A COMPARATIVE STUDY BETWEEN LED AND METAL HALIDE FLOODLIGHTING SYSTEM FOR BADMINTON COURT ILLUMINATION

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR DEGREE OF

MASTER OF ENGINEERING

IN

ILLUMINATION ENGINEERING

SUBMITTED BY

ASMAUL HOQUE

EXAMINATION ROLL NO.- M4ILN22004

REGISTRATION NO.–154027 of 2020-2021

UNDER THE SUPERVISION OF

Prof.(Dr.) Biswanath Roy

ELECTRICAL ENGINEERING DEPARTMENT

FACULTY OF ENGINEERING AND TECHNOLOGY

JADAVPUR UNIVERSITY
Kolkata - 700032

August,2022

JADAVPUR UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY
ELECTRICAL ENGINEERING DEPARTMENT

RECOMMENDATION CERTIFICATE

This is to certify that the thesis entitled " A COMPARATIVE STUDY BETWEEN LED AND METAL HALIDE FLOODLIGHT SYSTEM FOR BADMINTON COURT ILLUMINATION " submitted by ASMAUL HOQUE, (Examination Roll No.M4ILN22004, Registration No.154027 of 2020-2021) of this University in partial fulfilment of requirements for the award of degree of Master of Engineering in Illumination Engineering, Electrical Engineering Department, is a bonafide record of the work carried out by him under my guidance and supervision.

(Thesis supervisor)
Dr. Biswanath Roy
Professor
Electrical Engineering Department
Jadavpur University

Countersigned:

Prof.(Dr.) Saswati Mazumder
Head of the Department,
Electrical Engineering Department,
Jadavpur University

Prof.(Dr.) Chandan Mazumdar
Dean of the Faculty of Engg. and Tech.
Jadavpur University

JADAVPUR UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY
ELECTRICAL ENGINEERING DEPARTMENT

CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a creditable study in the area of Illumination Engineering, carried out and presented by ASMAUL HOQUE, in a manner of satisfactory warrant its acceptance as a pre-requisite to the degree for which it has been submitted. It is notified to be understood that by this approval, the undersigned do not necessarily endorse or approved the thesis only for the purpose for which it has been submitted.

FINAL EXAMINATION FOR EVALUATION OF THESIS

BOARD OF EXAMINERS

____

____

(Signature of Examiners)

DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Illumination Engineering studies.

All information in this document have been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by thesis rules and conduct, I have fully cited and referenced all material and results which are not original to this work.

.

NAME	: ASMAUL HOQUE
EXAMINATION ROLL NO.	: M4ILN22004
THESIS TITLE	: "A COMPARATIVE STUDY BETWEEN LED AND METAL HALIDE FLOOD-LIGHT SYSTEM FOR BADMINTON COURT ILLUMINATION".

Asmaul Hoque

DATE : 12/08/2022 SIGNATURE

ACKNOWLEDGEMENT

I take this opportunity to express my deep sense of gratitude and indebtedness to Dr.Biswanath Roy, Professor, Department of Electrical Engineering,Jadavpur University, Kolkata, without his mission and vision, this project would not have been possible.

I would like to acknowledge my sincere thanks to Dr.Suddhasatwa Chakraborty,Assistant Professor of Electrical Engineering Department, Jadavpur University, Kolkata and Sangita Sahana,Assistant Professor of Electrical Engineering Department, Jadavpur University for their constant guidance.I would also like to thank them for providing me their valuable time and helpful suggestions.

Again, I would like to acknowledge my sincere thanks to Prof.(Dr.) Saswati Mazumder,Former Incharge of Illumination Engineering and Head of the Department (HOD) of Electrical Engineering Department, Jadavpur University, Kolkata for providing me the opportunity to carry out my project work in Illumination Engineering Laboratory, Jadavpur University.

I am also thankful to Mr.Pradip Pal and Samir Mandi of the Illumination Engineering Laboratory for their co-operation during my project work.

