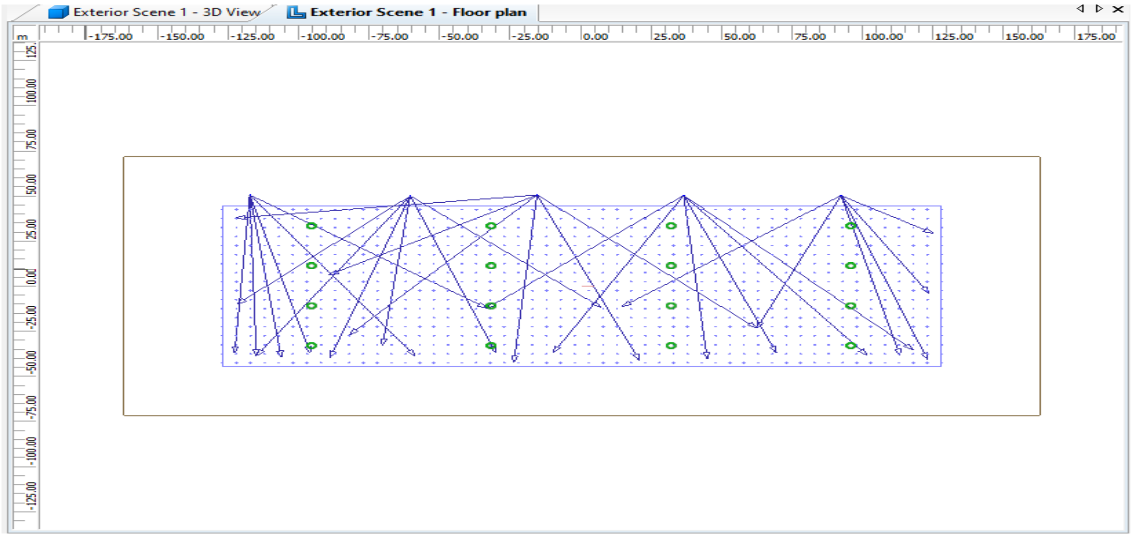

Fig no. 41 apron area A_2 in two dimensional view (for 400 watt luminaires).

Inserting 400 watt luminaires which specification details were tabulated below. In below tabular format, it contained what type of luminaire used in design, no of luminaire used in design, Luminous Flux for Luminaire (The lamp and the gear is mounted in the fixture and the luminous intensity distribution of the fixture was measured), Luminous flux for lamp (luminous flux of the bare lamp is measured) and what type of Wattage of the Lamp was used were mentioned.

The Luminaires specifications details were given in Table-10;

Table-10 Luminaires Specifications

SL. NO	Type of Luminaire Used in The Thesis	No of luminaire used	Luminous Flux For Luminaire (Lumen)	Luminous Flux for Lamp (Lumen)	Luminaire Wattage (Watt)
1	Flood Light LED Luminaire	30	50000	50000	400

In below tabular format contained no of luminaire in each pole were used in apron design, total no of luminaire used in apron design, no of poles were used in apron design, light source wattage and its maintenance factor were mentioned.

The Luminaires Technical Specifications details were given in Table-11;

Table-11 Luminaires Technical Specifications

No of luminaire in each pole	Total luminaire used in apron lighting	No of pole used in lighting design	Light source wattage Watt	Maintenance factor/Light loss factor
6	30	5	400.0	0.8

In below tabular format the main three parameters i.e. average illuminance horizontal (E_{av}, H), average illuminance vertical (E_{av}, V), Horizontal uniformity (U_0, H), and pole heights are mentioned. The comparison was done between standard value to obtain value for average vertical illuminance, average horizontal illuminance and Horizontal uniformity factor.

In Table-12 luminaires other parameter specifications were given.

Table-12 Luminaires Other Parameters Specifications

SL. NO	AVARAGE ILLUMINANCE HORIZONTAL (Eav H) Lux		AVARAGE ILLUMINANCE VERTICAL (Eav V) Lux		HORIZONTAL UNIFORMITY U0 (H)		POLE HEIGHTS (M)
	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	
1	20	26	20	25	0.25	0.25	16
2	20	26	20	24	0.25	0.28	18
3	20	27	20	23	0.25	0.26	20
4	20	26	20	21	0.25	0.26	22

Horizontal illuminance is the amount of light falling on horizontal activity plane.

Vertical illuminance is the amount of light fall onto the vertical surface.

Horizontal uniformity factor is the ratio between minimum lighting levels to average lighting level.

Isolux diagram is a special type of diagram where it perceived the light distribution characteristics of luminaire.

While changing the mounting height at 16 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 42.

Respective isolux diagram (horizontal illuminance) for 16 m height was given in Fig no. 42;

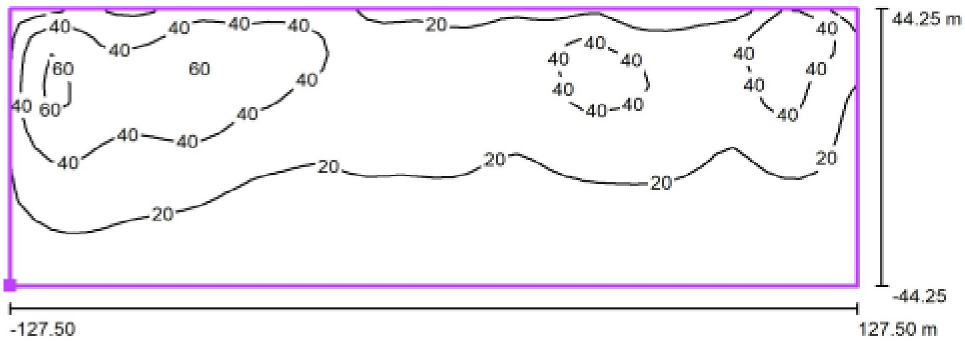

Fig no. 42 isolux diagram (horizontal illuminance) for 16 m pole height.

While changing the mounting height at 16 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 43.

Respective isolux diagram (vertical illuminance) for 16 m height was given in Fig no. 43;

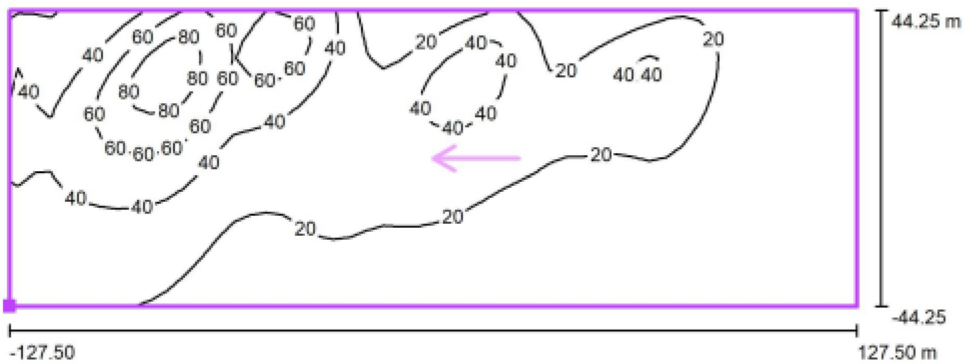

Fig no. 43 isolux diagram (vertical illuminance) for 16 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 44.

Respective isolux diagram (horizontal illuminance) for 18 m height was given in Fig no. 44;

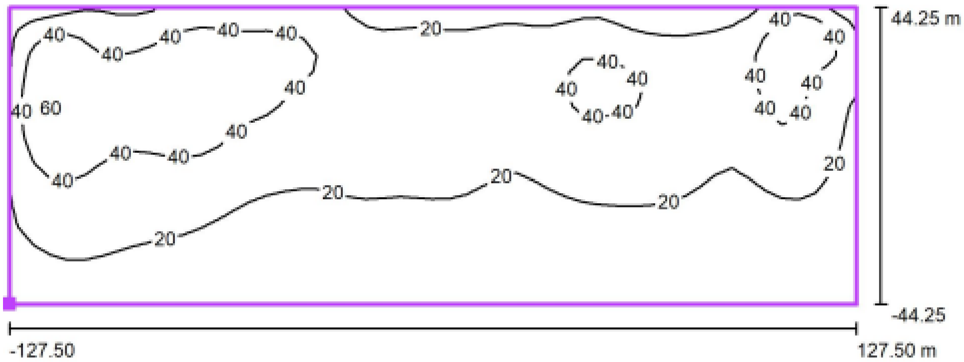

Fig no. 44 isolux diagram (horizontal illuminance) for 18 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 45

Respective isolux diagram (vertical illuminance) for 18 m height was given in Fig no. 45;

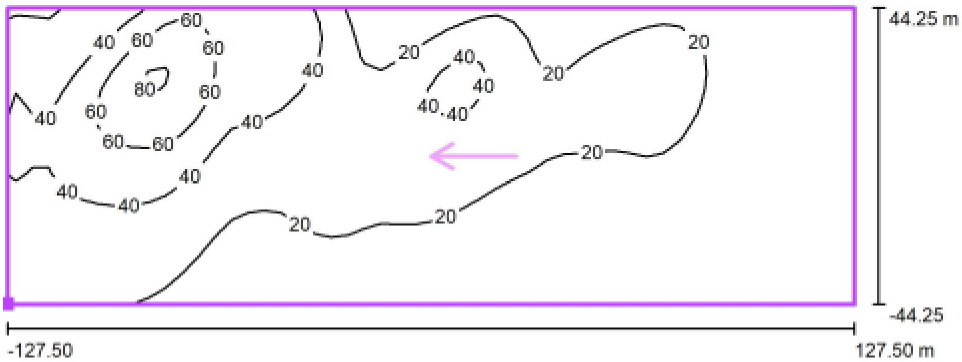

Fig no. 45 isolux diagram (vertical illuminance) for 18 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 46.

Respective isolux diagram (horizontal illuminance) for 20 m height was given in Fig no. 46;

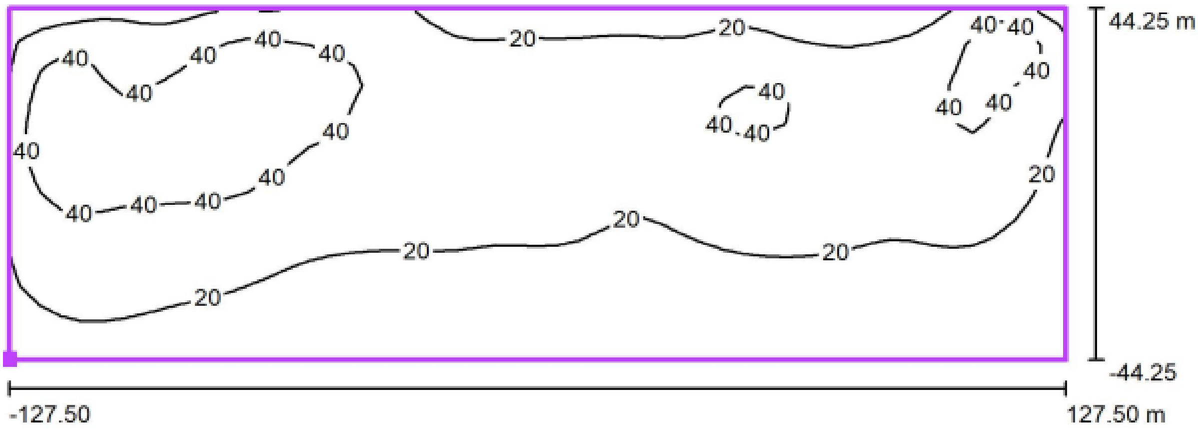

Fig no. 46 isolux diagram (horizontal illuminance) for 20 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 47

Respective isolux diagram (vertical illuminance) for 20 m height was given in Fig no. 47;

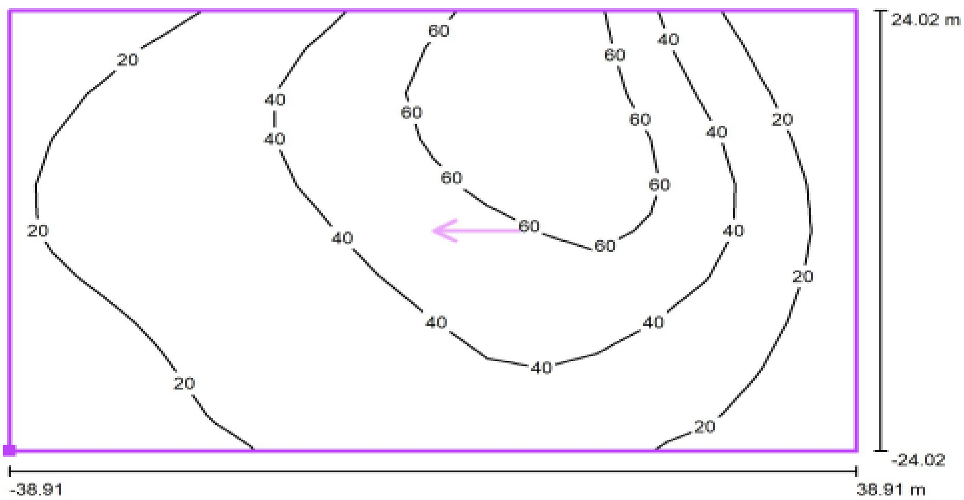

Fig no. 47 isolux diagram (vertical illuminance) for 20 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 48.

Respective isolux diagram (horizontal illuminance) for 22 m height was given in Fig no. 48;

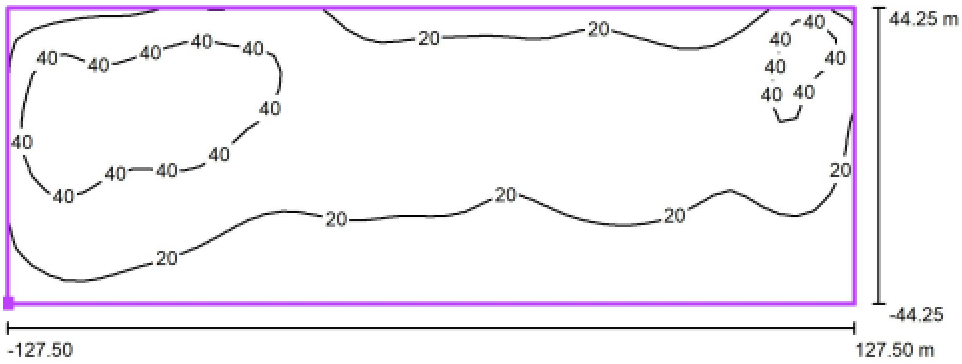

Fig no. 48 isolux diagram (horizontal illuminance) for 22 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 49.

Respective isolux diagram (vertical illuminance) for 22 m height was given in Fig no. 49;

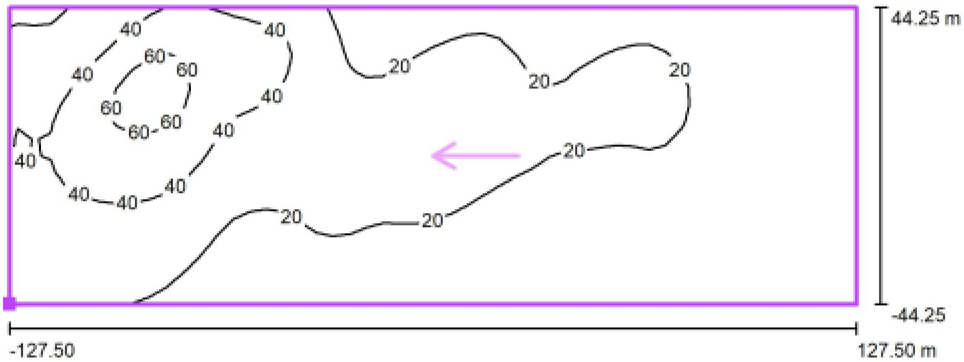

Fig no. 49 isolux diagram (vertical illuminance) for 22 m pole height.

Now in case of horizontal illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of horizontal illuminance can be observed.

In Fig no. 50 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

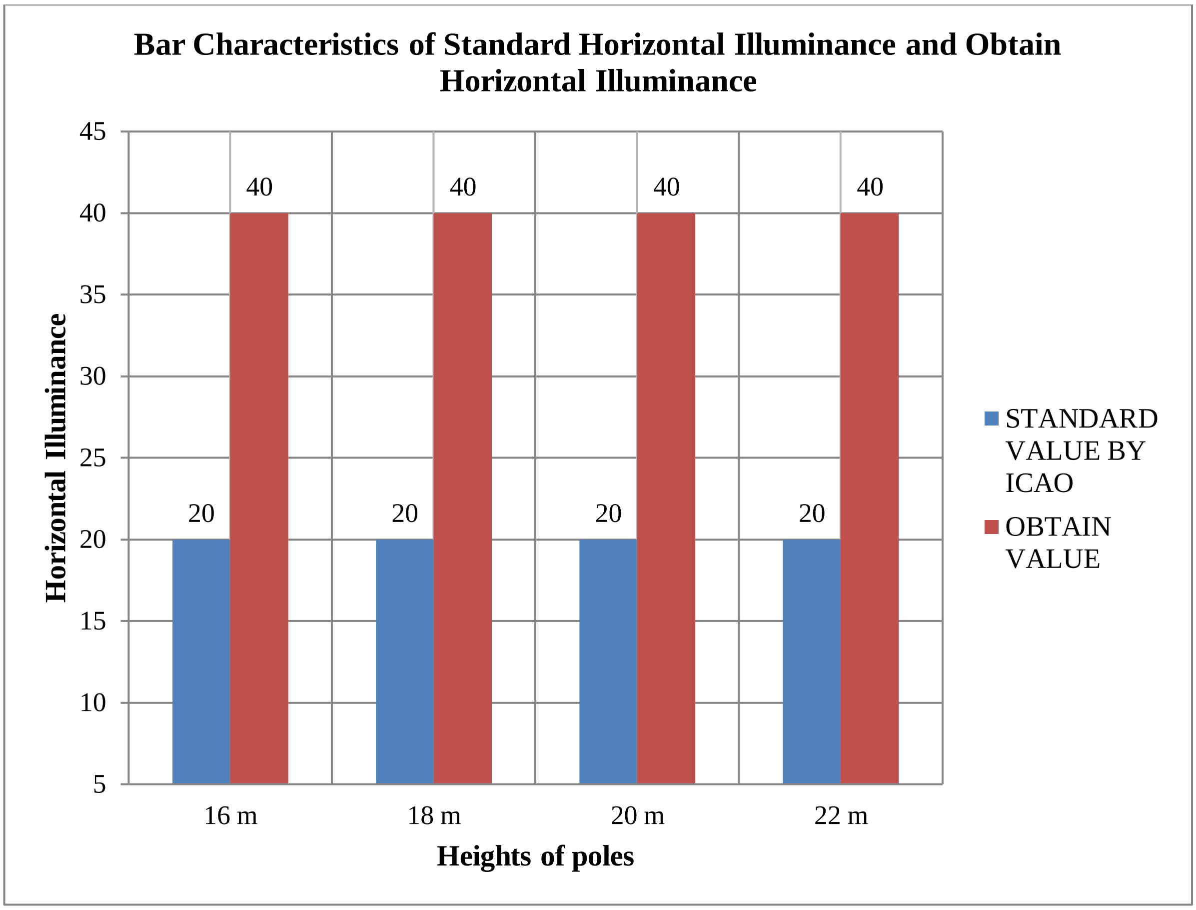

Fig no. 50 comparison plot between standard values and obtain values in case of horizontal illuminance.

Now in case of vertical illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Vertical illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of vertical illuminance can be observed.

In Fig no. 51 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

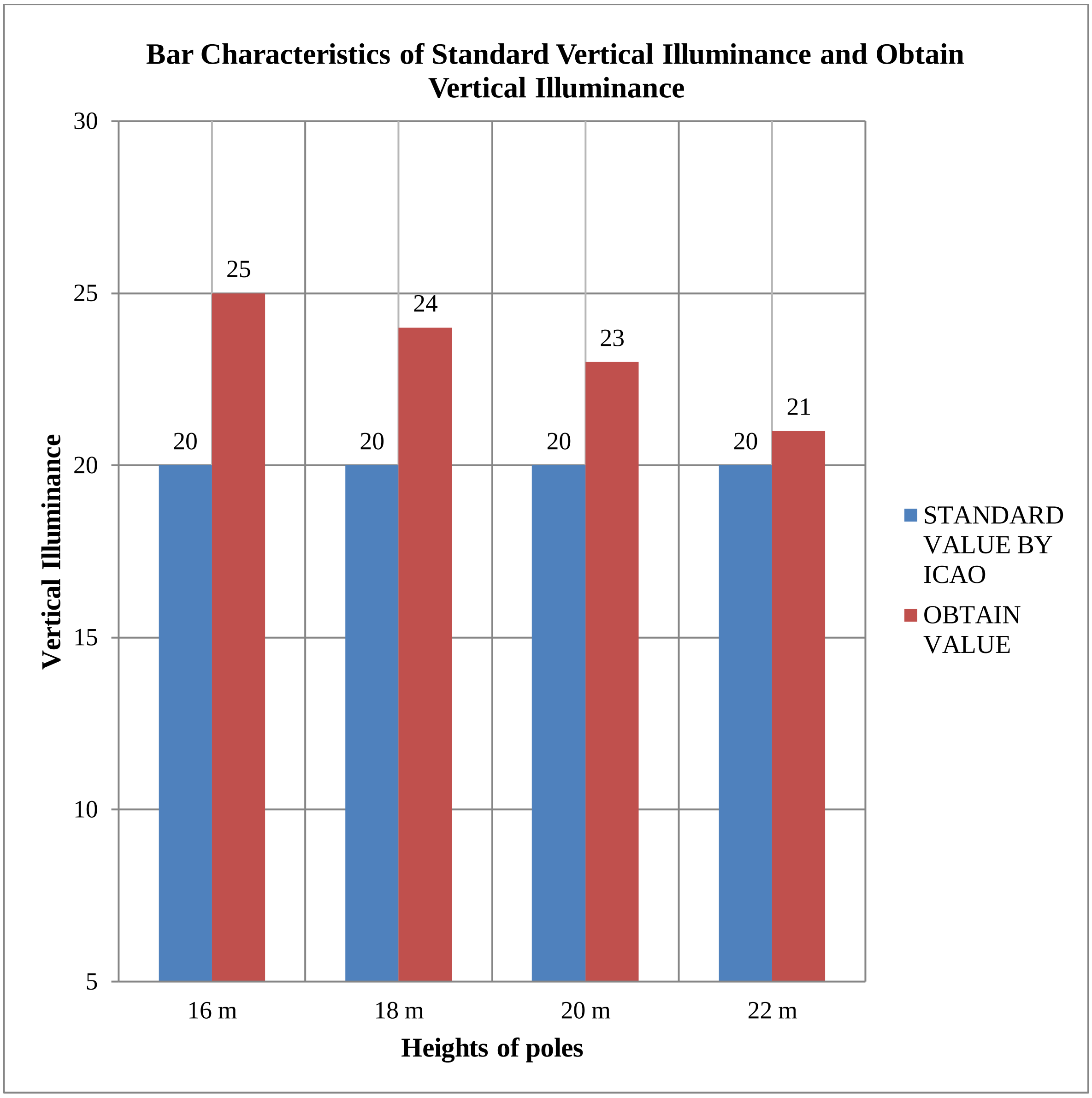

Fig no. 51 comparison plot between standard values and obtain values in case of vertical illuminance.