At last I give my special thanks to all my friends who helped me directly in completing my thesis successfully.

Last but not least, I wish convey my gratitude to my parents, whose love, teachings and support have brought me this far.

Date: 12/08/2022

Asmaul Hoque

ASMAUL HOQUE

Place: Kolkata

Contents

Chapter 1

1 Introduction

Badminton is a very popular sport around the world and it is popularly growing more and more every year.Since Badminton leagues often play at night,it is imperative to have proper lighting system installed in the Badminton stadium for both the players and spectators.The creation of an appropriate visual environment is a fundamental requirement in sports design.The effective integration of artificial lighting system should be considered as a standard part of a modern sports facility.
• European Commission recognizes that the large amount of energy consumed for lighting,which is 15 percent of electricity consumed in the E.U.Thus, it proposes the creation of several initiative to develop a policy on the subject of public lighting applications in order to increase energy efficiency in public lighting and reduce CO2 emission.The electricity demand for Sports lighting has been increased over the last few years mainly due to high requirements for transmitting High definition images for television viewing.The establishment of minimum Lux requirements for playing surfaces of semi-professional and non-professional sports has also highlighted the issue of energy efficient sports lighting.
• For years,sports stadiums have used metal-halide lights to illuminate playing surfaces.But now,,they are turning to LED lights,which can offer the same or more luminous flux with better Luminous performance or efficacy,resulting into less power consumption and thus reducing the operating costs,Maintenance costs also reduce.
• This paper presents the investigation of the benefits of replacing the old lighting system of a Badminton court,consisting of metal halide ,with a new efficient LED system.Installation parameters such as field geometric details,position are taken under consideration.Comparison of the two systems in terms of lighting performance and energy efficiency is also presented.

1.1 Literature Review

For the lighting of badminton courts it is essential that there should be complete freedom from glare and that the light should have a high speed of discrimination. In Philips Technical Review (*Eindhoven*) of August last, it is pointed out that both these requirements are exceptionally well fulfilled by a lighting system employing sodium lamps. Although no satisfactory method was found for making quantitative measurements of the disturbing effect produced with different types of light, experience has shown that the presence of a source of light in the field of vision is less disturbing with sodium lamps than with other lamp sources of equivalent total candle power. This is due to the comparatively low luminous intensity of sodium lamps. Several experimenters have also proved that the speed of discriminating objects is quicker with sodium light than with other types of light. Professional and collegiate sport venues consume huge electrical energy. Therefore, a smart management of their electric energy is essential for significant energy saving.

R. A. Hargroves, et. al proposed a method for Glare evaluation of tennis court floodlighting(*CIE TC 5-04* ' Glare in Outdoor Lighting ' has proposed a formula which predicts the subjective impression of glare for a floodlighting scheme on a nine-point scale. This formula was initially developed from appraisals made on football pitches. The Formula is :

$$GF = 7.3 - 2.4log\frac{L_v}{L_(ve)^{0.9}}$$

where GF is the glare control mark for floodlighting, related to the nine-point scale of subjective appraisals. At its meeting on 25 November 1985, CIE Technical Committee TC 5-04 adjusted the glare formula to change the scale and to rename 'Glare Control Mark, GF' as ' Glare Rating,GR'. This was done in order to express glare by a number between 0 and 100, with a higher figure denoting greater glare. The basic concept, philosophy and validity of the method are not affected by this adjustment.