Now in case of Horizontal uniformity factor comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal uniformity factor can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of Horizontal uniformity can be observed for different heights.

In Fig no. 52 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

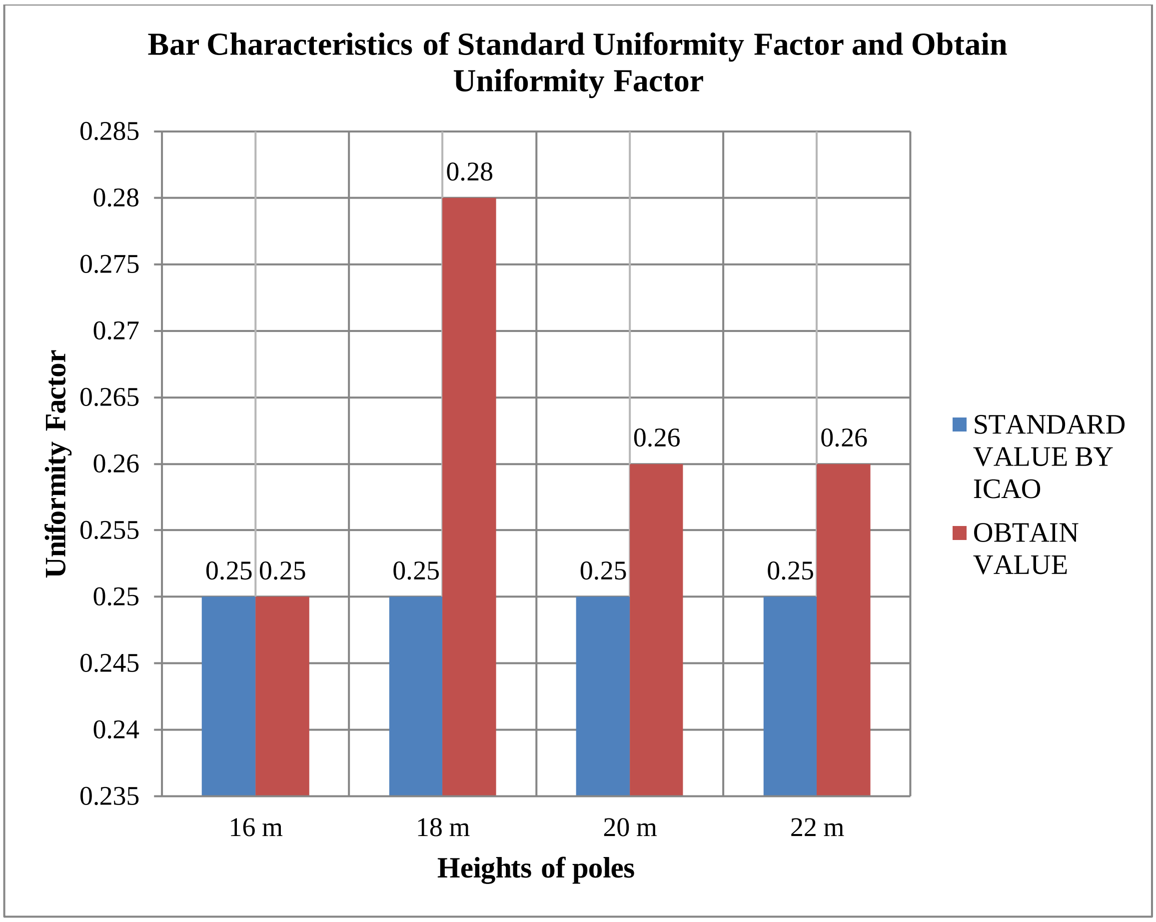

Fig no. 52 comparison plot between standard values and obtain values in case of Horizontal uniformity.

4.1.4 Case -2b for Apron areas A_2 using 440 watt LED luminaire

In the 2b case apron lighting design let considering the apron Length is 255 m and Breadth is 88.5 m.

Calculation point in the apron area will be fixed in between (5.000 m*5.000 m) for achieving good result and good Horizontal uniformity in apron area.

In two dimensional view planned apron area can be shown and after that detailed analysis were done.

In Fig no. 53 planned apron area was shown;

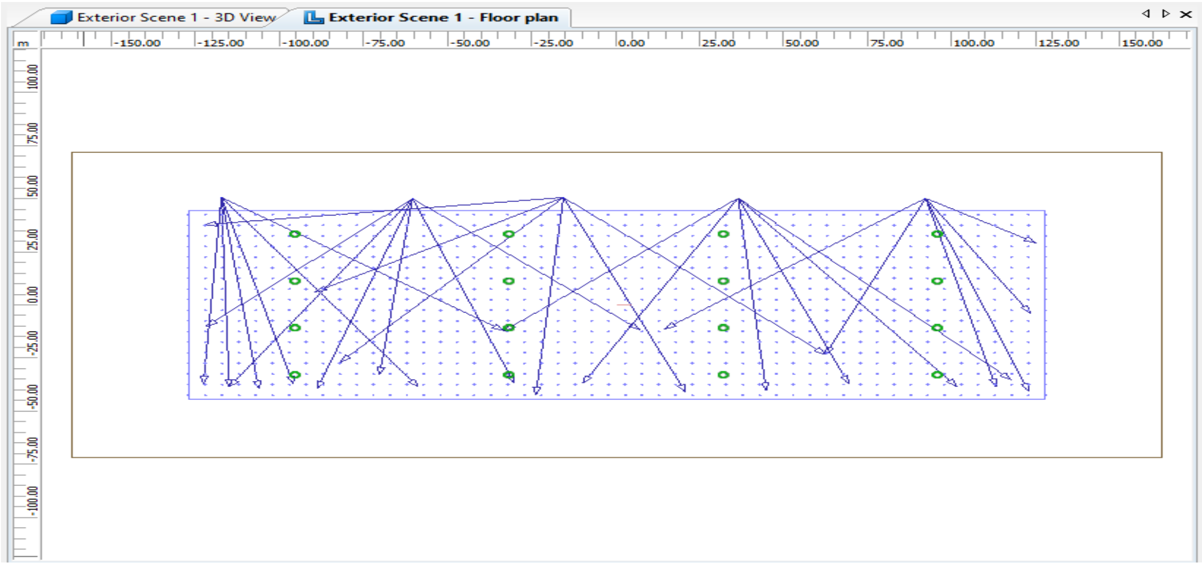

Fig no. 53 apron area A_2 in two dimensional view (for 440 watt luminaires).

Inserting 440 watt luminaires which specification details were tabulated below. In below tabular format, it contained what type of luminaire used in design, no of luminaire used in design, Luminous Flux for Luminaire (The lamp and the gear is mounted in the fixture and the luminous intensity distribution of the fixture was measured), Luminous flux for lamp (luminous flux of the bare lamp is measured) and what type of Wattage of the Lamp was used were mentioned.

The Luminaires specifications details were given in Table-13;

Table-13 Luminaires Specifications

SL. NO	Type of Luminaire Used in The Thesis	No of luminaire used	Luminous Flux For Luminaire (Lumen)	Luminous Flux for Lamp (Lumen)	Luminaire Wattage (Watt)
1	Flood Light LED Luminaire	30	53096	52790	440

In below tabular format contained no of luminaire in each pole were used in apron design, total no of luminaire used in apron design, no of poles were used in apron design, light source wattage and its maintenance factor were mentioned.

The Luminaires Technical Specifications details were given in Table-14;

Table-14 Luminaires Technical Specifications

No of luminaire in each pole	Total luminaire used in apron lighting	No of pole used in lighting design	Light source wattage Watt	Maintenance factor/Light loss factor
6	30	5	440.0	0.8

In below tabular format the main three parameters i.e. average illuminance horizontal (E_{av}, H), average illuminance vertical (E_{av}, V), Horizontal uniformity (U_0, H), and pole heights are mentioned. The comparison was done between standard value to obtain value for average vertical illuminance, average horizontal illuminance and Horizontal uniformity factor.

In Table-15 luminaires other parameter specifications were given.

Table-15 Luminaires Other Parameters Specifications

SL. NO	AVARAGE ILLUMINANCE HORIZONTAL (Eav H) Lux		AVARAGE ILLUMINANCE VERTICAL (Eav V) Lux		HORIZONTAL UNIFORMITY U0 (H)		POLE HEIGHTS (M)
	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	STANDARD VALUE BY ICAO	OBTAIN VALUE	
1	20	26	20	27	0.25	0.27	16
2	20	27	20	25	0.25	0.26	18
3	20	26	20	23	0.25	0.27	20
4	20	26	20	21	0.25	0.26	22

Horizontal illuminance is the amount of light falling on horizontal activity plane.

Vertical illuminance is the amount of light fall onto the vertical surface.

Horizontal uniformity factor is the ratio between minimum lighting levels to average lighting level.

Isolux diagram is a special type of diagram where it perceived the light distribution characteristics of luminaire.

While changing the mounting height at 16 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 54.

Respective isolux diagram (horizontal illuminance) for 16 m height was given in Fig no. 54;

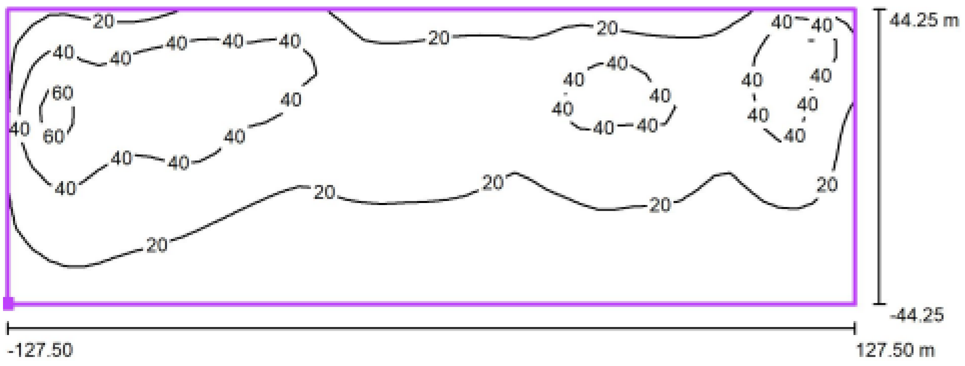

Fig no. 54 isolux diagram (horizontal illuminance) for 16 m pole height.

While changing the mounting height at 16 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 55.

Respective isolux diagram (vertical illuminance) for 16 m height was given in Fig no. 55;

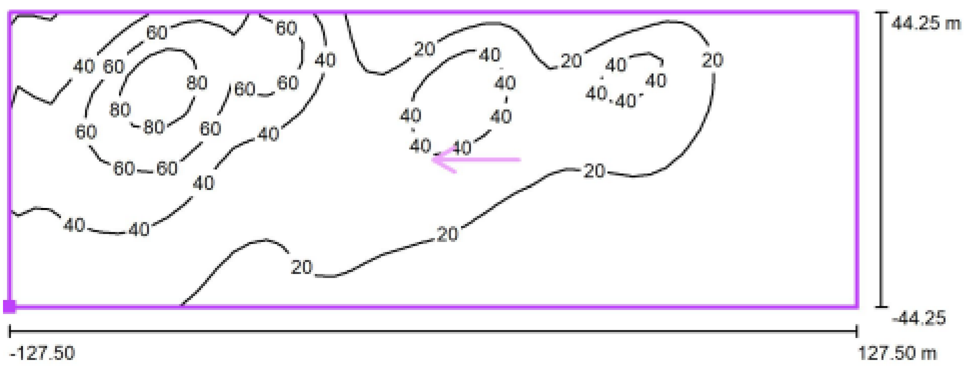

Fig no. 55 isolux diagram (vertical illuminance) for 16 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 56.

Respective isolux diagram (horizontal illuminance) for 18 m height was given in Fig no. 56;

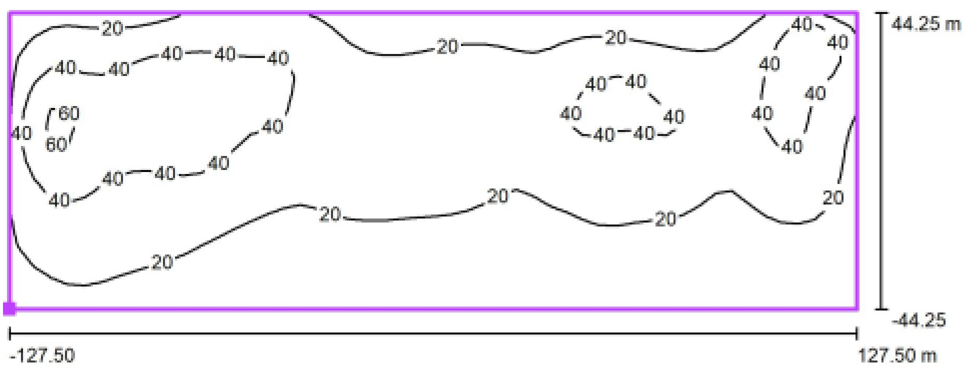

Fig no. 56 isolux diagram (horizontal illuminance) for 18 m pole height.

While changing the mounting height at 18 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 57.

Respective isolux diagram (vertical illuminance) for 18 m height was given in Fig no. 57;

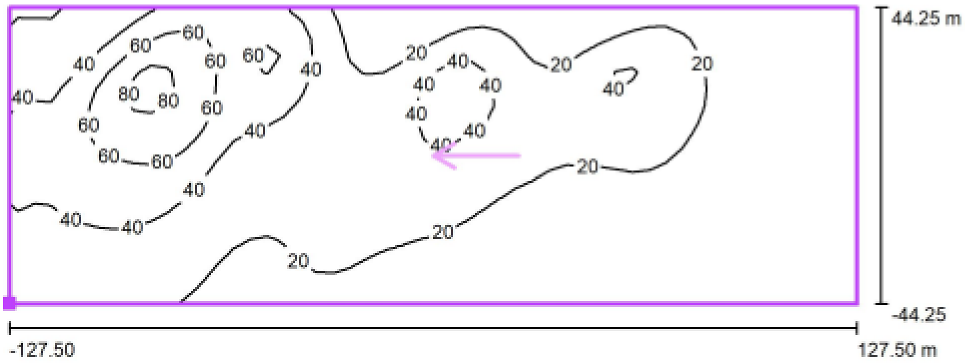

Fig no. 57 isolux diagram (vertical illuminance) for 18 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 58.

Respective isolux diagram (horizontal illuminance) for 20 m height was given in Fig no. 58;

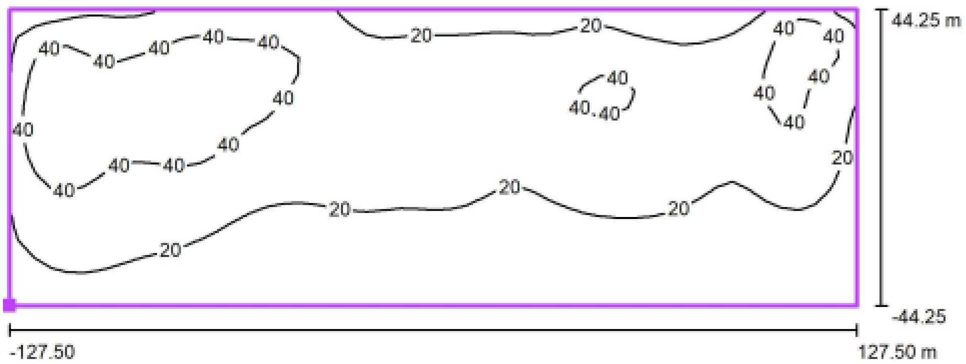

Fig no. 58 isolux diagram (horizontal illuminance) for 20 m pole height.

While changing the mounting height at 20 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 59.

Respective isolux diagram (vertical illuminance) for 20 m height was given in Fig no. 59;

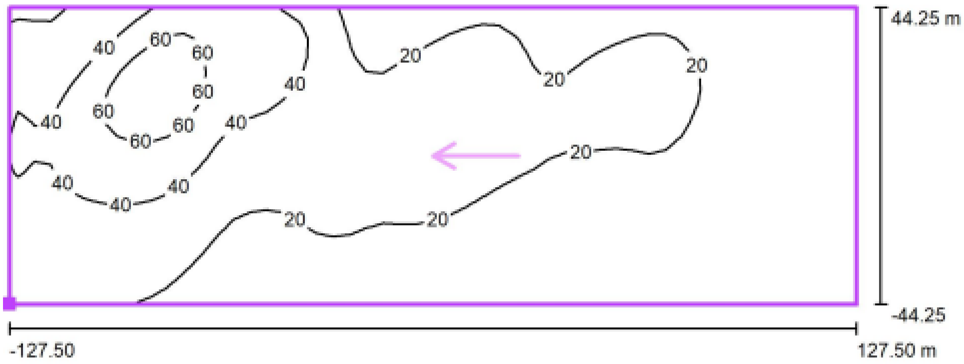

Fig no. 59 isolux diagram (vertical illuminance) for 20 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for horizontal illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 60.

Respective isolux diagram (horizontal illuminance) for 22 m height was given in Fig no. 60;

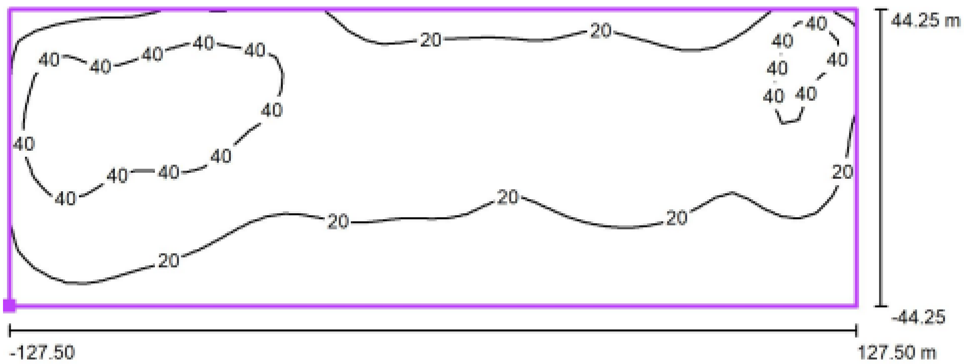

Fig no. 60 isolux diagram (horizontal illuminance) for 22 m pole height.

While changing the mounting height at 22 m some changes occurred in isolux diagram for vertical illuminance. Light distribution variation was seen in isolux diagram mentioned in Fig no. 61.

Respective isolux diagram (vertical illuminance) for 22 m height was given in Fig no. 61;

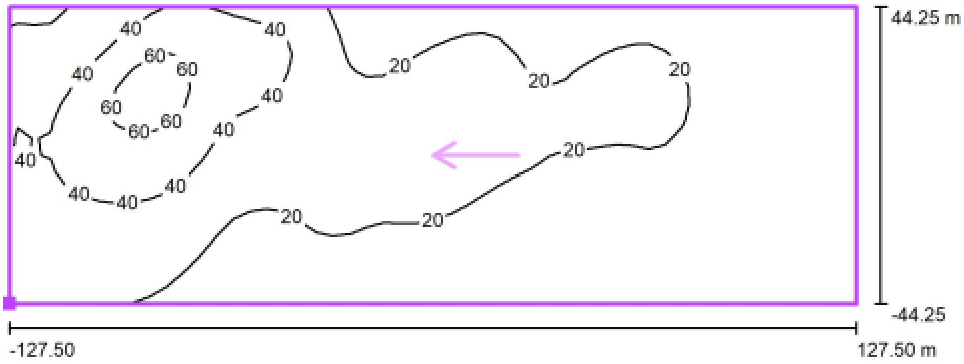

Fig no. 61 isolux diagram (vertical illuminance) for 22 m pole height.

Now in case of horizontal illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of horizontal illuminance can be observed.

In Fig no. 62 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

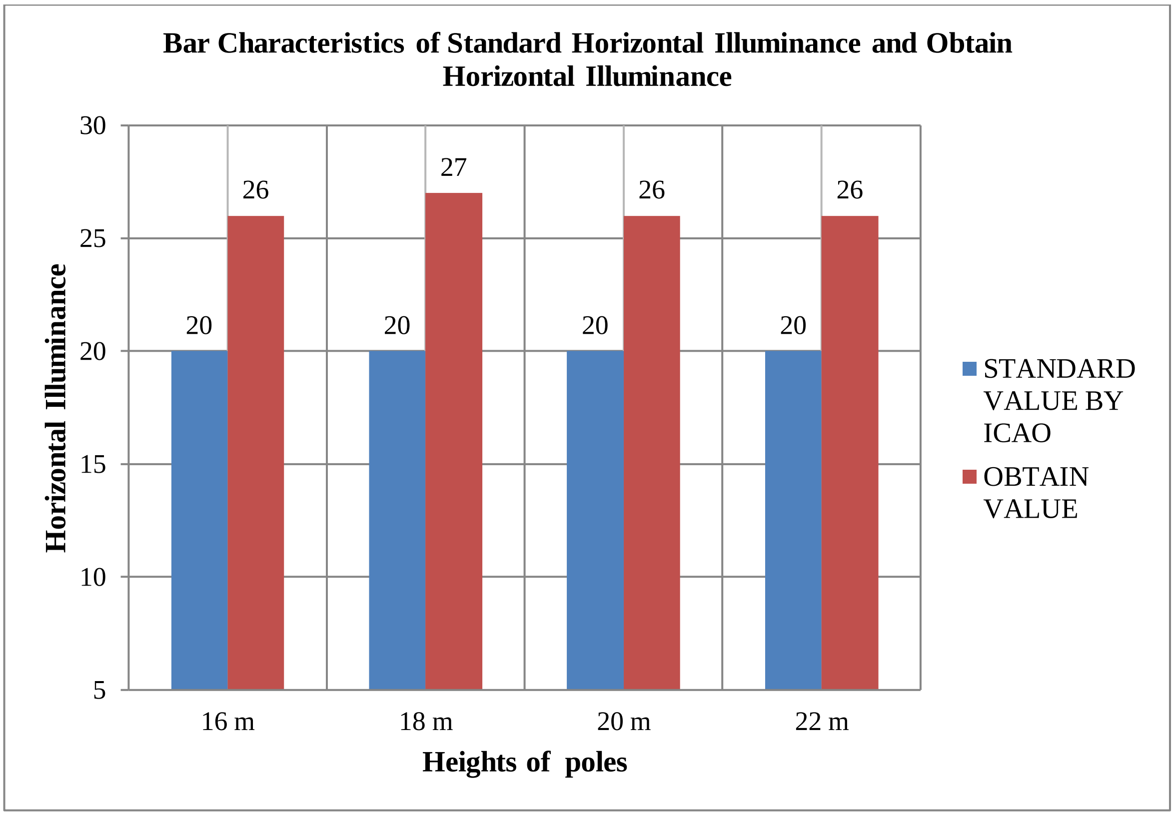

Fig no. 62 comparison plot between standard values and obtain values in case of horizontal illuminance.