The ultimate objective of sports lighting is providing good visibility for players and spectators , with adequate comfort and agreeable colour rendition . Visibility depends mainly on illuminance and contrast but can be seriously affected by disability and discomfort glare. Glare is, to a certain extent, dependent on floodlight characteristics and aiming, but mainly on their mounting height. Recommendations on glare in sports lighting are made by CIE TC-5.04. They are based on *W.J.M. van Bommel et al's* research which found that glare is determined by the empirical ratio :

$$Ratio = \frac{L_v}{L_(ve)^0.9} = 10\sum(E_{eye}/\theta^2)/(0.035 * E_h * \rho/\pi)^{0.9}$$

TC-5 .04 further decided to convert this to a 'Glare Rating' :

$$GR = 27 + 24log(Ratio)$$

From the above two expressions we can write,

$$GR = 27 + 24log[572\sum(E_{eye}/\theta^2/(E_h * \rho)^{0.9})$$

where, L_v =veiling luminance due to luminaires seen.
$L_(ve)$= equivalent veiling luminance of the environment.
$E_(eye)$= illuminance at the eye, on plane normal to line of sight.
$theta$= angle between glare incidence and LoS.

So, the basis of glare assessment is as proposed 0, by TC-5.04, the Van Bommel relation Lv /Lve or, derived from it, L_v/L_0, where L is the luminance of the task to be seen, which in the case of a large sports field is also a measure of the adaptation level. Van Bommel's research was based on a blend of disability glare and discomfort glare assessment. It is the most extensive investigation of glare on sports fields done and justifies its use as a basis of specifications for sports lighting, where both discomfort and disability glare play a role.

In another paper *Alexis Polycarpou et. al* showed that MH Lighting system luminosity is less than LED. Furthermore, the MH lighting system illuminates many parts of the playing area insufficiently. Whereas the LED system illuminates the field uniformly.

MH lamp has many qualities such as good color rendering, high lighting efficiency, stable luminance as well as long lifetime. Because the increment impendence of MH lamp is negative, the current through the lamp will tend to run away unless ballast is connected in series with the lamp. Conventionally, an inductor, called as electromagnetic fype ballast, is employed to nm the lamps. The electromagnetic type ballast has a few drawbacks, such as low efficiency, heavy weight, large size and low power factor. *Dongyan Zhang et. al* extensively explored the High power-High frequency resonant mode electronic ballast for metal balide lamp. In this paper, .a novel type of ballast has been developed for high power. The new ballast operates at high frequency-resonant mode. The operating frequency is about 100 kHz-500 ldIz in which range the acoustic resonance of the lamps can be avoided. The LCC resonant inverter has been employed to match the characteristic of the lamps. ZVS soil switching technique is utilized in this design to reduce the switching loss of power devices and to improve the efficiency of the ballast as well as to reduce EMI. Moreover, by using resonant mode, the output power can be easily adjusted by varying operating frequency. In additions, the over-voltage and over-current protections are provided to make sure that the ballast is always work safely. Operating MH lamps at high frequency permits the use of a relatively small inductor and capacitors in the resonant tank. This makes the ballasts small size, low cost, because only two power stages are needed at this type of ballast, compared with second generation ballast, containing PFC, DCiDC converter, DCiAC inverter and high voltage igniter. One-400W-prototype ballast was built and several hundreds of lamps had been tested. The experimental results showed that not all manufacturer's 400W MH lamps are stable in the range of 80 kHz- 250 Hz, however, the MH lamps from the manufactures, GE, Osram and k are stable in this operating frequency range.

Wei Han et. al proposed a high-order compensated wireless power transfer (WPT) system for dimmable metal halide (MH) lamps without using any ignitor or ballast. This is LCC-LC compensated WPT system for the dimmable MH lamp. The LCC-LC compensation network is identified to be more suitable than other compensation networks for the wireless MH lamp because of its higher ignition voltage and more constant current output. Meanwhile, the continuous dimming control can be achieved by adopting the phase-shift modulation. This proposed system can be extended to other types of HID lamps such as low-pressure and high-pressure sodium lamps.

Jane Preema Salis et. al did a case study on Lighting Design Of An Indoor Sports Facility. Their work aims at the quality analysis and energy effective design of a table tennis court. The design and analysis of the lighting system is done in accordance to Philips lighting standards. The newly designed system is able to give required lux levels without compromising the quality. By the reduction in number of luminaries the cost is also reduced. It was shown that the newly designed system has uniform illumination contours with lesser lux levels compared with the existing lighting system.

Ashwathi Suresh et. al presented an evaluation of quality and quantity analysis in a squash court according to different levels of play, in the building of Marena, Manipal University (MIT). The proposed lighting design is in compliance with the World Squash Federation (WSF) to achieve energy efficient lighting. It shows that the proposed system with LED luminaires provides an energy saving of 77 percent compared to the existing system with metal halides. From the DIALux simulations it has been shown that Metal halide-based lighting system uses approximately 30 percent more power compared to LED lighting system. The total power consumption of the existing system is 3.16 kW and the LPD is 60.93 W/m^2, which is very high. A combination of metal halide and LED fixtures are used in the existing lighting system. The metal halide lamps used in sports facilities causes high energy consumption.

X-H Lee et. al designed a luminaire for badminton court illumination.In this paper, a user-friendly design of an LEDbased diffusive luminaire for illumination of a badminton court is presented. The proposed LED luminaire is composed of high-performance LED lighting modules, volume-scattering diffusers with higher than 70 percent one-shot transmittance and a reflecting cavity with higher than 85 percent reflectivity.The below figure shows a schematic diagram of the proposed luminaire system.[Figure1]

This is composed of two high-performance lighting modules, volume scattering diffusers and a reflecting cavity with high reflectivity. The design concept, an LED cavity with three projecting exit surfaces, is aimed to obtain enough illuminance across the playing field with reduced glare. The luminous flux emitted from the lighting modules is directed to the three volume scattering diffusers, which serve as the effective light sources of the luminaire. The function of the volume scattering diffuser is to produce a comfortable and soft lighting effect and to restrain the amount of glare by reducing the luminance of the LED luminaire. The reflecting cavity with high reflectivity plays a key role in enhancing the optical efficiency. Partially reflected light from the volume-scattering diffusers can be reused by a photon-recycling mechanism. This reflected luminous flux has an opportunity to exit out the luminaire again and that increases the optical efficiency of the whole lumi-

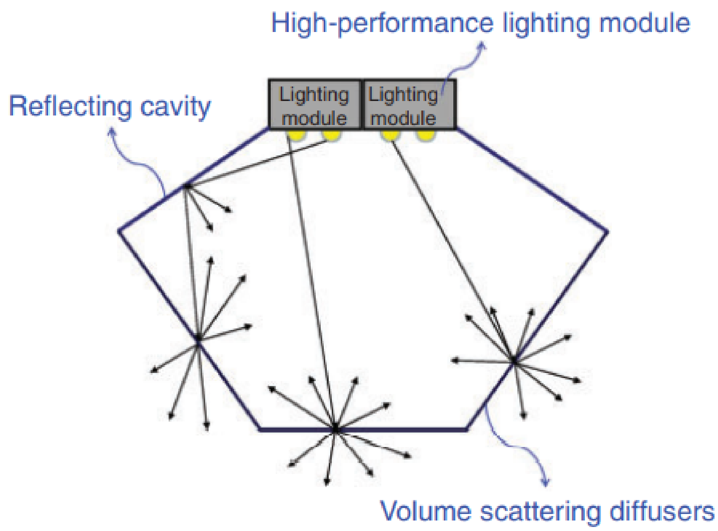


Figure 1: A schematic diagram of the proposed luminaire system(*X.H Lee et al.*)

naire system. Also, the luminous flux emitted at large angles and which is not directed to the diffusers could hit the high-reflectivity wall in the lighting cavity, and so have more chances to reach the three exit surfaces. Therefore, light from lighting modules can be all radiated and controlled by the three output surfaces of the proposed luminaire system to avoid the appearance of arbitrary lighting of the badminton court. To distribute the light to the whole field above each badminton court, we must adjust the tilt angle of the volume-scattering diffusers. Therefore, each large slanted surface of the luminaire faces a different part of the court. Compared with original traditional lighting in the badminton centre, the average illuminance on the floor was enhanced by about 300 percent and the uniformity was obviously improved. The LED luminaire, which uses the three-large-surfaces radiation method to reduce luminance, results in a comfortable and soft lighting effect and restrains the influence of direct glare. Besides, the switch-on speed of luminaire is greatly reduced from 5 to 10 minutes to 1 second.