Now in case of vertical illuminance comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Vertical illuminance can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of vertical illuminance can be observed.

In Fig no. 63 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

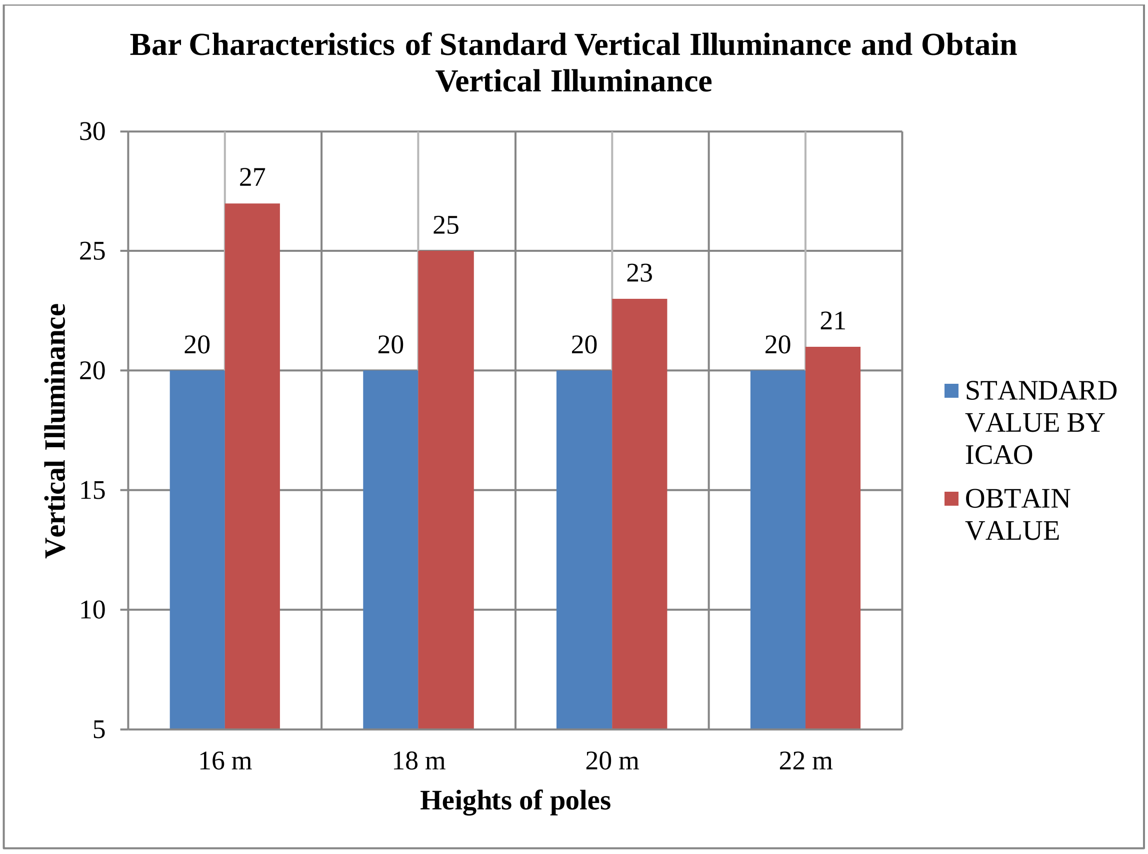

Fig no. 63 comparison plot between standard values and obtain values in case of vertical illuminance.

Now in case of Horizontal uniformity factor comparison should be made between standard value which was mentioned by "ICAO" (International Civil Aviation Organisation) and obtain value which can figure out after simulation process. Horizontal uniformity factor can be plotted in 'Y' axis. Different values of heights different obtain value can be achieved. Height was plotted in 'X' axis. In these characteristics variation of Horizontal uniformity can be observed.

In Fig no. 64 bar characteristics the variation between standard values vs. obtain values has been plotted for different heights were shown.

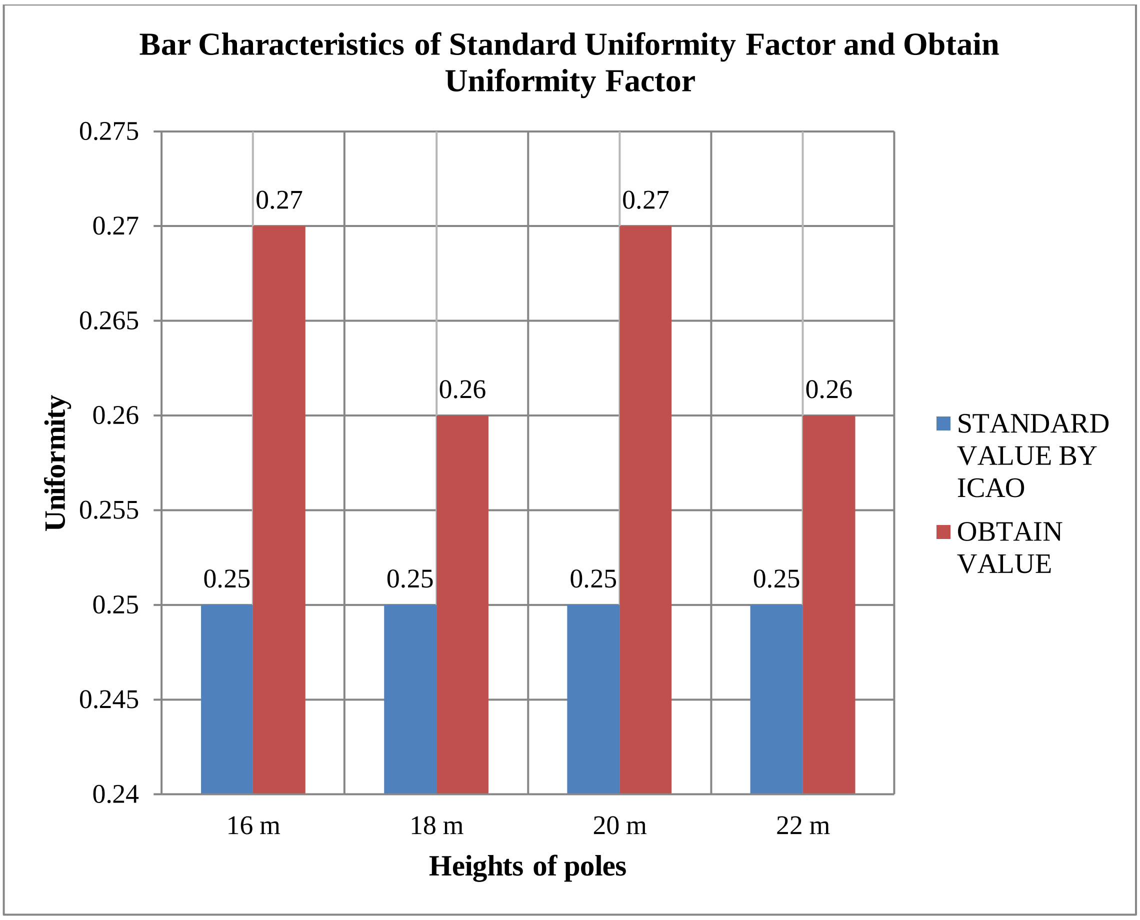

Fig no. 64 comparison plot between standard values and obtain values in case of Horizontal uniformity.

4.2 Cost Calculation

This part was the most crucial part of this thesis. In this part it has been discussed about expenditure of the thesis. Cost calculation can be done in these two areas A_1 and A_2 for 400 watt and 440 watt luminaires. Apron areas where cost calculation was done as mention in below;

A_1 apron area is (77.816 * 48.034) m^2.

A_2 apron area is (255 * 88.5) m^2.

In market the price of the pole varied with cost of the materials (iron and steel).

Let the 16m height pole cost be 2,15,000 Rupees [10] and 400 watt LED luminaire price be 22,000 Rupees [11] and 440 watt LED luminaire price be 35,000 Rupees [12].

In below tabular format we calculated total cost of the poles for different heights. Table has contained various data like Total no of poles used, per pole cost, Pole mounting heights, Total cost of the poles.

In Table-16 Total used poles Cost Calculations for Apron Area A_1 was done (for 400 watt luminaire).

Table- 16 Cost Calculations of Poles (for 400watt luminaire)

Total No of Pole Used	Per Pole Cost (Rupees) [11]	Pole Mounting Height (Meter)	Total Cost of the pole (Rupees)
2	2,15,000	16	4,30,000
2	2,41,875	18	4,83,750
2	2,68,750	20	5,37,500
2	2,95,625	22	5,91,250

Luminaires cost calculations were done in other table after that total cost of the entire system can be calculated. Total system cost should be calculated as

(Total Luminaires Cost + Total Poles Cost).

In this tabular format contained no of luminaires used in the thesis, per luminaire cost, total cost of poles, mounting height of luminaires, total cost of luminaires and total cost of the system.

In Table-17 detail cost calculation of total system was done (for 400 watt luminaire).

Table-17 Cost Calculations of Total System (400 watt LED Luminaires)

Total No of Luminaire Used in Thesis	Per Luminaire Cost (Rupees)	Total Cost of poles (Rupees)	Mounting Height of Luminaires (Meter)	Total Cost of Luminaires (Rupees)	Total Cost of the System (Total Luminaires Cost + Total Poles Cost) (Rupees)
8	22,000	4,30,000	16	1,76,000	6,06,000
8	22,000	4,83,750	18	1,76,000	6,59,750
8	22,000	5,37,500	20	1,76,000	7,13,500
8	22,000	5,91,250	22	1,76,000	7,67,250

In the bar graph total cost of the system was on ‘Y’ axis and different heights on ‘X’ axis. Variation can be showed on ‘Y’ axis.

Total cost increased with increased their heights.

In this characteristics total cost increased with respect to their heights.

In Fig no. 65 bar characteristics of total cost of the system was showed.

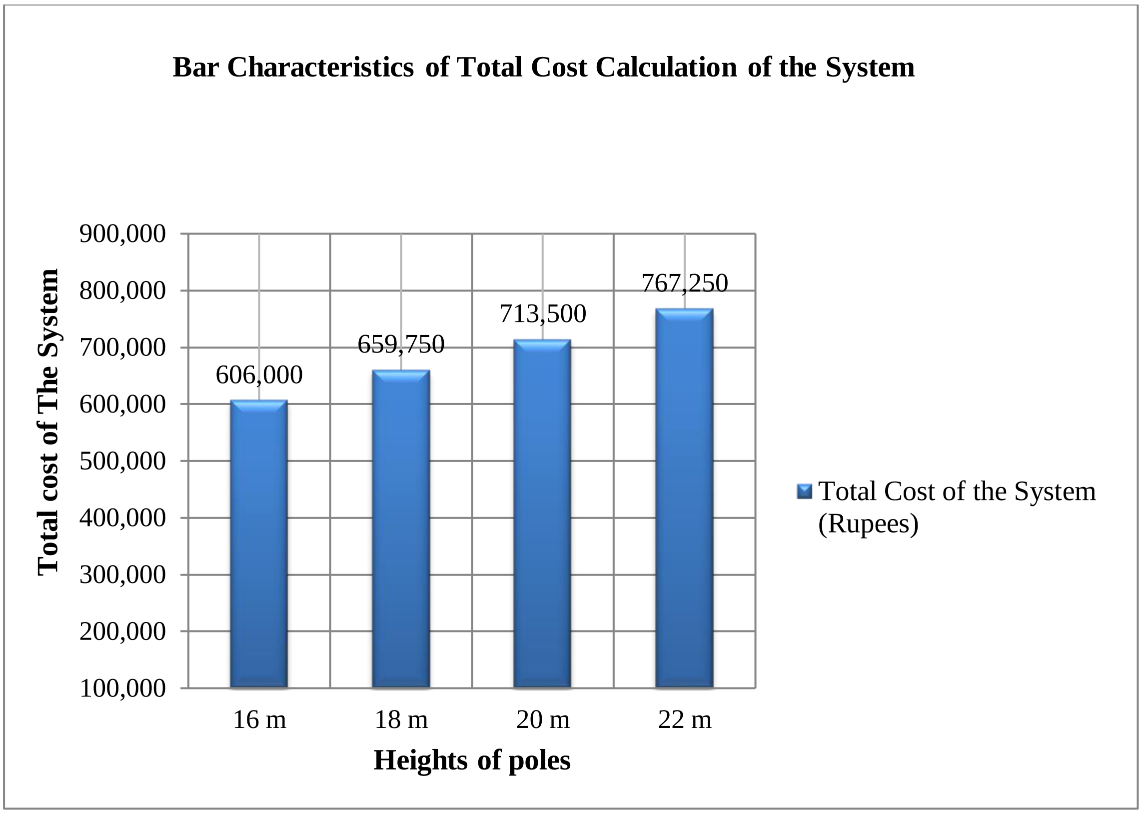

Fig no. 65 bar characteristics of total cost calculation of the system for apron area A_1 (for 400 watt Luminaires).

In this tabular format contained no of luminaires used in the thesis, per luminaire cost, total cost of poles, mounting height of luminaires, total cost of luminaires and total cost of the system.

In Table-18 detail cost calculation of total system was done (for 440 watt luminaire).

Table-18 Cost Calculations of Total System (440 watt LED Luminaires)

Total No of Luminaire Used in Thesis	Per Luminaire Cost (Rupees)	Total Cost of poles (Rupees)	Mounting Height of Luminaires (Meter)	Total Cost of Luminaires (Rupees)	Total Cost of the System (Total Luminaires Cost + Total Poles Cost) (Rupees)
8	35,000	4,30,000	16	2,80,000	7,10,000
8	35,000	4,83,750	18	2,80,000	7,63,750
8	35,000	5,37,500	20	2,80,000	8,17,500
8	35,000	5,91,250	22	2,80,000	8,71,250

In the bar graph total cost of the system was on 'Y' axis and different heights on 'X' axis. Variation can be showed on 'Y' axis.

In this characteristics total cost increased with respect to their heights.

In Fig no. 66 bar characteristics of total cost of the system were showed.

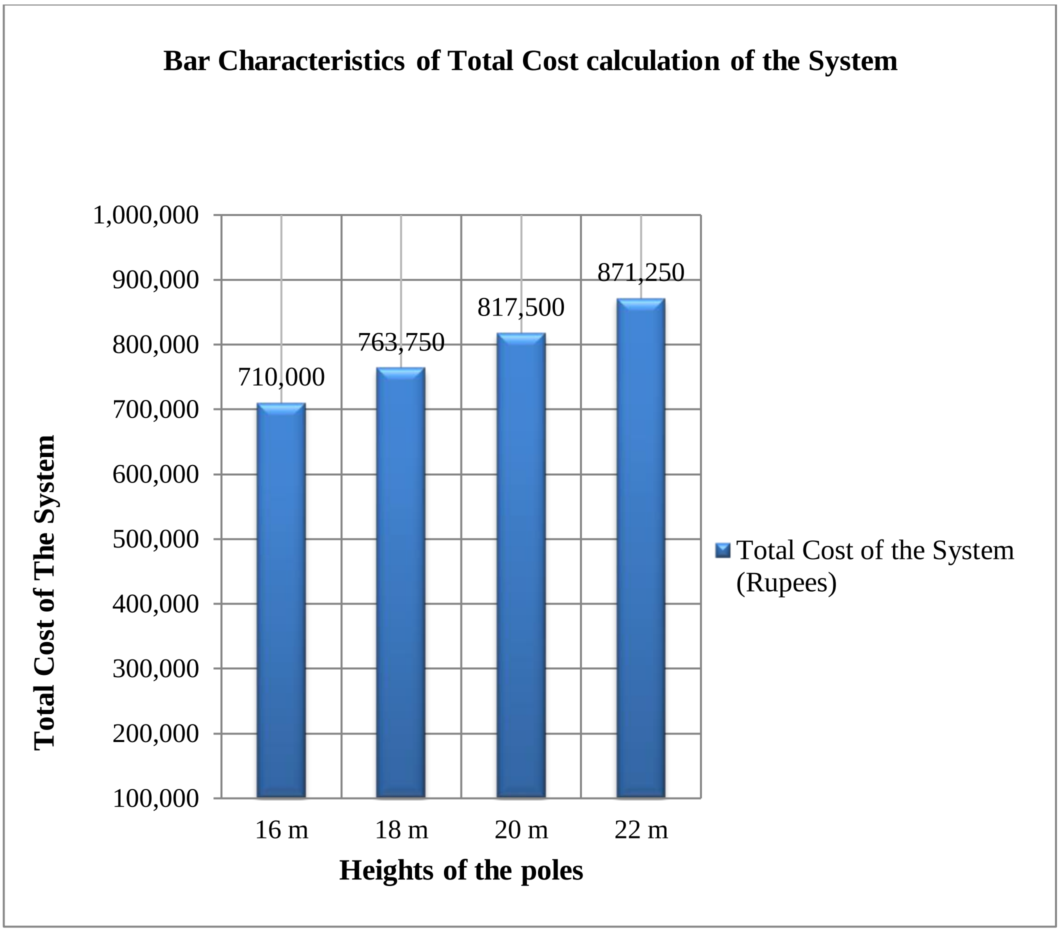

Fig no. 66 bar characteristics of total cost calculation of the system for apron area A_1 (for 440 watt Luminaires).

In below tabular format we calculated total cost of the poles for different heights. Table has contained various data like Total no of pole used, per pole cost, Pole mounting heights, Total cost of the poles.

In Table-19 Total used poles Cost Calculations for Apron Area A_2= (255 * 88.5) m^2.

Table-19 Cost Calculations of Poles

Total No of Pole Used	Per Pole Cost (Rupees)	Pole Mounting Height (Meter)	Total Cost of the pole (Rupees)
5	2,15,000	16	10,75,000
5	2,41,875	18	12,09,375
5	2,68,750	20	13,43,750
5	2,95,625	22	14,78,125

Luminaires cost calculations were done in other table after that total cost of the entire system can be calculated. Total system cost should be calculated as

(Total Luminaires Cost + Total Poles Cost).

In this tabular format contained no of luminaires used in the thesis, per luminaire cost, total cost of poles, mounting height of luminaires, total cost of luminaires and total cost of the system.

In Table-20 detail cost calculation of total system was done (for 400 watt luminaire).

Table- 20 Cost Calculations of Total System (400 watt LED Luminaires)

Total No of Luminaire Used in Thesis	Per Luminaire Cost (Rupees)	Total Cost of poles (Rupees)	Mounting Height of Luminaires (Meter)	Total Cost of Luminaires (Rupees)	Total Cost of the System (Total Luminaires Cost + Total Poles Cost) (Rupees)
30	22,000	10,75,000	16	6,60,000	17,35,000
30	22,000	12,09,375	18	6,60,000	18,69,375
30	22,000	13,43,750	20	6,60,000	20,03,750
30	22,000	14,78,125	22	6,60,000	21,38,125

In the bar graph total cost of the system was on ‘Y’ axis and different heights on ‘X’ axis. Variation can be showed on ‘Y’ axis.

In this characteristics total cost increased with respect to their heights.

In Fig no. 69 bar characteristics of total cost of the system was showed.

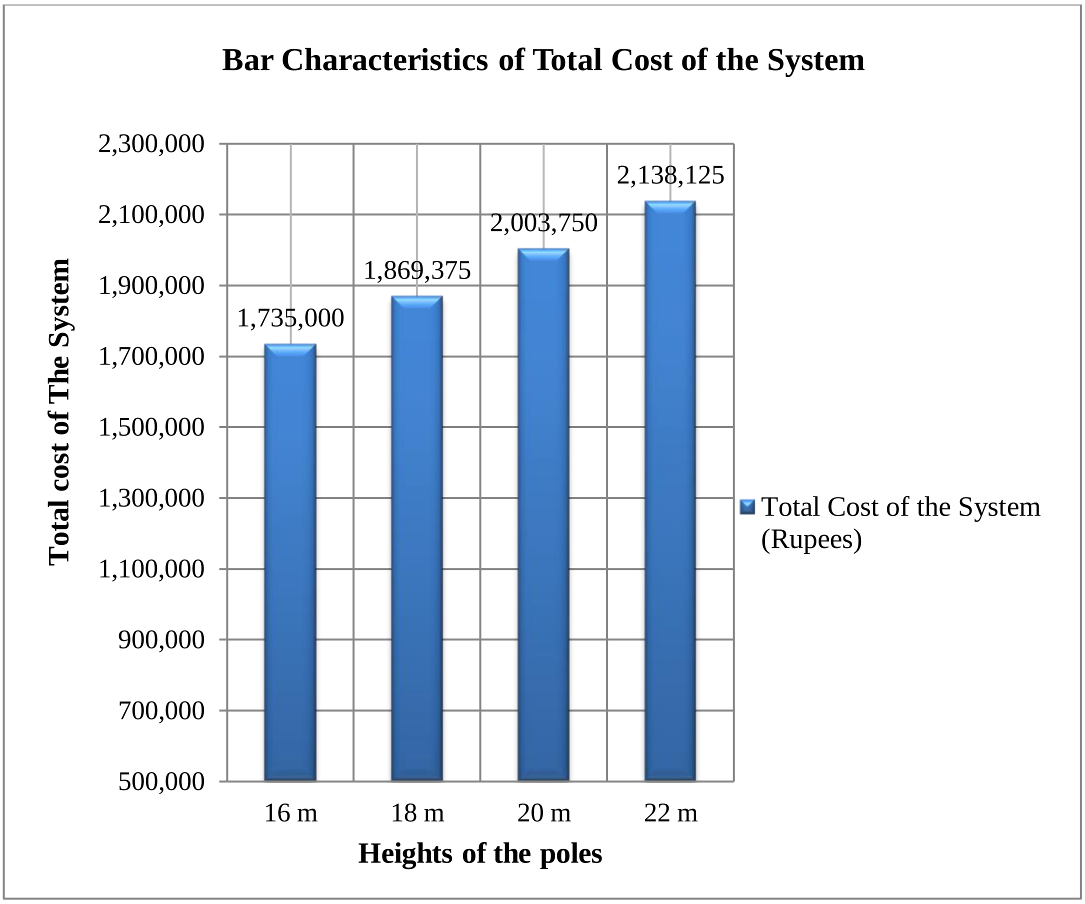

Fig no.69 bar characteristics of total cost calculation of the system for apron area A_2 (for 400 watt Luminaires).