M. Di Pede et. al has described the development of an innovative procedure, for the in situ measurements of vertical illuminance in fencing halls. Despite the technical standards provide qualitative and quantitative indications on the main lighting parameters, they do not provide sufficient information on the measurement procedures necessary for the in situ verification of the vertical illuminance and its uniformity. These evaluations are very important to ensure similar visual conditions for competitors, especially in the case of sports like fencing for which the recognition of the opponent's silhouette or part of it (the target) becomes fundamental. From the analysis conducted in this work it has been possible to highlight the need to have measurement procedures customized for each sport.

Safaa Alaa Eldeen Hamza et. al has discussed the use of Pulse Width Modulation "PWM" Technique in LED Lighting Systems. Figure shown below describes the duty cycle for PWM.[Figure2]

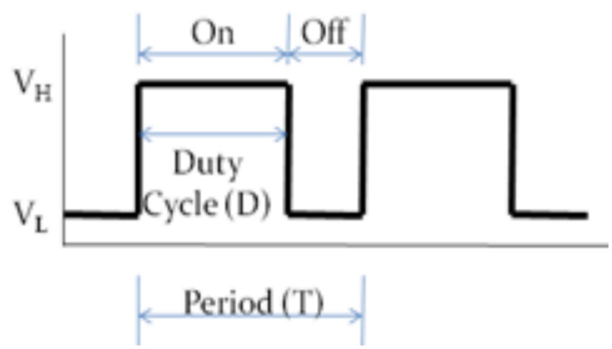


Figure 2: PWM signal (*Safaa Alaa Eldeen Hamza et al.*)

LEDs require a device that can convert incoming AC power to the proper DC voltage, and regulate the current flowing through the LED during operation. The driver converts 120V (or other voltage) 60Hz AC power to low-voltage DC power required by the LEDs, and protects the LEDs from line-voltage fluctuations. PWM driving methods is used in LEDs driving circuits, as shown in Figure, the ideal LED current waveform based on this driving method, where the current is periodically switched between a constant level IOH and zero level at a period of Td. The duty cycle of the period output current, controlling the dimming level ,rang from zero to one.

Since the output current changes with time, the current time function can be represented by equation :

$$i_o(t) = I_{OH} \sum_{n=1}^{\infty} [u(nt) - u(nt - nT_d D_d)$$

D. Nath et. al proposed a rough set-based method for aiming angle tuning of luminaires for outdoor sports lighting. All the optical parameters are enhanced simultaneously by considering overall horizontal uniformity as the decisive optical parameter for design optimisation. The validation is done using a real-time dataset of the Yuvabharati football stadium.

Shady S. Refaat et.al proposed a novel embedded real-time, smart, and active energy management system to monitor and efficiently manage such huge and typically uncontrolled energy for minimizing energy consumption and cost per day while considering spectators preferences, comfort level in behavioural modification program, and health aspects(*Shady S. Refaat, Haitham Abu-Rub, Omar Ellabban, Mladen Kezunovic:A Novel Smart Energy Management System in Sports Stadiums*). In addition, the proposed energy management system is equipped with embedded tools to collect and monitor energy information for each stadium's area. The data are processed and fed to the artificial neural network algorithm that is used for managing and controlling stadium loads. This strategy does not require any change in the conventional stadium electrical panel. The proposed online algorithm yields to improve the overall grid efficiency, reliability, and increase awareness of the importance of energy conservation. During the game days, the energy consumption in a typical stadium may reach 10 MW that us used to for lighting fixtures, water pumps, fans, air-conditioning, etc [1]. Electrical energy management is one of the most important and effective way toward improving energy efficiency in different grid sectors. Active energy efficient system basically depends on two different categories; technological modification program and behavioral modification program [2]. Both programs are required for energy efficient stadiums. Technological modification program includes a use of high efficiency appliances, eg. light emitting diode (LED), different smart sensors, control lighting, variable speed drives, temperature control, etc. In this paper they proposed active energy management system architecture is shown in figure below.[Figure3]