Luminaires cost calculations were done in other table after that total cost of the entire system can be calculated. Total system cost should be calculated as

(Total Luminaires Cost + Total Poles Cost).

In this tabular format contained no of luminaires used in the thesis, per luminaire cost, total cost of poles, mounting height of luminaires, total cost of luminaires and total cost of the system.

Table- 23 Cost Calculations of Total System (440 watt LED Luminaires)

Total No of Luminaire Used in Thesis	Per Luminaire Cost (Rupees)	Total Cost of poles (Rupees)	Mounting Height of Luminaires (Meter)	Total Cost of Luminaires (Rupees)	Total Cost of the System (Total Luminaires Cost + Total Poles Cost) (Rupees)
30	35,000	10,75,000	16	10,50,000	21,25,000
30	35,000	12,09,375	18	10,50,000	22,59,375
30	35,000	13,43,750	20	10,50,000	23,93,750
30	35,000	14,78,125	22	10,50,000	25,28,125

In the bar characteristics total cost of the system was on ‘Y’ axis and different heights on ‘X’ axis. Variation can be showed on ‘Y’ axis. In this characteristics total cost increased with respect to their heights.

In Fig no. 70 bar characteristics of total cost of the system was showed.

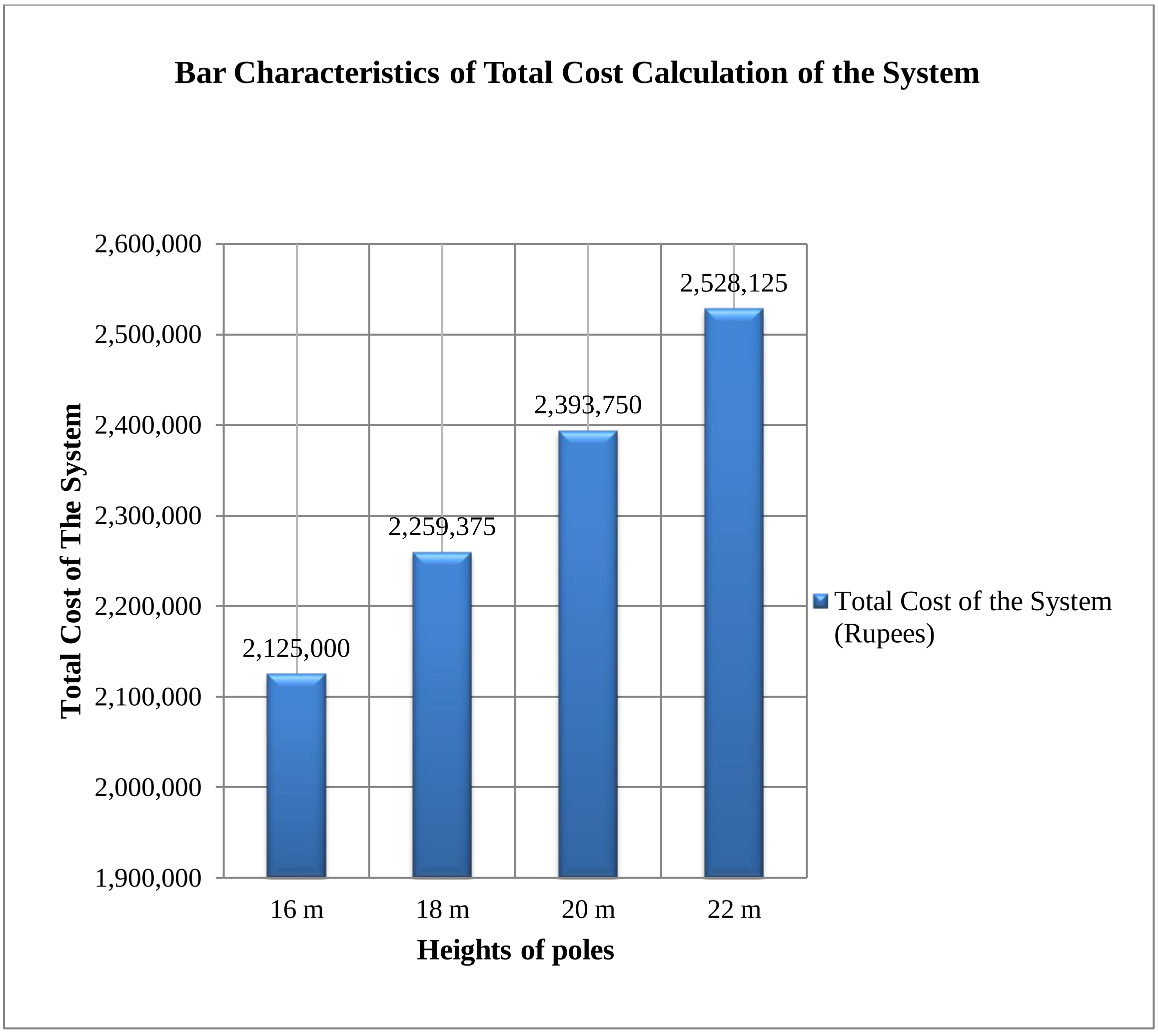

Fig no. 70 bar characteristics of total cost calculation of the system for apron area A_2 (for 440 watt Luminaires).

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

In this thesis it has chosen two apron areas considered A_1 and A_2 for simulating the lighting design. In this thesis we use 400 watt and 440 watt LED luminaires for simulation. After that we simulated theses two apron areas and three parameters Horizontal illuminance, vertical illuminance and uniformity factor obtained. After that these three parameters obtained values were varied with their respective standard values mentioned in "National Lighting Code". After that how much change would happen after simulation, these standard values and obtain values were plotted. After simulation result comparison study were showed after that cost calculation were showed. Their cost calculation comparisons were presented.

Being an illumination engineer in this thesis it realized that vertical illuminance values were drop down when height of the pole was increased.

5.2 Future scope

In this thesis many future scopes will be occurred in apron lighting design. These future scopes will mention detail as under;

- Detailed energy calculation will be done for LED luminaires. After the energy calculation, detailed characteristics will happen.

- In this proposed design, higher wattage of LED luminaries will use for simulation instead of lower wattage to find out horizontal illuminance, vertical illuminance and uniformity and obtain values will be matched with standard values. Detail characteristics will be occurred for this higher wattage LED luminaries to see any changes of those values.

- Detailed energy calculation will be done for higher wattage LED luminaries and detail comparisons will occur.

- Detail cost calculation will be done for higher wattage LED luminaries. After that detail characteristics will occur.

- Smart monitoring system should be implemented in apron lighting.

- Smart protection of lighting system should be implemented in apron lighting.

- Renewable sources (solar cell) should be implemented in apron lighting.

- Improved visor should be implemented in LED luminaire to keep glare level low. [13]

These scopes will do in future for fulfilling ambition to design apron lighting.

REFERENCES

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3. https://info.midstreamlighting.com/blog/icao-lights-understanding-the-rules-of-apron-floodlighting-an-faq-guid
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5. Luoxi, Hu Guojian Hao. “Comparison and Analysis of lighting calculation Software DIALux & Agi32 [J] “China Illuminating Engineering Journal.
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7. https://www.oakled.com/
8. https://lightingequipmentsales.com/uniformity.html
9. https://iarc.uncg.edu/elight/learn/qualitative/la_sub/isolux.html
10. https://www.aajjo.com/street-flood-and-commercial-lights_12-16-mtt-bajaj-high-mast-pole
11. https://www.indiamart.com/proddetail/surya-400w-led-floodlight-
12. https://www.indiamart.com/proddetail/led-sports-flood-lighting
13. https://aviationrenewables.com/product/total-light-structure-system/

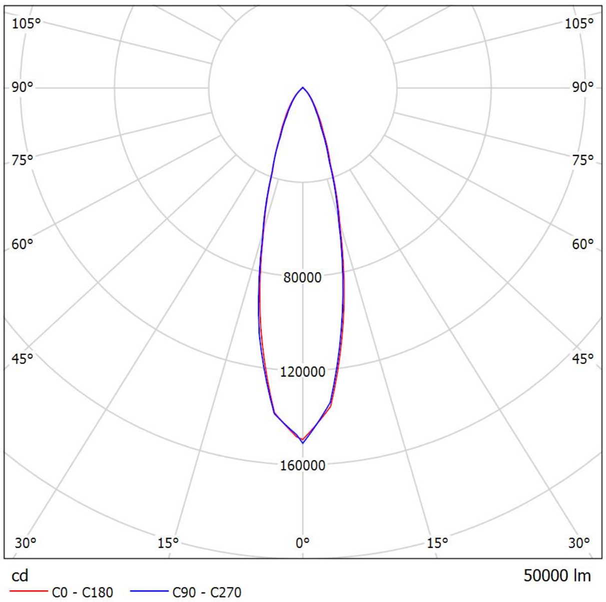
APPENDIX

Operator
Telephone
Fax
e-Mail

Surya SLE FL 400W IP66 LIVIA G2 Y3 / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.



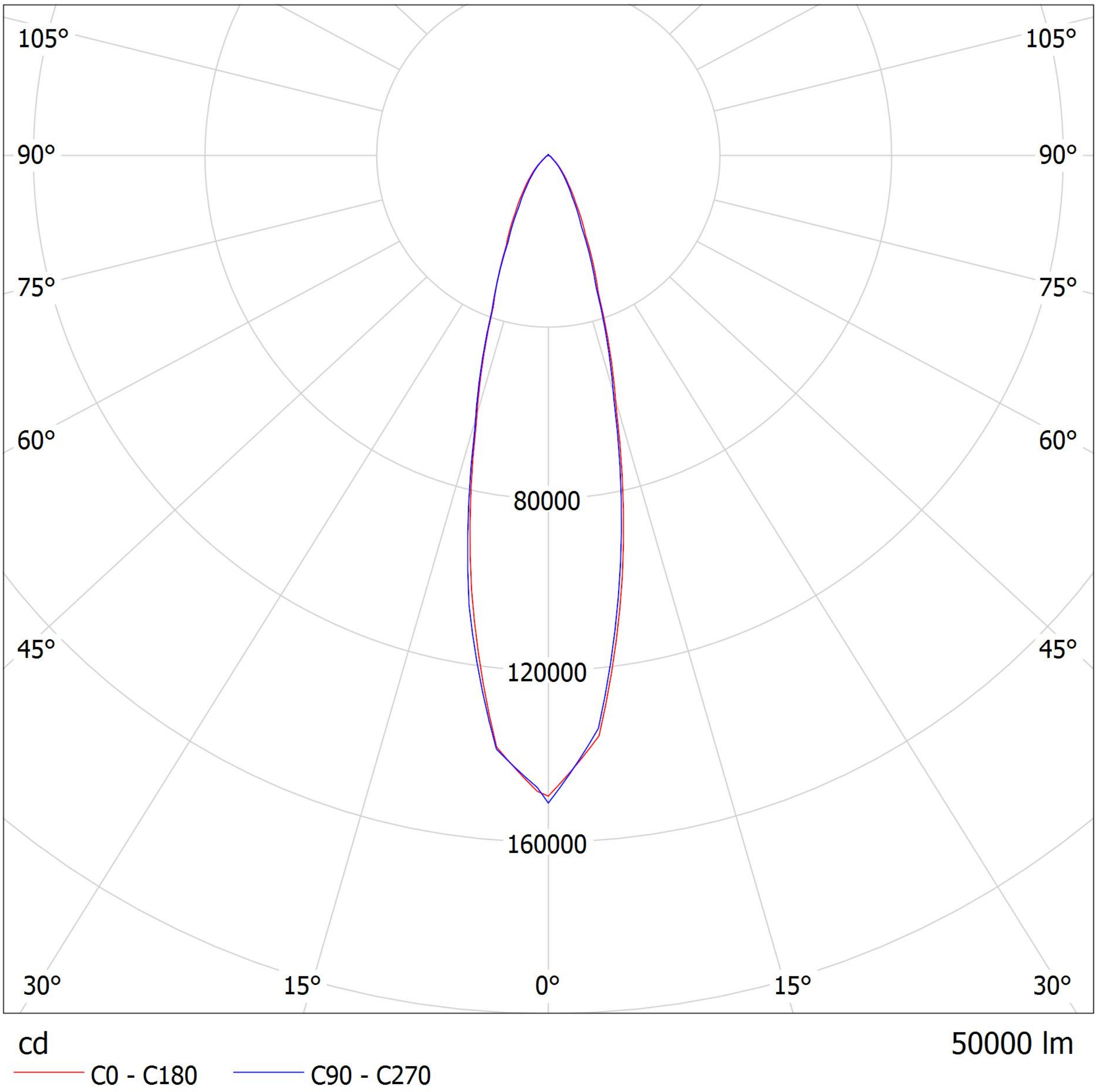
Luminaire classification according to CIE: 100
CIE flux code: 91 98 100 100 101

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

Operator
Telephone
Fax
e-Mail

Surya SLE FL 400W IP66 LIVIA G2 Y3 / LDC (Polar)

Luminaire: Surya SLE FL 400W IP66 LIVIA G2 Y3
Lamps: 1 x

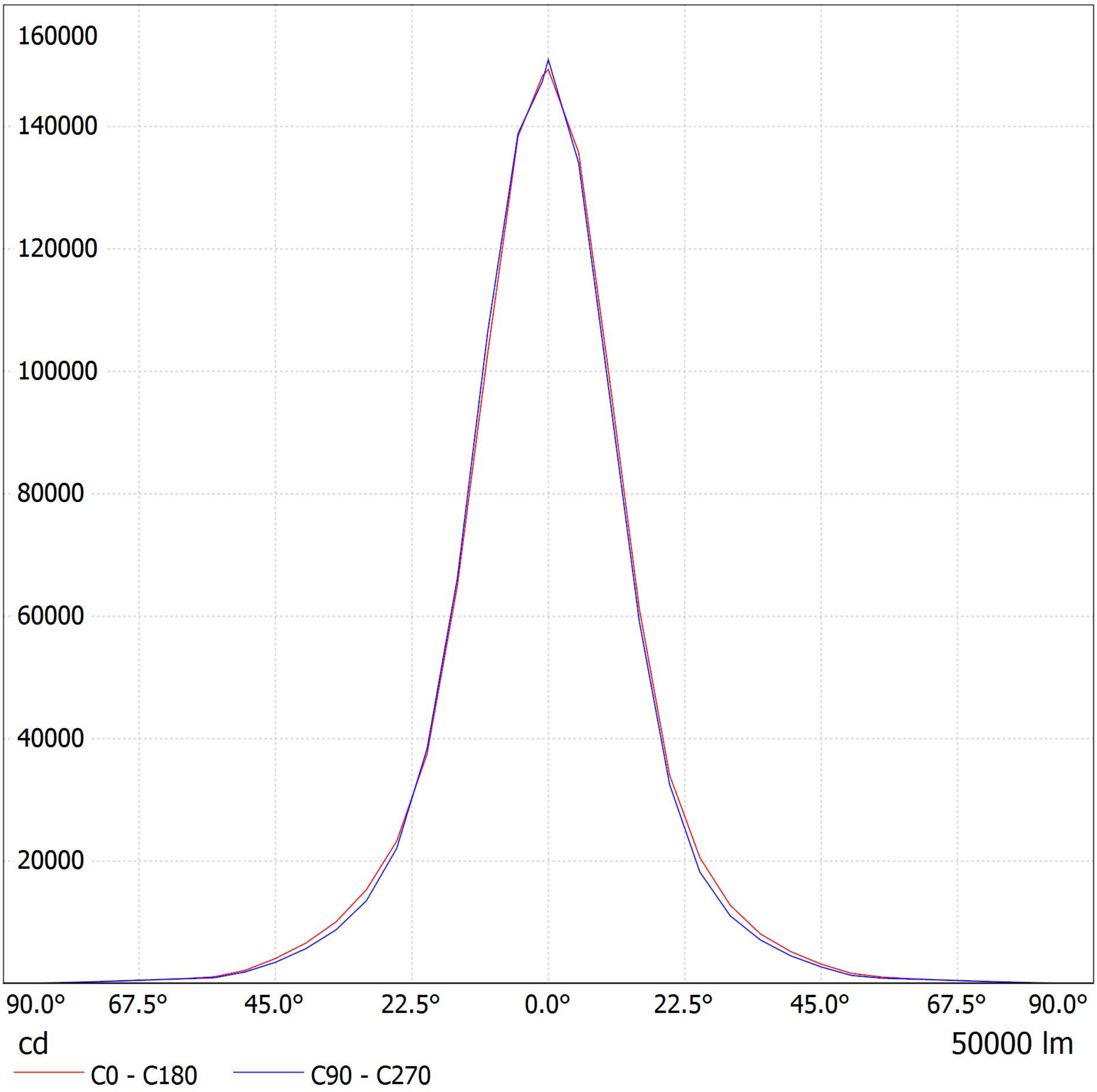


DIALux
09.08.2022

Operator
Telephone
Fax
e-Mail

Surya SLE FL 400W IP66 LIVIA G2 Y3 / LDC (Linear)

Luminaire: Surya SLE FL 400W IP66 LIVIA G2 Y3
Lamps: 1 x

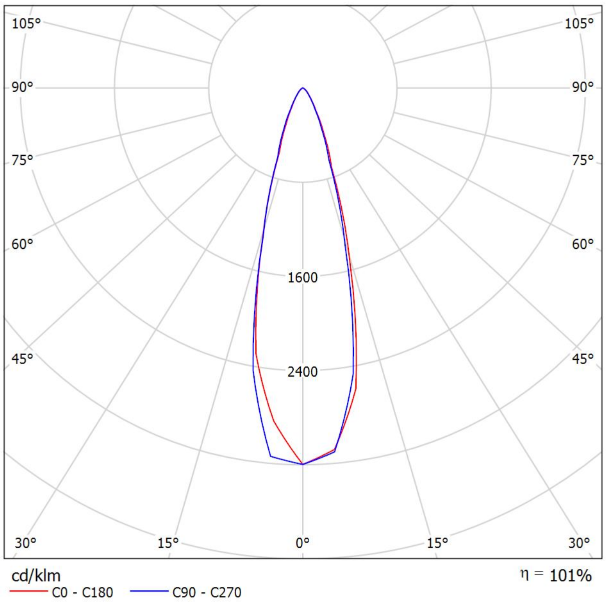


Operator
Telephone
Fax
e-Mail

INTEGRATED POWER FL FLA400BL5KN02 / Luminaire Data Sheet

Luminous emittance 1:

See our luminaire catalog for an image of the luminaire.



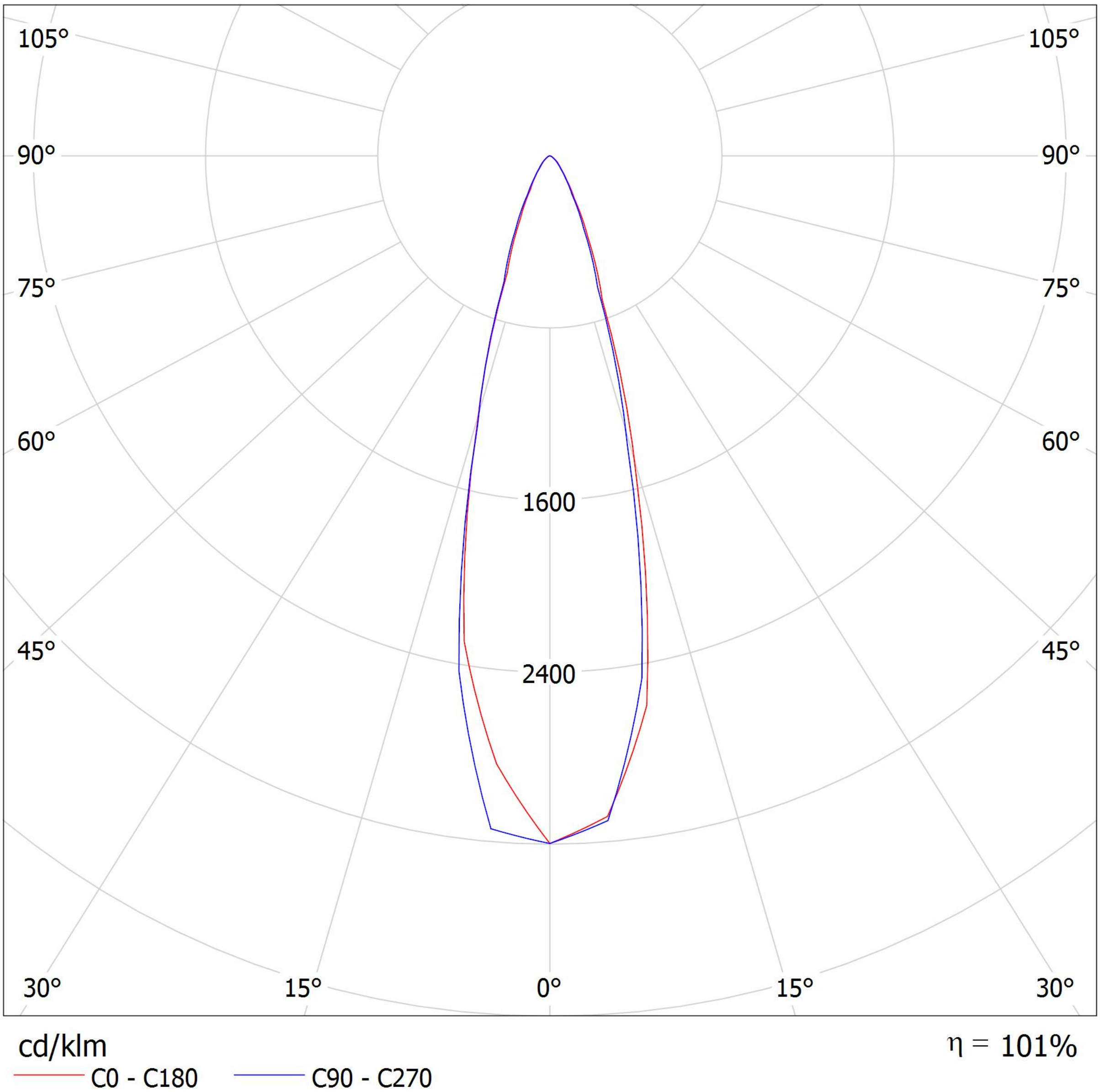
Luminaire classification according to CIE: 100
CIE flux code: 92 98 100 100 101

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

Operator
Telephone
Fax
e-Mail

INTEGRATED POWER FL FLA400BL5KN02 / LDC (Polar)

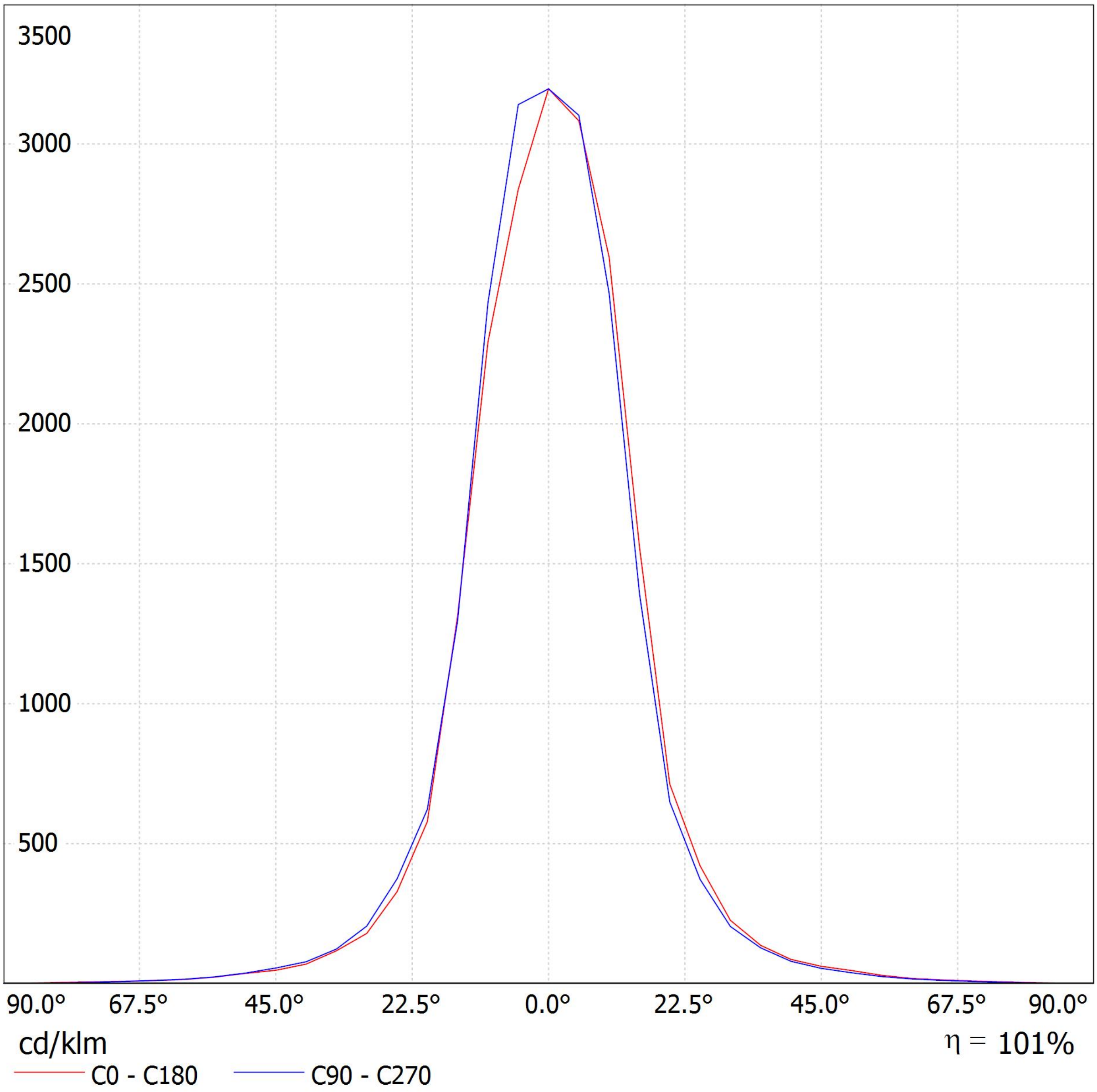
Luminaire: INTEGRATED POWER FL FLA400BL5KN02
Lamps: 1 x



Operator
Telephone
Fax
e-Mail

INTEGRATED POWER FL FLA400BL5KN02 / LDC (Linear)

Luminaire: INTEGRATED POWER FL FLA400BL5KN02
Lamps: 1 x



Apron Area (77.816*48.034) m^2

(400 Watt)

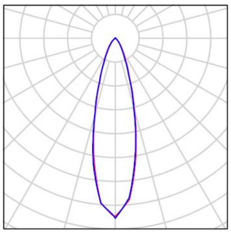
Operator
Telephone
Fax
e-Mail

Project 1 / Luminaire parts list

8 Pieces

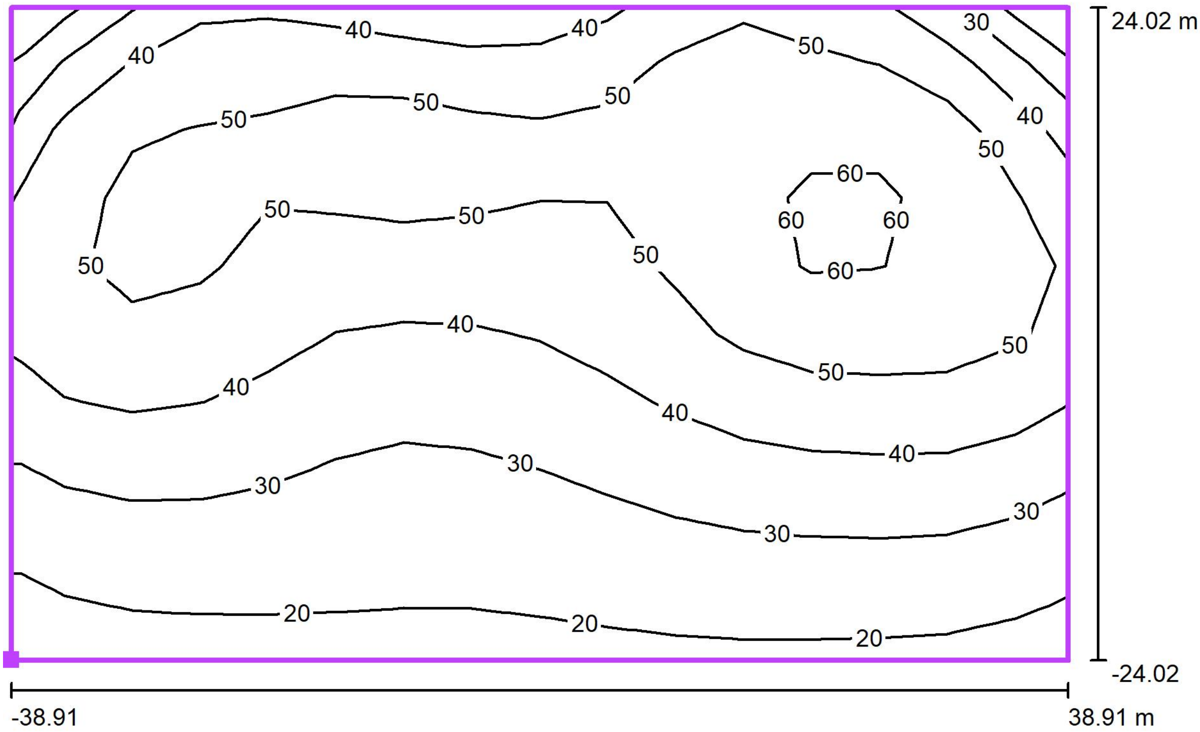
Surya SLE FL 400W IP66 LIVIA G2 Y3
Article No.: SLE FL 400W IP66 LIVIA G2 Y3
Luminous flux (Luminaire): 50000 lm
Luminous flux (Lamps): 50000 lm
Luminaire Wattage: 400.0 W
Luminaire classification according to CIE: 100
CIE flux code: 91 98 100 100 101
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



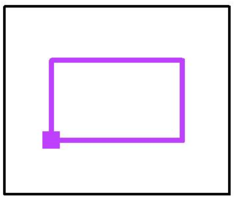
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

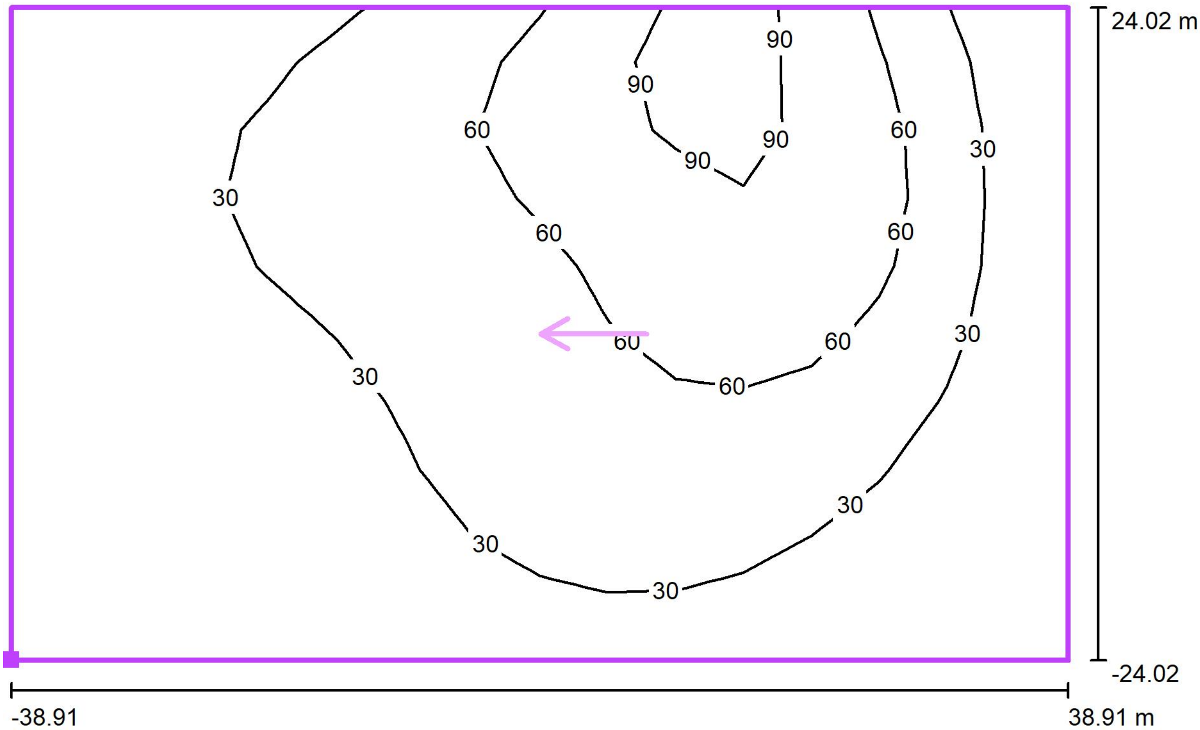


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
39	16	64	0.39	0.24

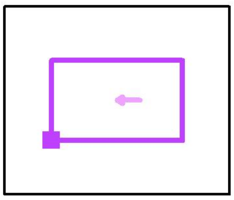
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

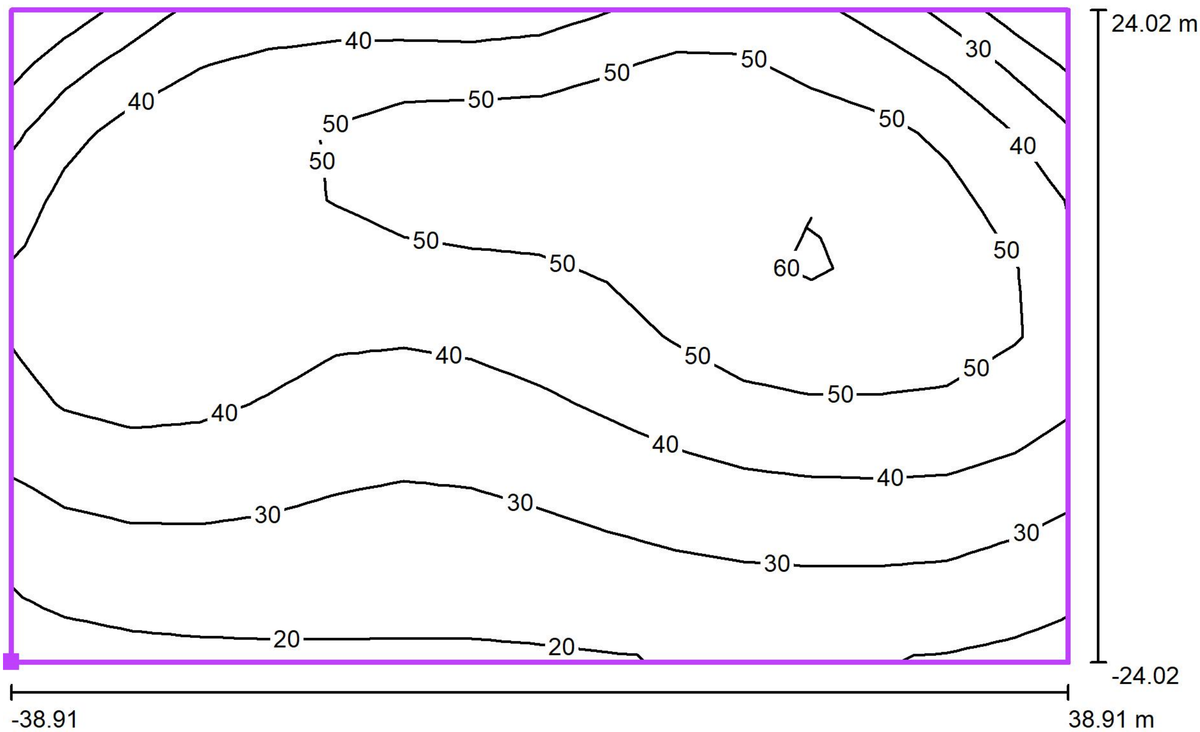


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
37	2.22	104	0.06	0.02

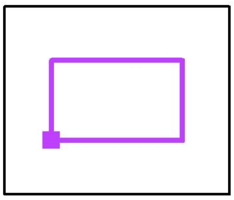
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

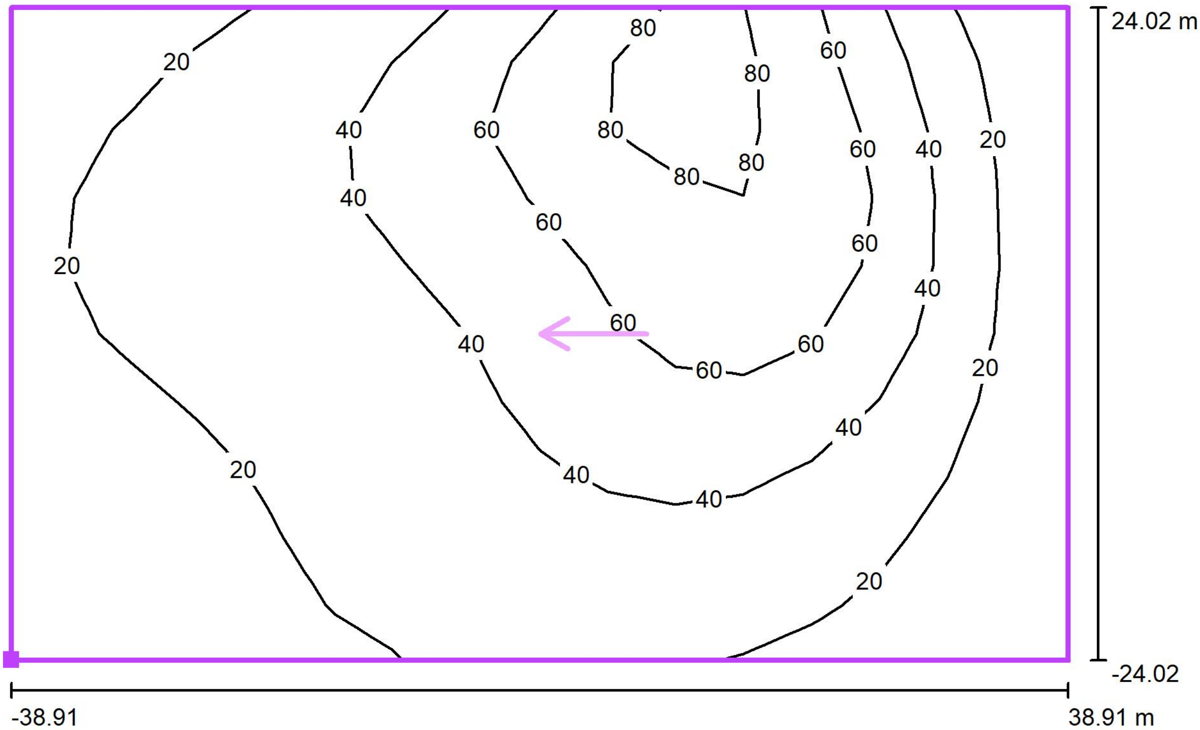


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
40	13	62	0.33	0.21

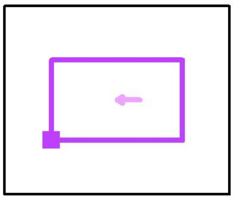
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

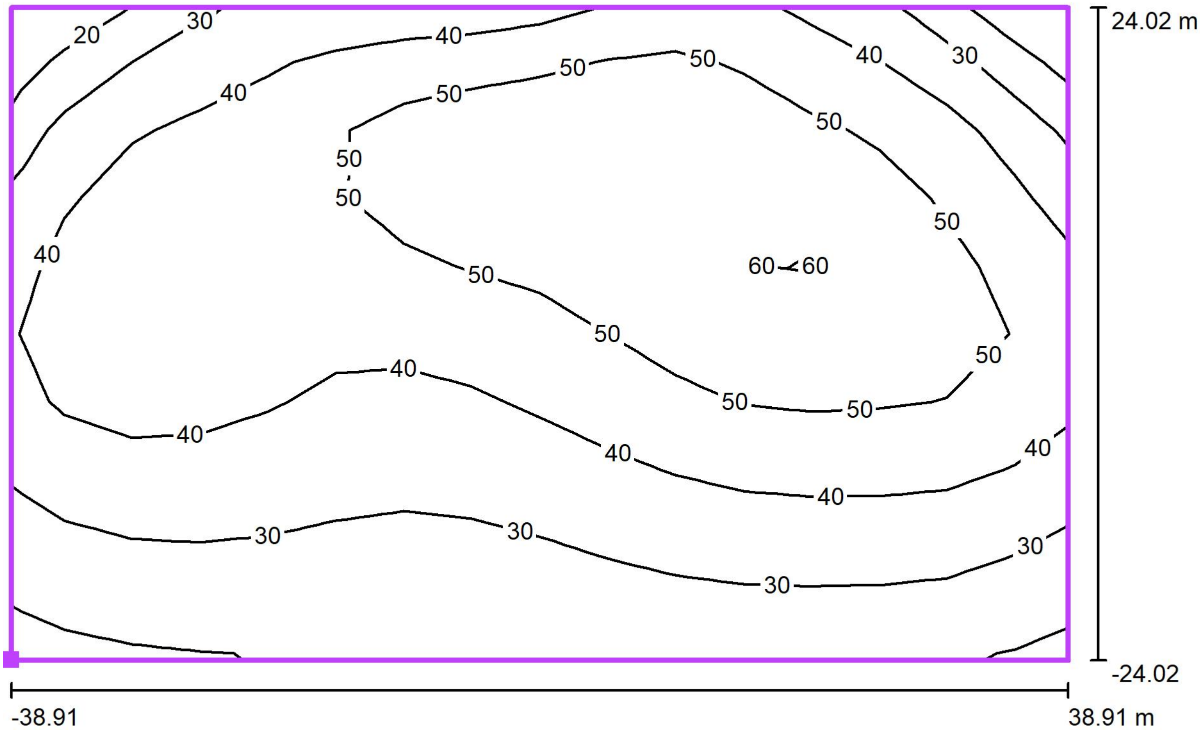


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
34	1.98	92	0.06	0.02

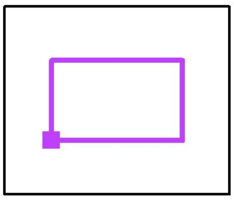
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

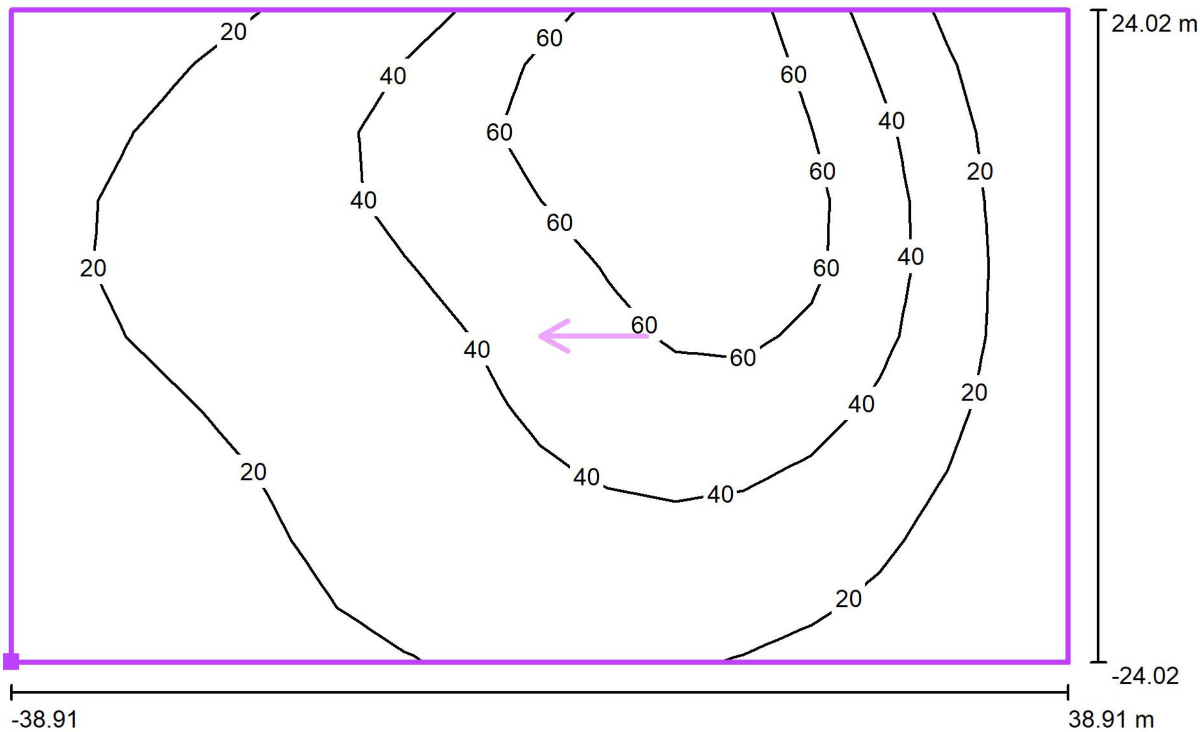


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
40	12	62	0.30	0.19

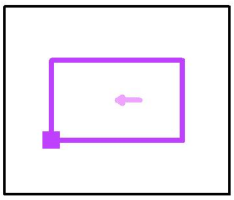
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