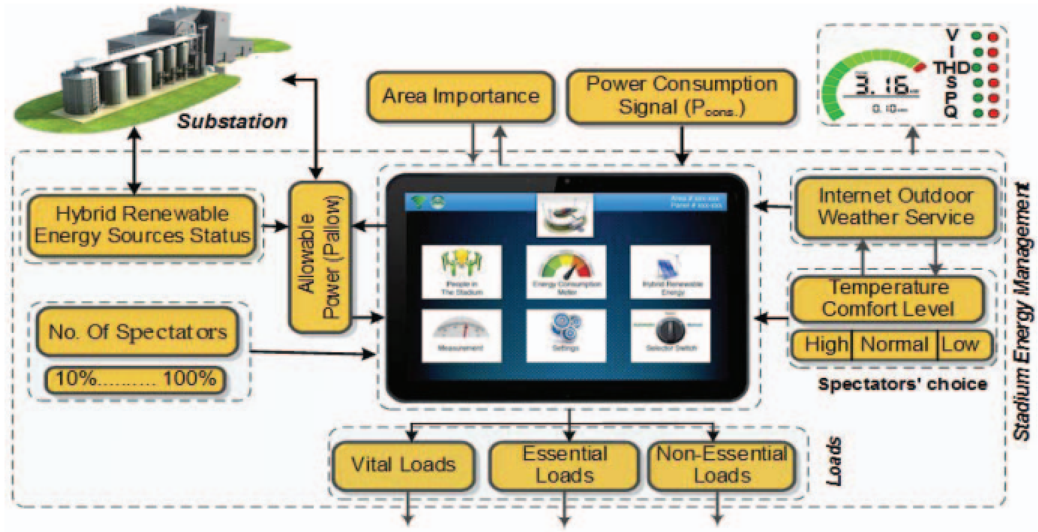


Figure 3: Active Energy Management System Architecture(*Shady S. Refaat et.al*)

1.2 Problem Identification

• Design of illumination system for a typical indoor badminton court for both televised and non-televised events (by using Metal halide and LED separately) following standards given in National Lighting Code 2010 (SP 72: 2010) published by Bureau of Indian Standards.
• Drawing of the single line diagram of the corresponding electrical systems with ratings of different electrical components required for the illumination purpose.

1.3 Objectives

• To illuminate a typical indoor badminton court using 400 W Metal Halide luminaire.
• To illuminate a typical indoor badminton court using 400 W LED luminaire.
• To achieve different photometric parameters according to the standard values for both televised case and non-televised case separately as given in National Lighting Code 2010 (SP 72: 2010) published by Bureau of Indian Standards.

• To compare MH and LED floodlighting system for the badminton court illuminatin.
• To calculate ratings of different electrical components used in the MH and LED lighting systems.