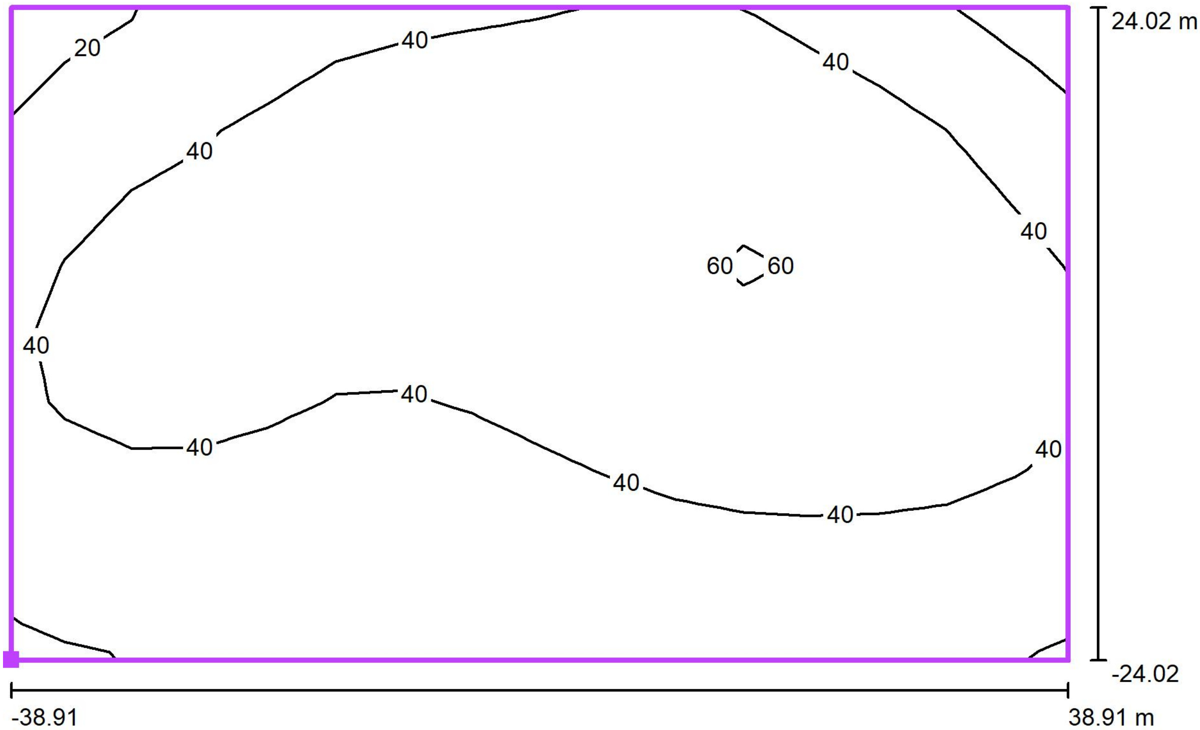


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
32	1.73	84	0.05	0.02

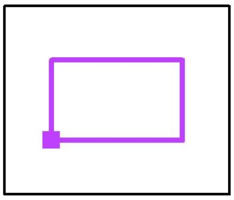
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

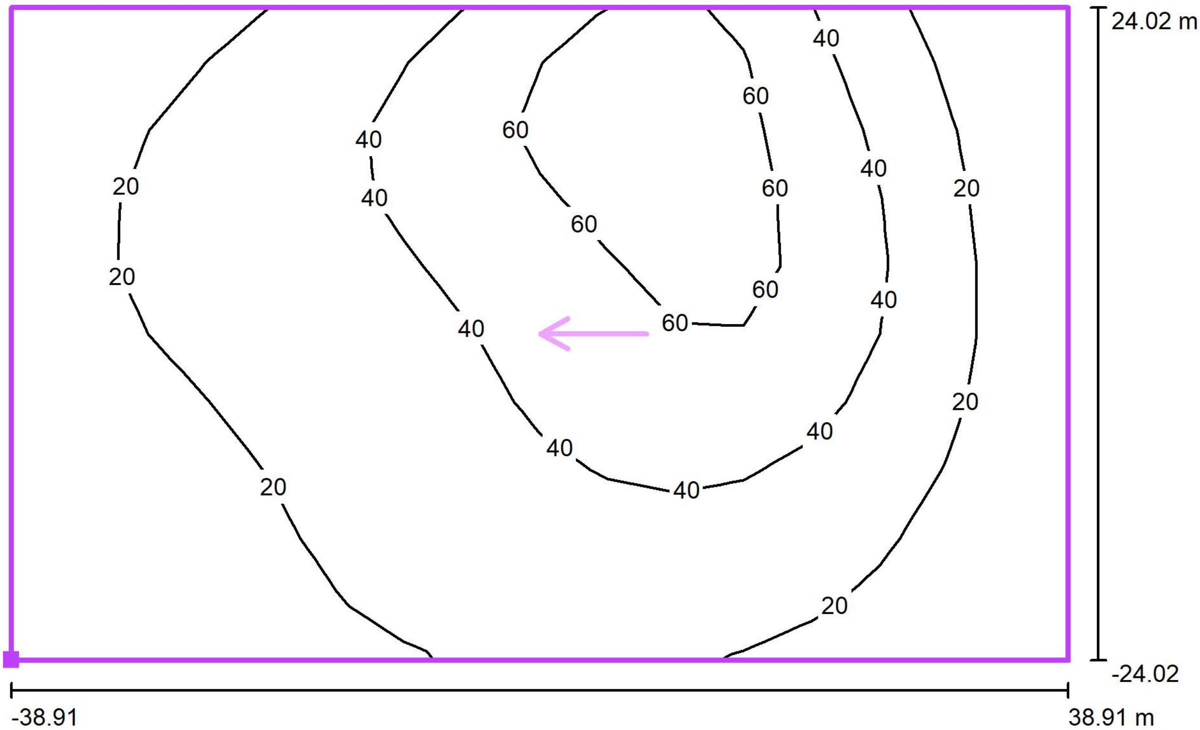


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
40	11	62	0.28	0.18

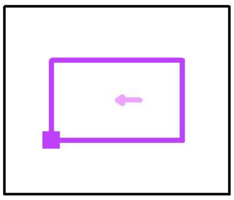
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)



Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
30	1.57	77	0.05	0.02

Apron Area (77.816*48.034) m^2

(440 Watt)

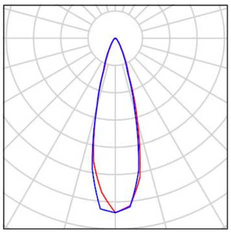
Operator
Telephone
Fax
e-Mail

Project 1 / Luminaire parts list

8 Pieces

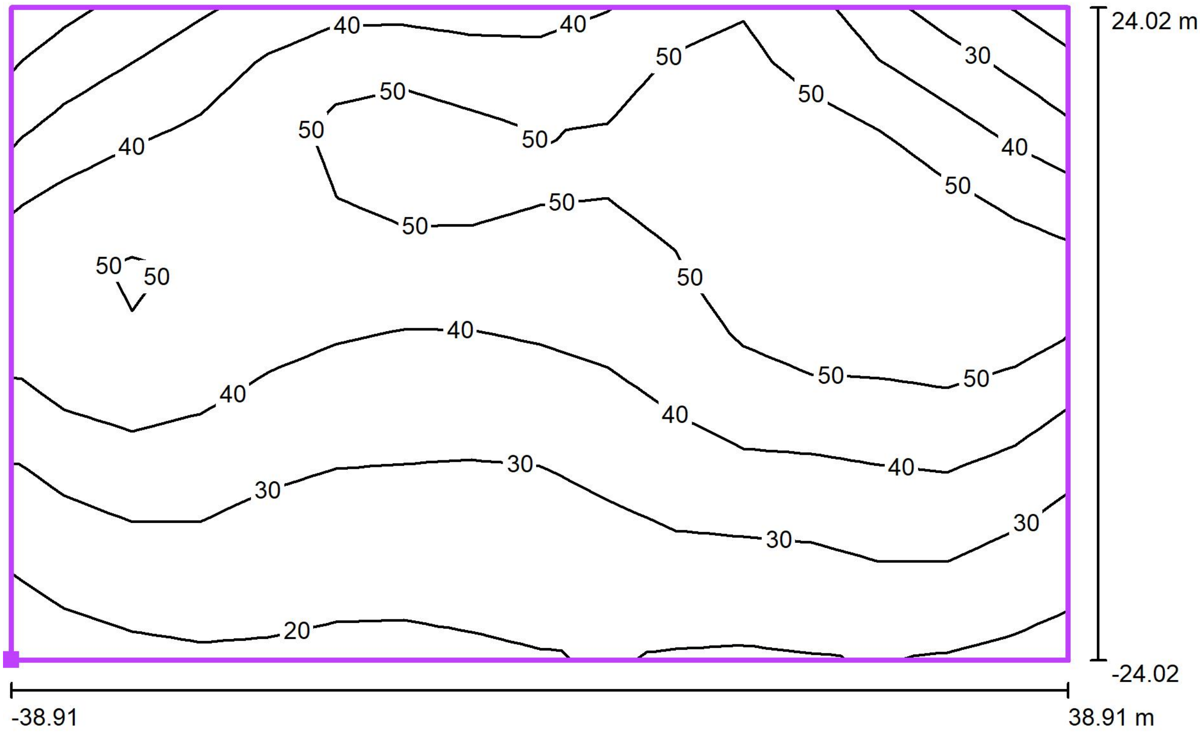
INTEGRATED POWER FL FLA400BL5KN02
Article No.: FL
Luminous flux (Luminaire): 53096 lm
Luminous flux (Lamps): 52790 lm
Luminaire Wattage: 440.0 W
Luminaire classification according to CIE: 100
CIE flux code: 92 98 100 100 101
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



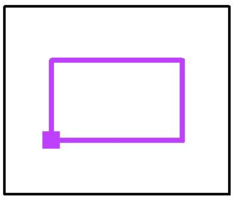
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

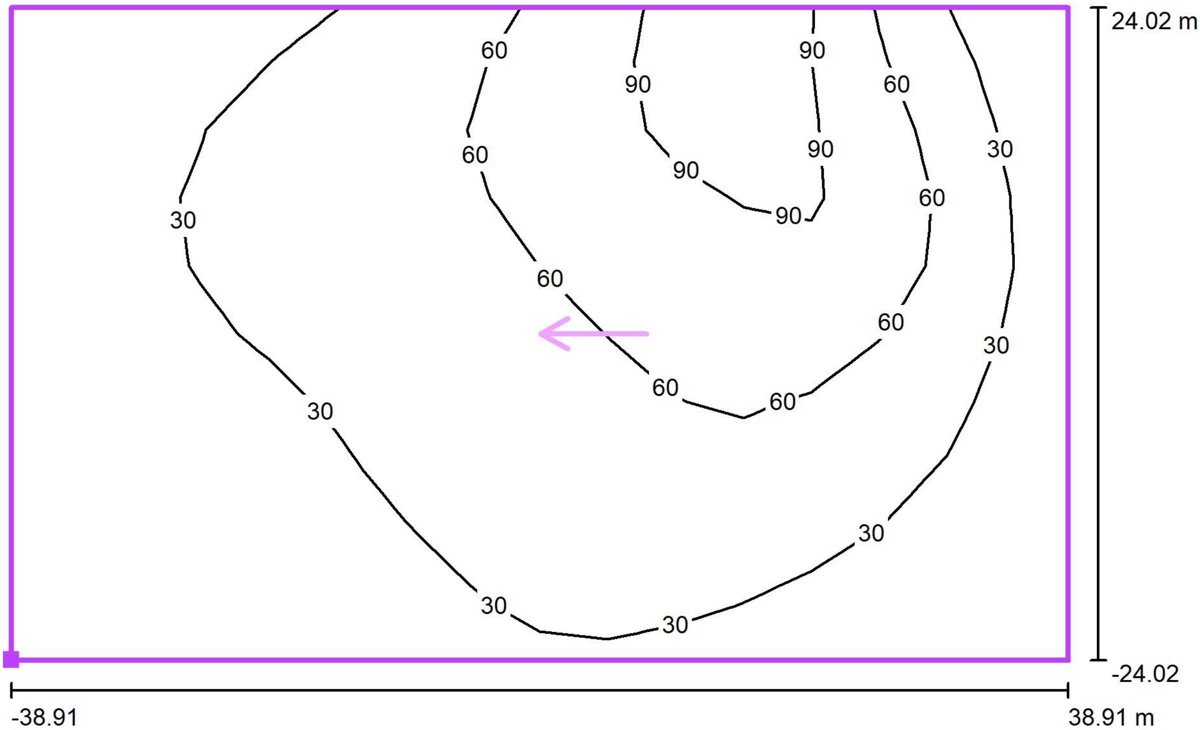


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
39	17	63	0.43	0.27

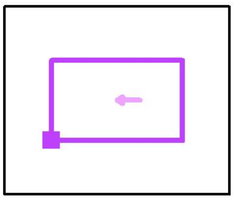
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

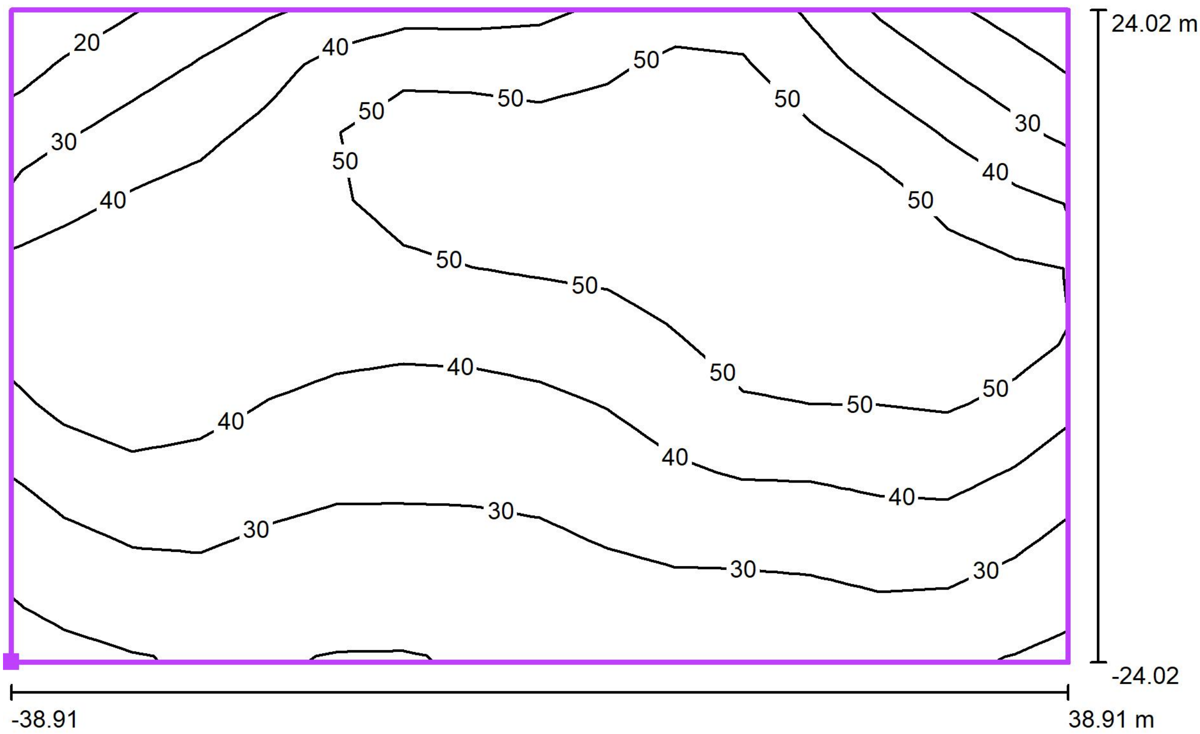


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
41	4.80	107	0.12	0.04

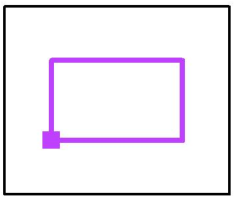
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

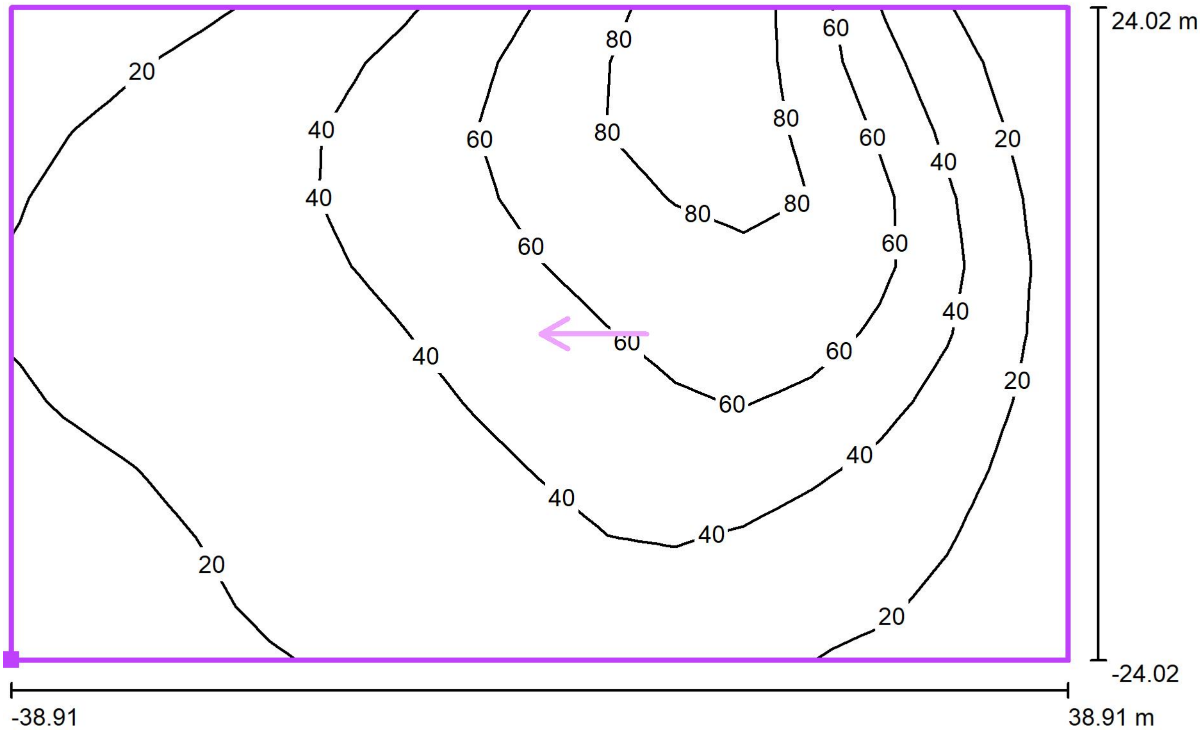


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
39	15	61	0.37	0.24

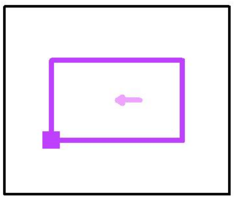
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

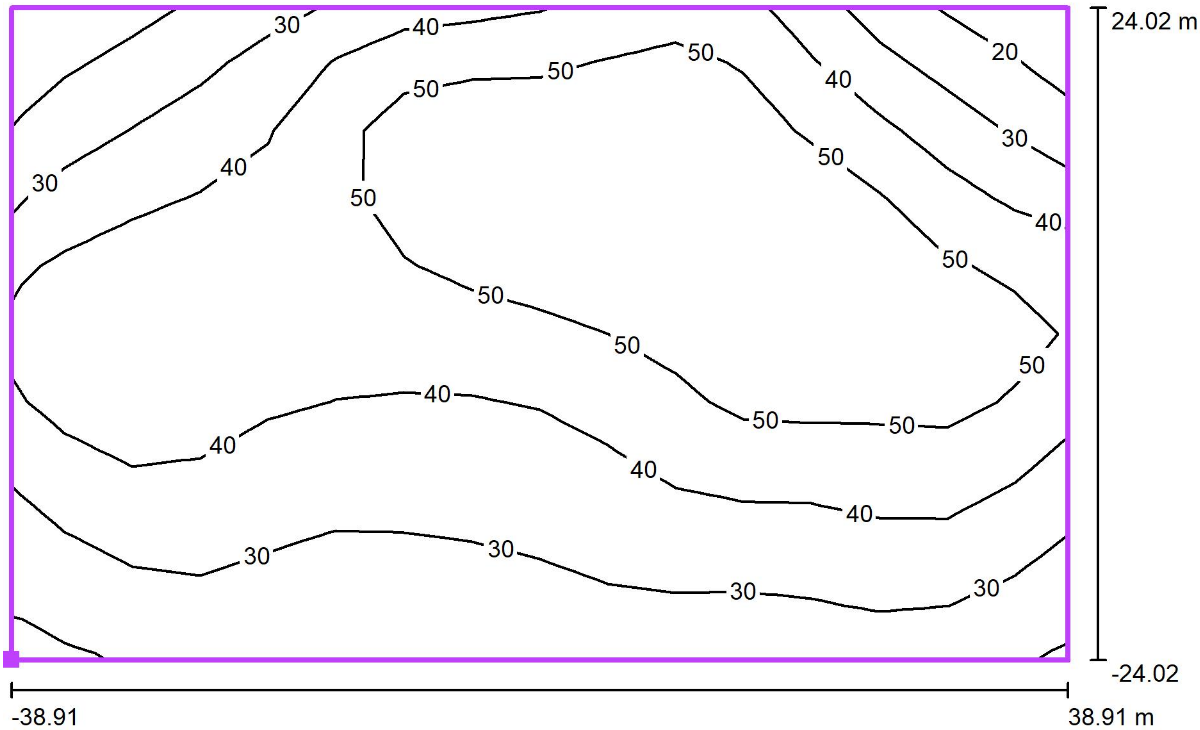


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
38	4.93	94	0.13	0.05

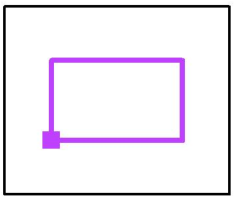
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

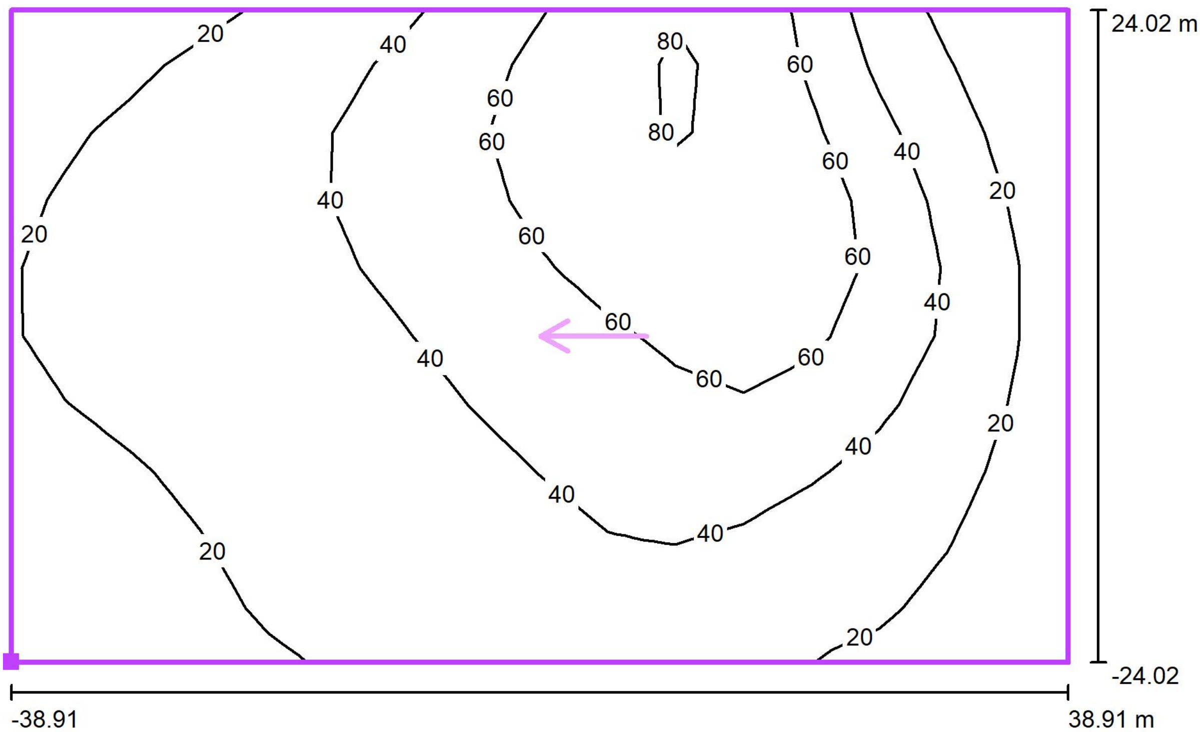


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
40	13	61	0.32	0.21

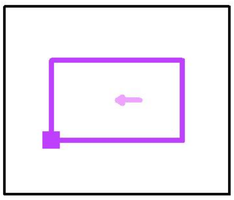
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

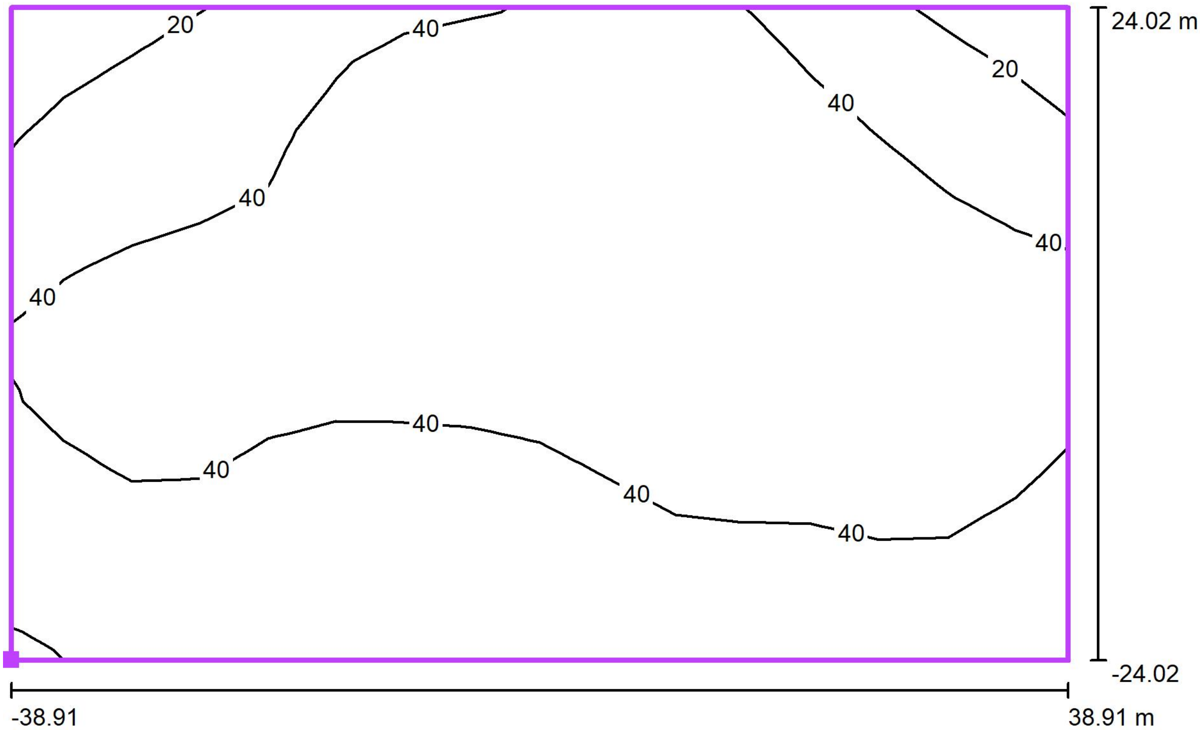


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
36	4.12	85	0.11	0.05

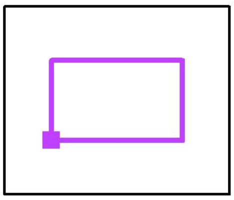
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)

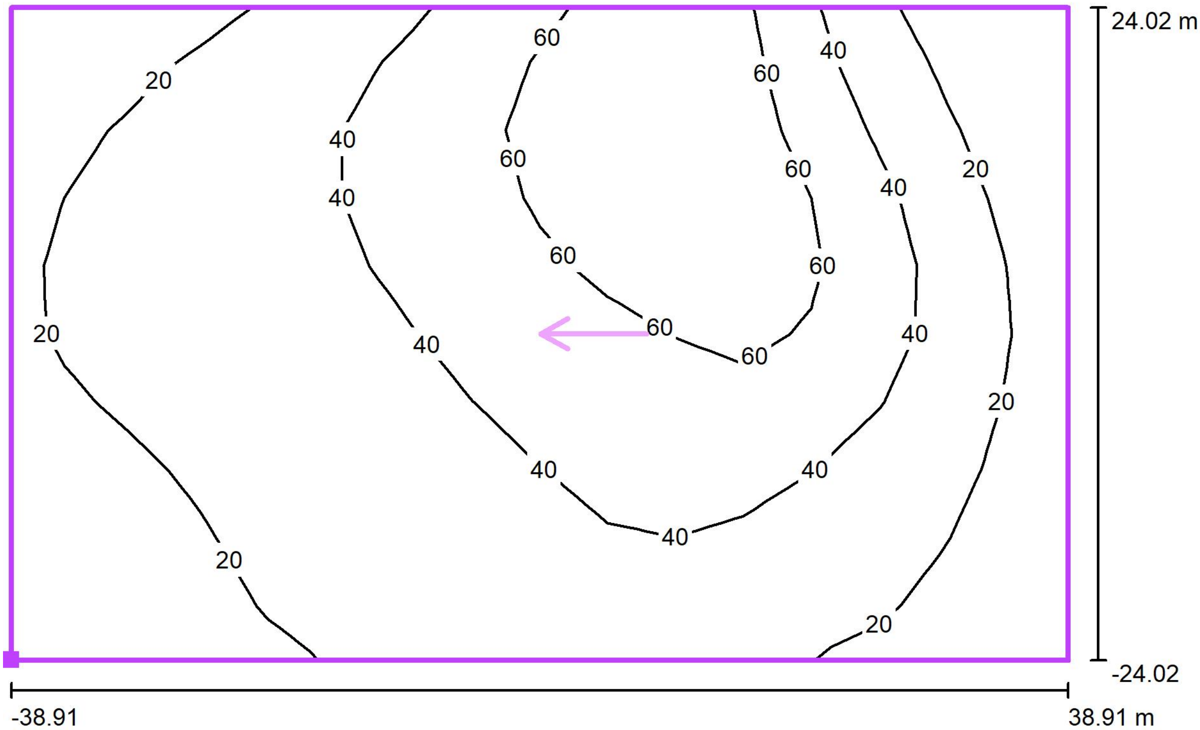


Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
40	12	62	0.29	0.19

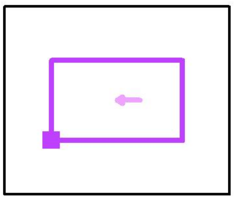
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 3 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 557

Position of surface in external scene:
Marked point: (-38.908 m, -24.017 m, 0.000 m)



Grid: 16 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
34	3.40	76	0.10	0.04

Apron Area (255*88.5) m^2

(400 Watt)

Operator
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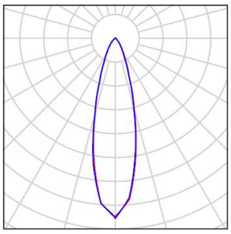
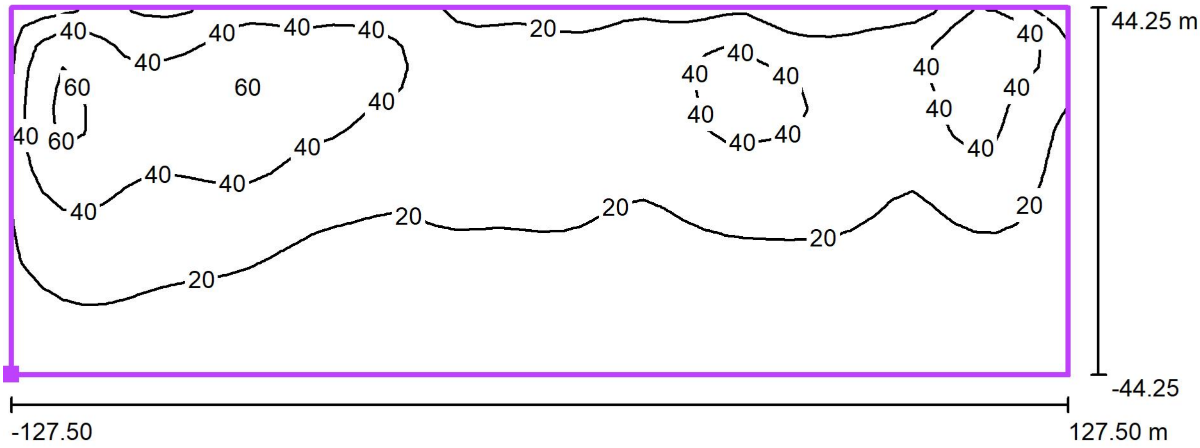
Project 1 / Luminaire parts list

30 Pieces	Surya SLE FL 400W IP66 LIVIA G2 Y3 Article No.: SLE FL 400W IP66 LIVIA G2 Y3 Luminous flux (Luminaire): 50000 lm Luminous flux (Lamps): 50000 lm Luminaire Wattage: 400.0 W Luminaire classification according to CIE: 100 CIE flux code: 91 98 100 100 101 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

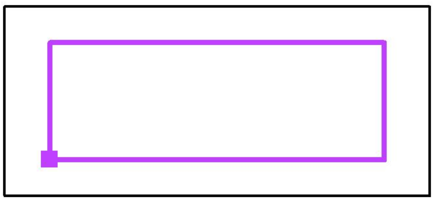
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

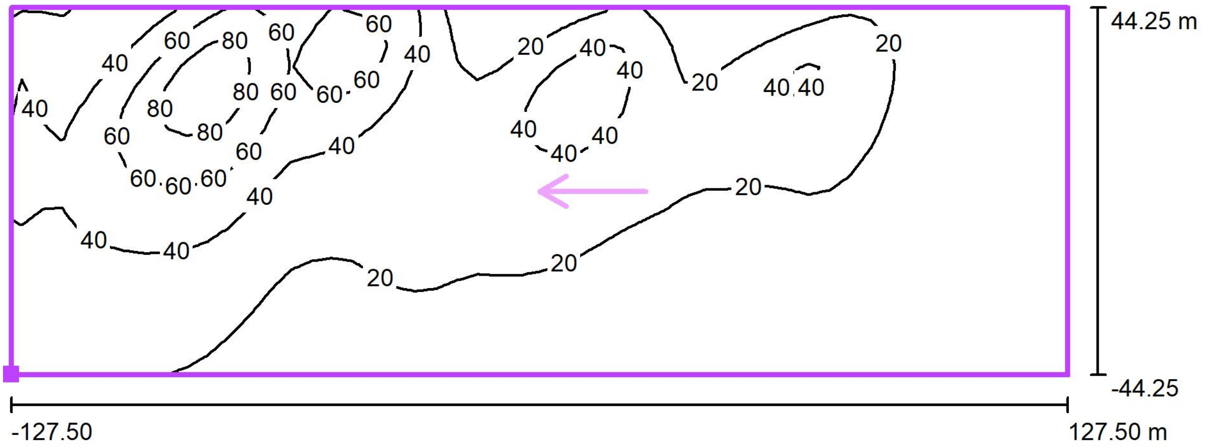


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
26	6.62	66	0.25	0.10

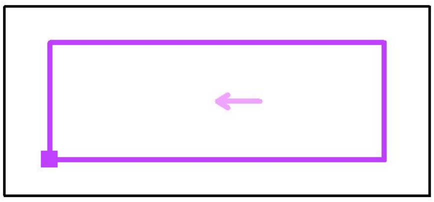
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

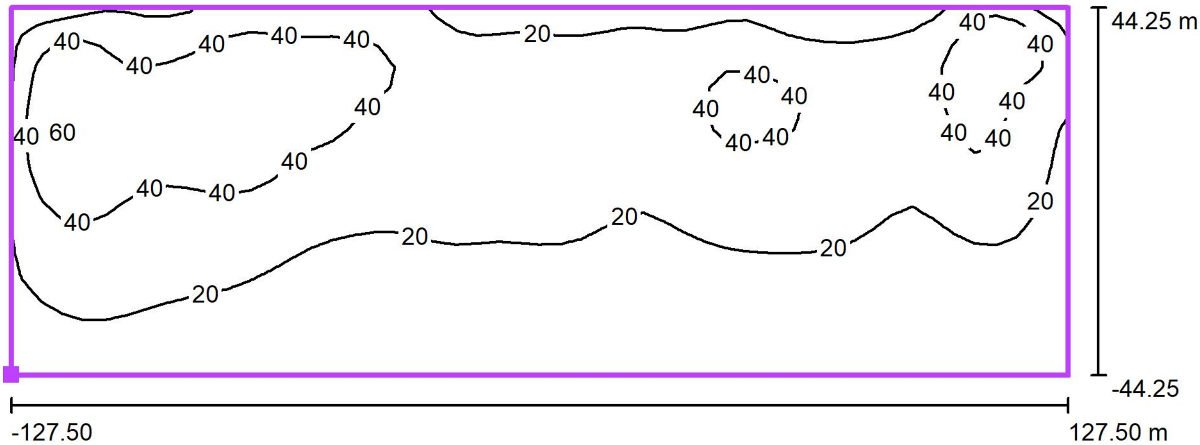


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
25	0.69	94	0.03	0.01

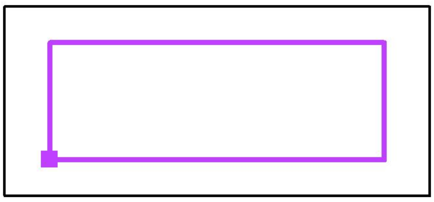
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

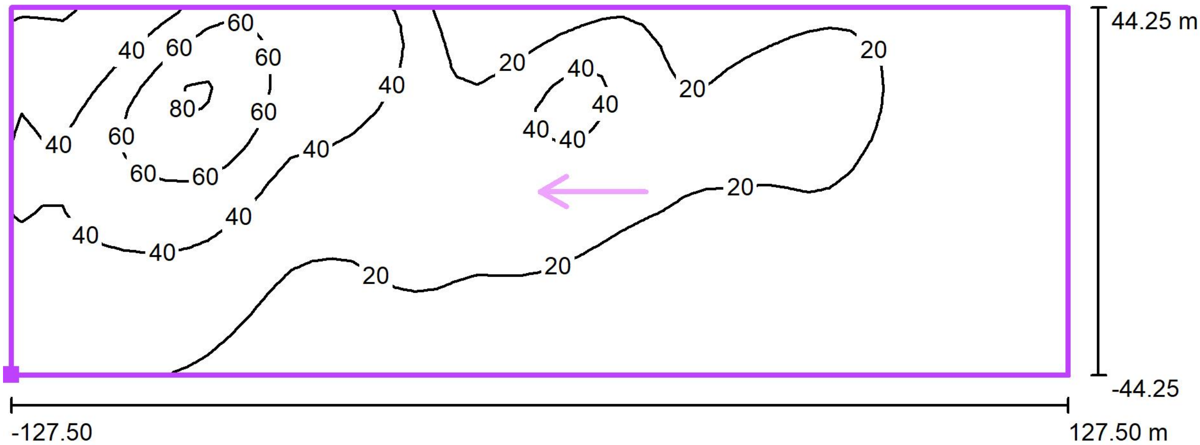


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
26	7.34	62	0.28	0.12

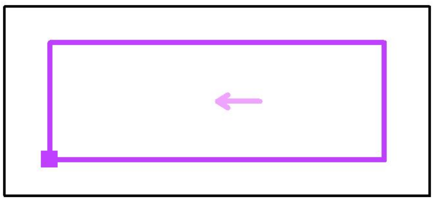
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

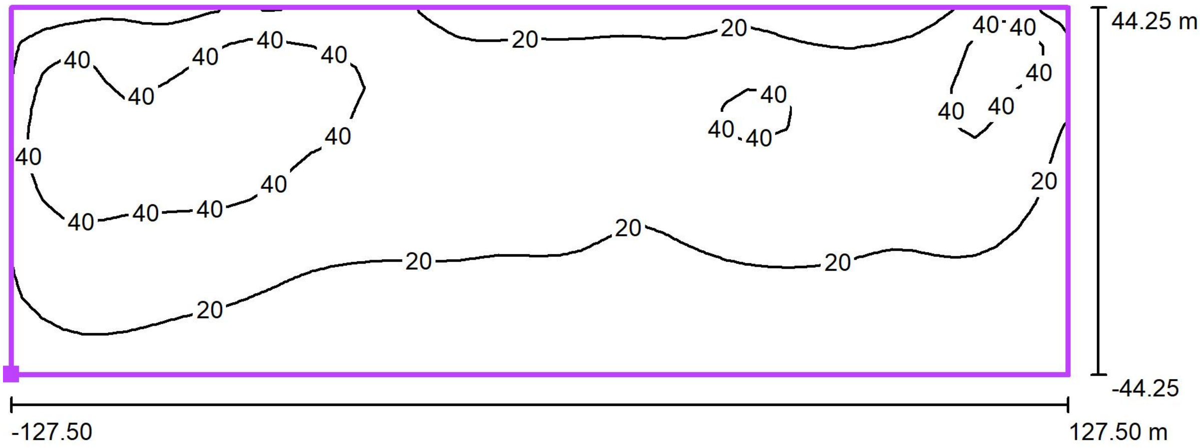


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
24	0.76	83	0.03	0.01

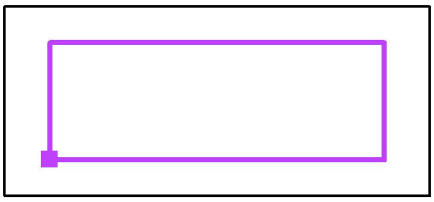
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)



Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
27	6.80	60	0.26	0.11

Operator
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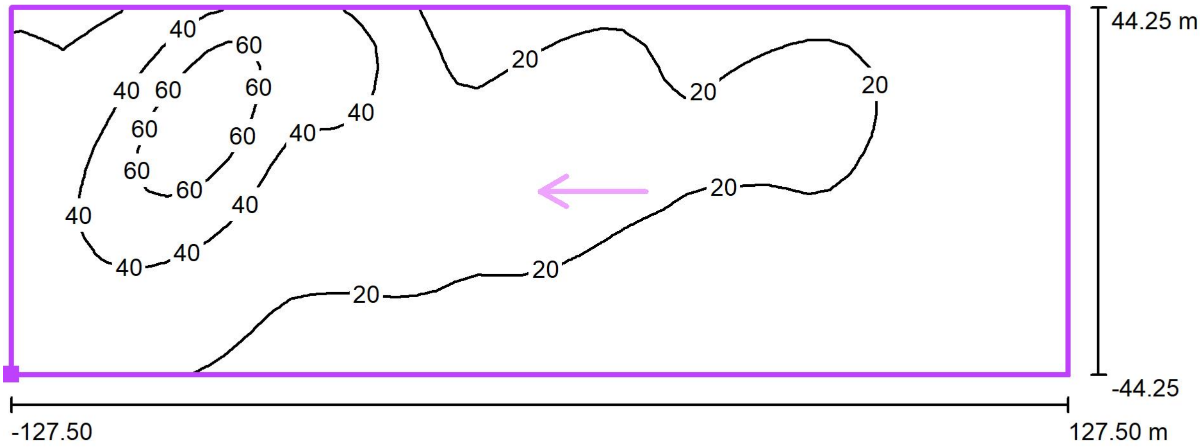
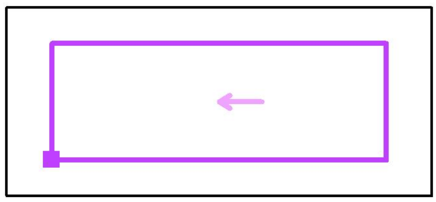
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