1.4 Steps of Execution

1. Doing necessary theoretical and background study to get an idea about the DIALux 4.13 software, different photometric parameters and their values standardized in Indian National Lighting Code 2010.
2. Studying previous literatures to get an idea about the process of executing the design.
3. Executing the design in DIALux 4.13 software for both televised and non-televised badminton game play for both MH and LED luminaires.
4. Comparing the obtained photometric parameters with that of National Lighting Code 2010 for both lighting system.
5. The number of luminaires is obtained from the design for the two lighting system, with the help of which drawing the single line diagram of the electrical system and calculating the ratings of different electrical components for both MH and LED lighting system and compare their bill of quantity.
• The methodology followed to implement this thesis work from the beginning has been described in the following flowchart[Figure4]-

1.5 Thesis Organization

The thesis is divided into six chapters.
• In chapter1, an introduction to the thesis work has been given. It includes Literature Review, Problem Identification,Objective,Steps of Execution of thesis and the Organisation of the thesis.
• Chapter3 deals with the design performed in DIALux 4.13 software using MH floodlight, comparison of the obtained parameter values with the NLC 2010.This Chapter also includes the Single Line Diagram(SLD) of the required Electrical System.
• Chapter4 deals with the design performed in DIALux 4.13 software using LED floodlight, comparison of the obtained parameter values with the NLC 2010.This Chapter also includes the Single Line Diagram(SLD) of the required Electrical System and dimming control of LED floodlight.
• Chapter5 deals with the comparison study between MH and LED flood-

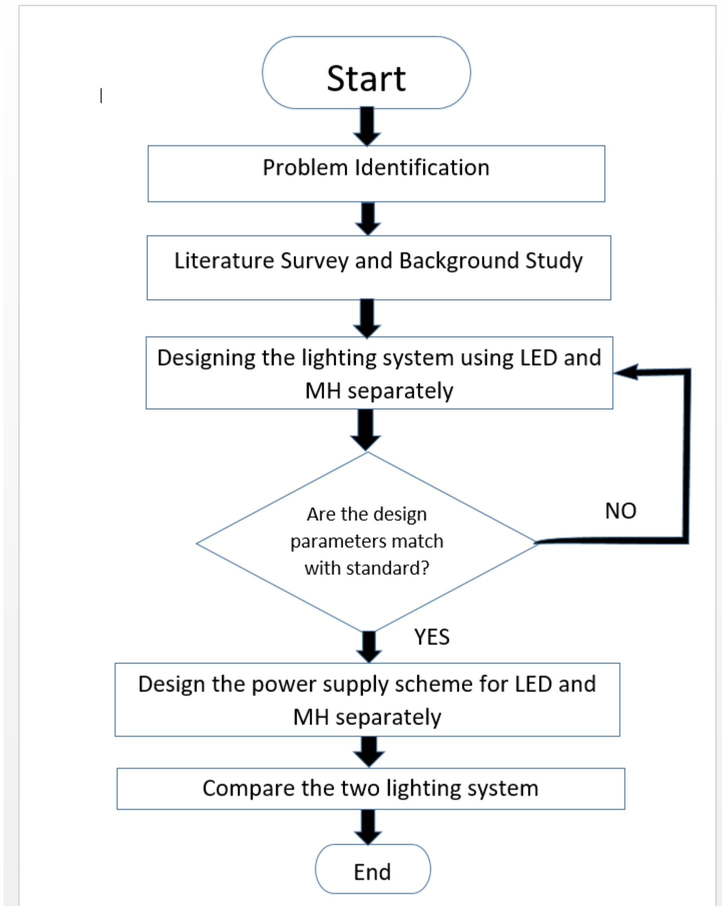


Figure 4: Flow Chart of the Execution Process

lighting system.

• Chapter6,deals with Conclusion of the thesis work and future scope of this work.

• After that,all the references have been given.

• At last,in Annexure-I.A-Dialux Simulating result for Metal Halide lamp and Annexure-I.B-Dialux Simulating result for LED lamps are given.