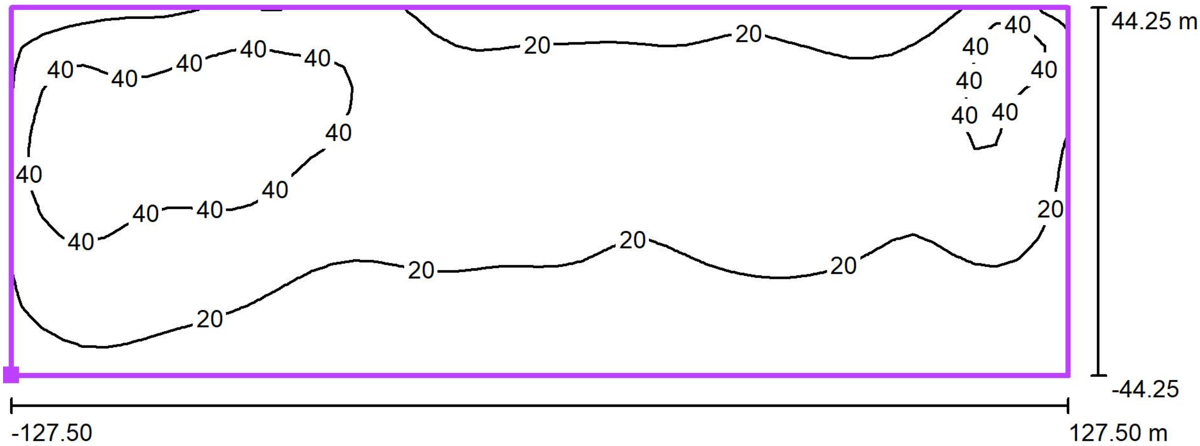


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
23	0.74	80	0.03	0.01

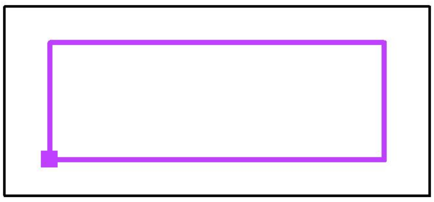
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

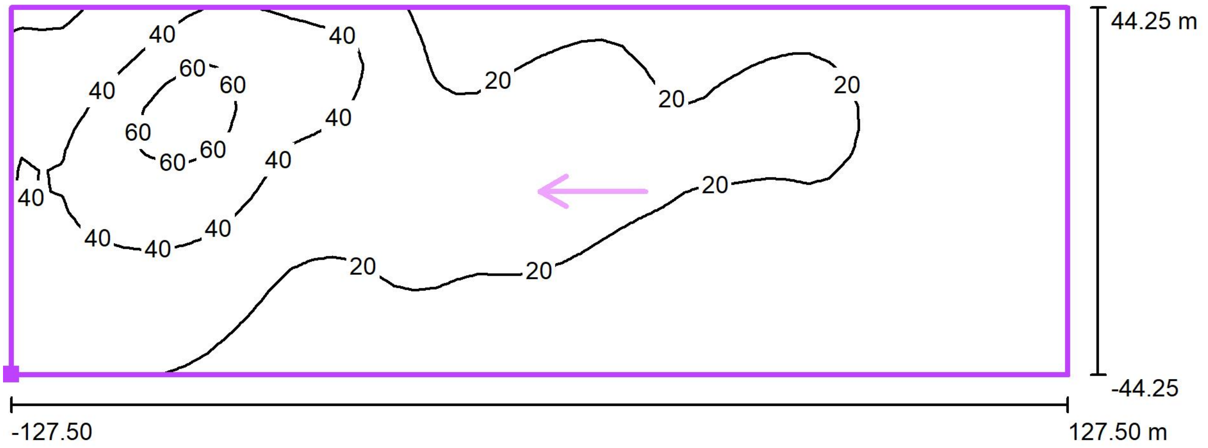


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
26	6.79	57	0.26	0.12

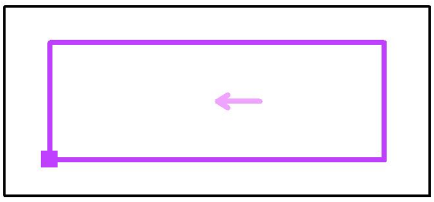
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)



Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
21	0.90	68	0.04	0.01

Apron Area (255*88.5) m^2

(440 Watt)

DIALux
04.08.2022

Operator
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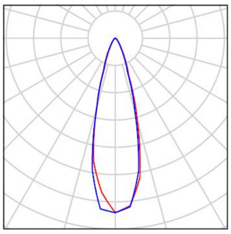
Project 1 / Luminaire parts list

30 Pieces

INTEGRATED POWER FL FLA400BL5KN02
Article No.: FL
Luminous flux (Luminaire): 53096 lm
Luminous flux (Lamps): 52790 lm
Luminaire Wattage: 440.0 W
Luminaire classification according to CIE: 100
CIE flux code: 92 98 100 100 101
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator
Telephone
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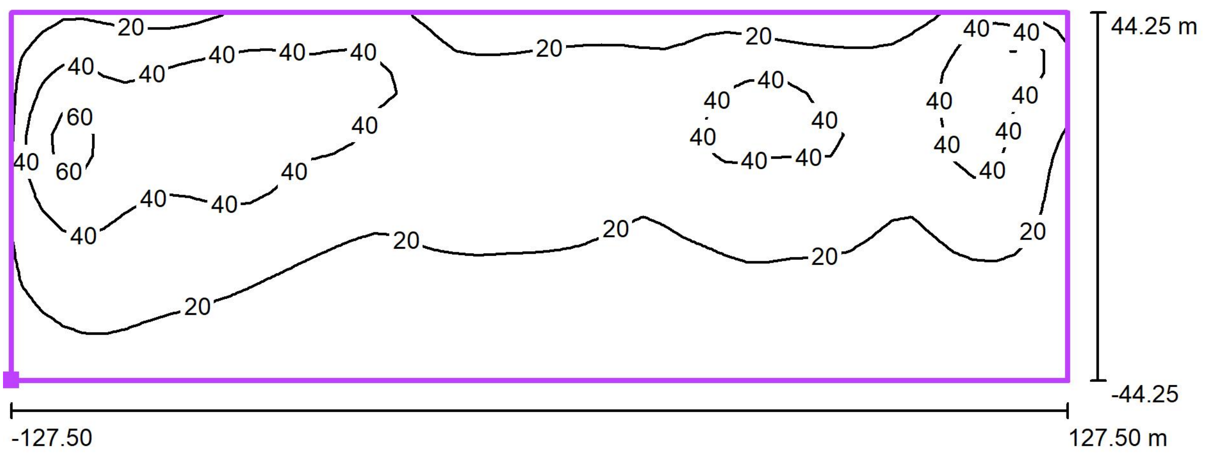
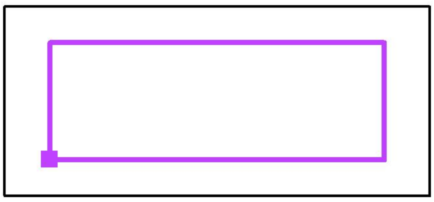
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

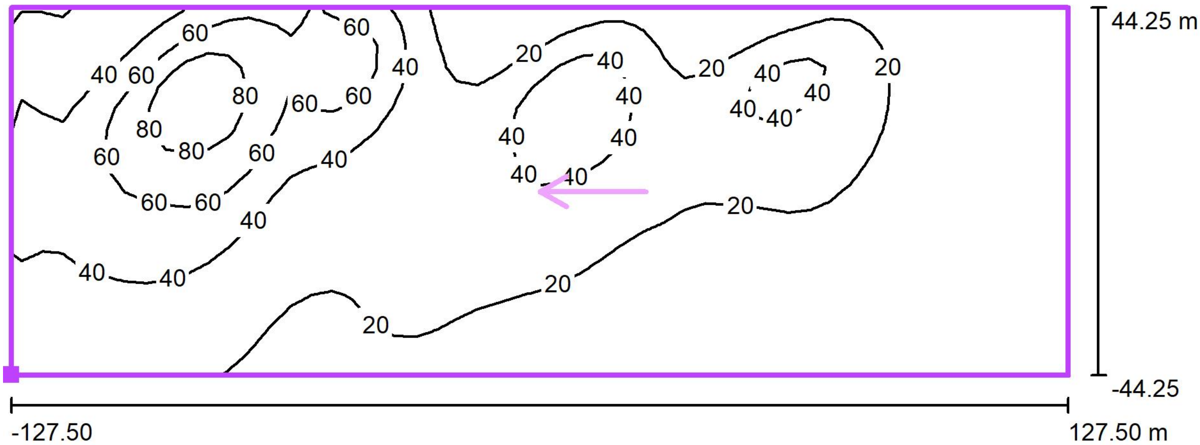


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
26	7.17	69	0.27	0.10

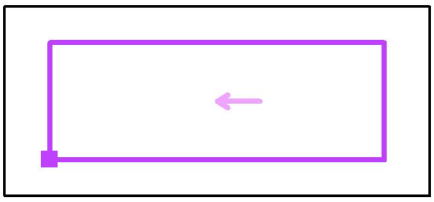
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

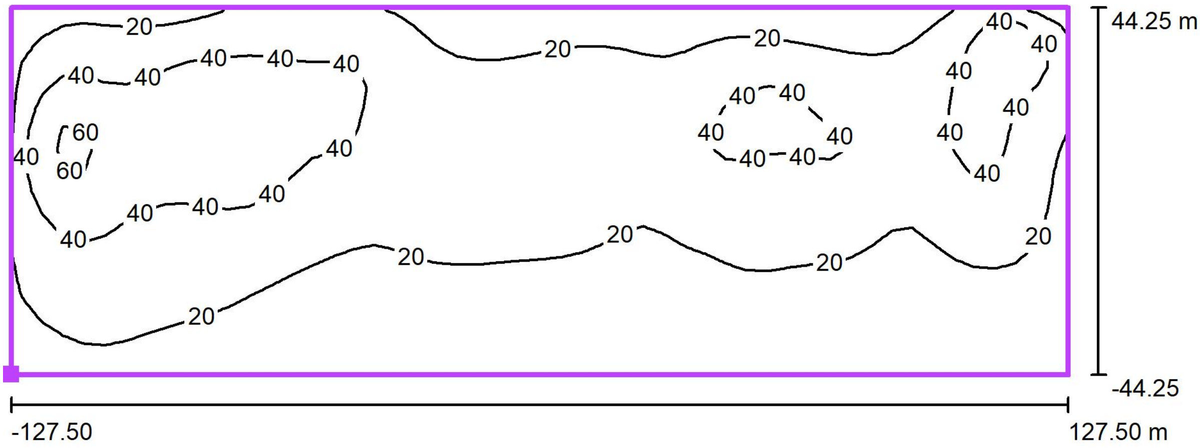


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
27	0.82	100	0.03	0.01

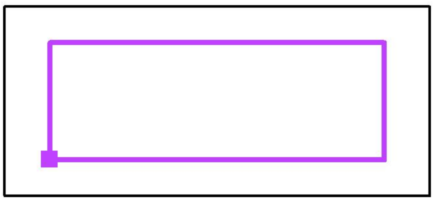
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)



Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
27	6.80	66	0.26	0.10

Operator
Telephone
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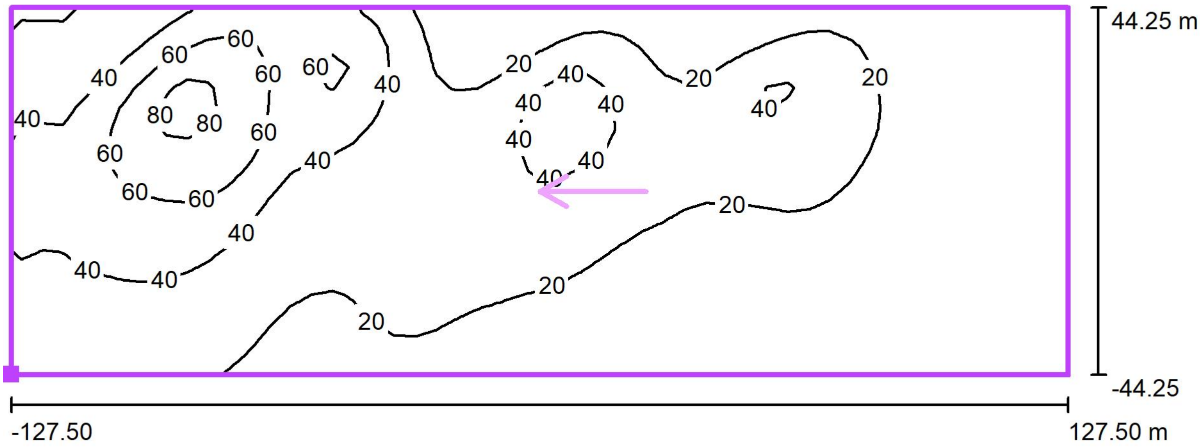
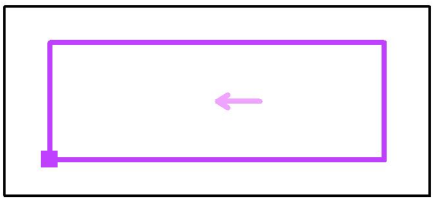
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

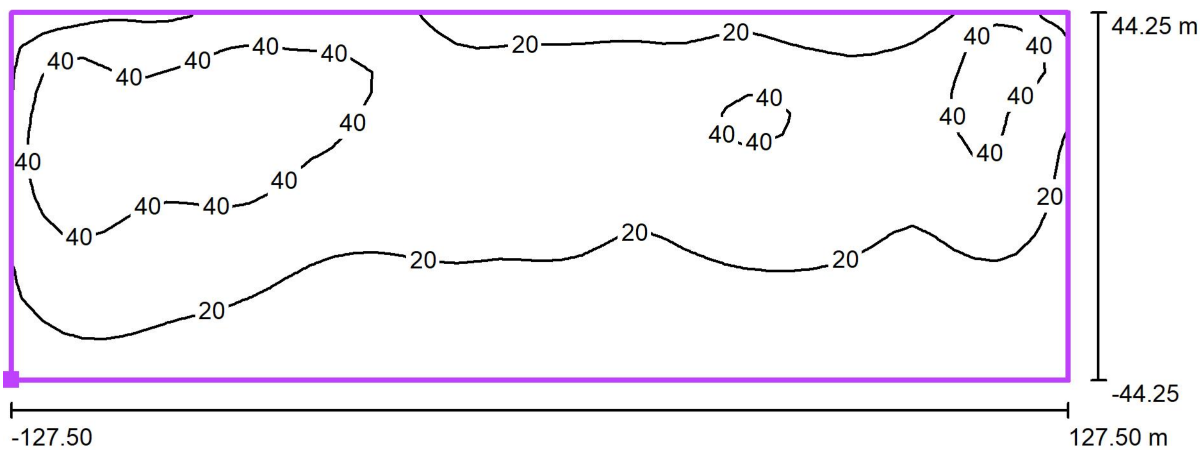


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
25	0.91	88	0.04	0.01

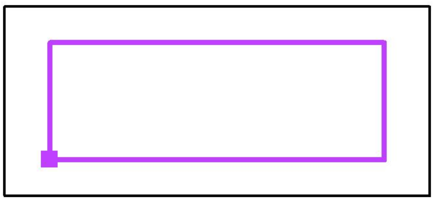
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)



Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
26	7.17	60	0.27	0.12

DIALux
19.08.2022

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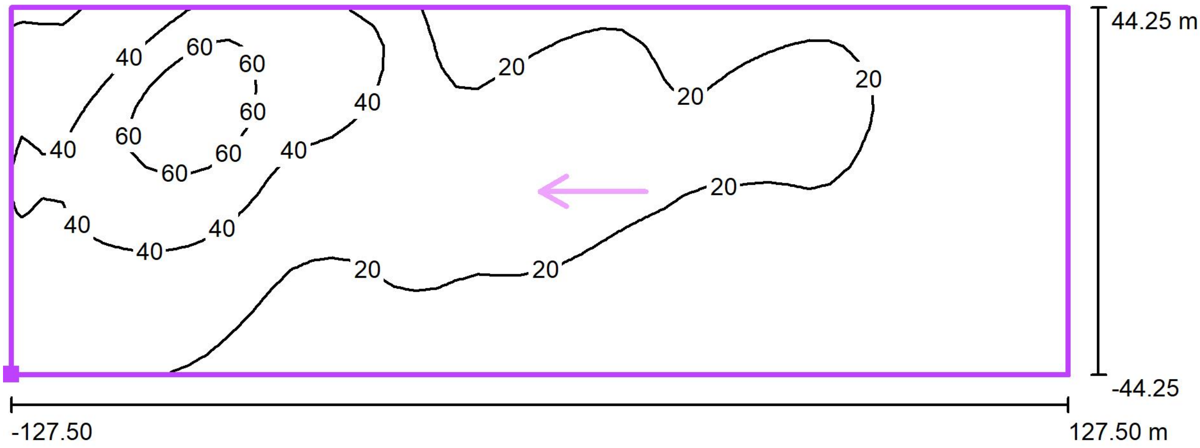
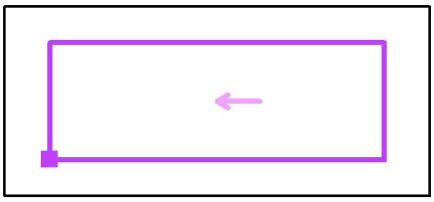
Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

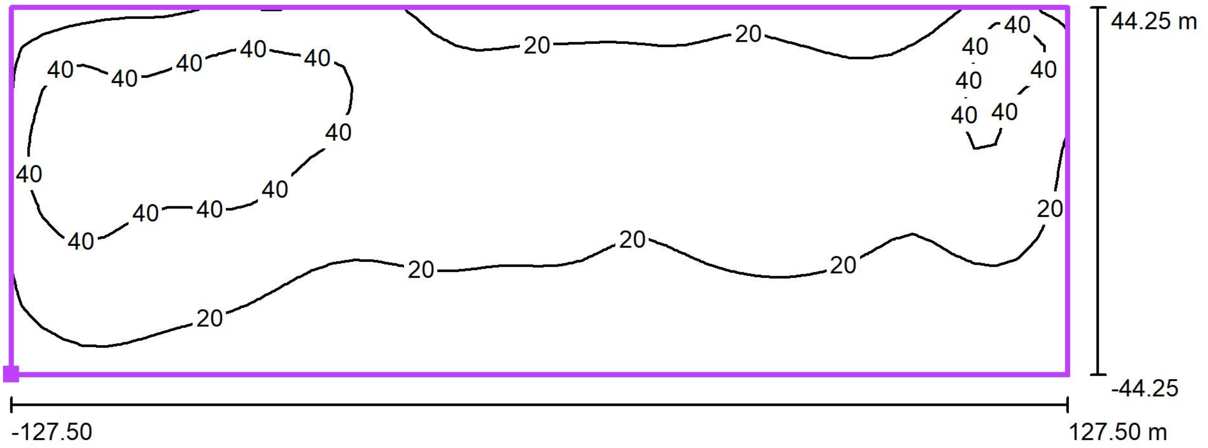


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
23	0.84	74	0.04	0.01

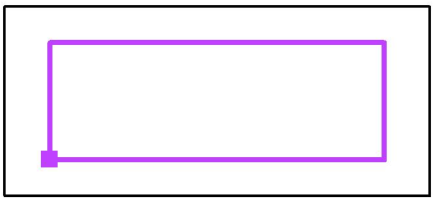
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)

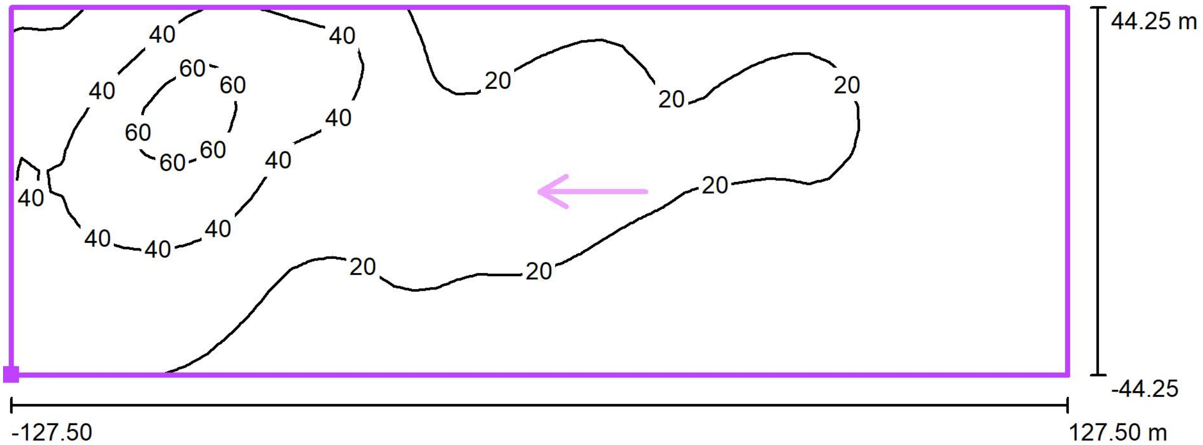


Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
26	6.79	57	0.26	0.12

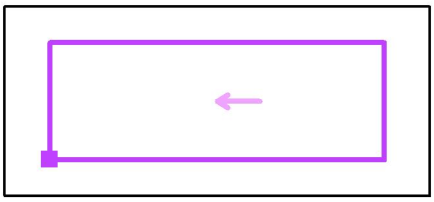
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Calculation Grid 1 / Isolines (E, Vertical)



Values in Lux, Scale 1 : 1824

Position of surface in external scene:
Marked point: (-127.500 m, -44.250 m, 0.000 m)



Grid: 52 x 18 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
21	0.90	68	0.04	0.01