Chapter 2

2 Theoretical Background

2.1 Fundamental of Sports and Sports Lighting Design Parameters

In recent years, considering the modern lifestyle of the developed countries, sports is attaining a vital social role among grown ups and children.In the design of sports environment both indoor and outdoor, the lighting represents a very interesting topic.Good quality sports lighting is required to satisfy the need of Professional users i.e the players and umpires/officials,so that they can perform their best skills and abilities.The lighting ambiance should also ensure the spectators (recreational users) participation and satisfaction.
Apart from the spectators present at the stadium,there are millions of peoples who are watching the games live on their television sets sitting in the comfort of their drawing room or club, miles away from the actual playing arena.Therefore,it is essential to transmit good quality picture on the Television network so that the watchers sitting at home or club, should feel that they are actually part of real action happening in the playing arena.It is worthwhile to mention here that the games like soccer,cricket,hockey,tennis and badminton have become more popular due live television coverage.
In short we can say that Sports lighting should satisfy mainly the requirement of-

- Players and Officials/Umpires
- Spectators present in the gallery and
- TV and Media Crew.

Before discussing the lighting design parameters it is important to know about different types of sports-

1. TYPES OF SPORTS : The sports events can be divided into two groups depending on lighting requirement-
i. Aerial Sports and
ii. Ground level Sports.

i. Aerial Sports- In the Aerial sports the playing objects (such as a ball) may be in the ground as well as in the ground.

The major subcategories in Aerial lighting are as follows-
a. Multi-directional and
b. Uni-directional.

a. Multi-directional : Multi directional aerial sports are sports where players and spectators view the playing object from multiple position and viewing angles.
• These sports required vertical Illuminance over the height of the playing area and horizontal Illuminance on the ground level.
• Typical examples are Badminton, basketball, volleyball, tennis, soccer, and cricket.

b. Uni-directional : Uni-directional aerial sports are sports where playing object is viewed in the air from the fixed position on the ground.
• General horizontal Illuminance is required at a place from where the playing object is launched and vertical Illuminance is required where the playing object lands.
• Typical examples include trap shooting, golf and skeet shooting etc.

ii. Ground level Sports- In the Ground level sports the playing objects are in the ground or at small height from the ground.
The major subcategories are-
a. Multi-directional and
b. Uni-directional.

a. Multi-directional : Multi-directional ground level sports where the players and spectators view playing objects from multiple position normally,looking downward,horizontally, and occasionally upward.
• Here horizontal Illuminance plays an important role.
• Typical examples are Boxing, wrestling, weight lifting, Ice hockey,swimming etc.

b. Uni-directional : Uni-directional ground level sports where the playing object is aimed at a fixed target near ground level.
• Vertical Illuminance is critical at the target. Typical examples are bowling, skiing, archery etc.

2. SPORTS LIGHTING DESIGN PARAMETERS : The desired luminous environment is created by proper luminance ratio between objects and background.Luminance depends on the amount of light incident on it i.e the illuminance,surface finish and reflectance of the surface and the direction of view.In sports lighting ,the illuminated surface environment involves objects having wide variety of reflecting surfaces and it also involves an almost infinite range of viewing angles.Because of this,it is extremely difficult,if not impossible to calculate luminance values for sports lighting.Design and specifications in sports lighting,therefore,are generally based on average illuminance concept and illunance ratio rather than luminance concept.
The illuminance level is predominantly determined by the following factors-

a. The level of Sports activity taking place: Broadly,the activity in any sports arena can be classified based on the decreasing demands of lighting level.The level of competition and and lighting classifications according to the European standard for sports lighting, EN 12193:2008 are as follows-

i. Lighting Class-I - International and National level competition which generally involves large spectators capacity with long potential viewing distance comes under Lighting ClassI.This class has the requirement of high definition TV coverage.

ii. Lighting Class-II - National and Regional level competitions which involves medium size spectator capacities and medium viewing distance, with or without the requirement of TV coverage.

iii. Lighting Class-III - Recreational and practice level without the requirement of TV coverage.Lighting class-III generally do not involve spectators.
Categorizations of the Activity level by several sports regulating authorities may differ from the above.So,it is recommended to follow the guideline of respective sports regulating authorities.

b. Size of the object and camera shooting distance: The apparent size of an object dependent upon the actual size of the object and camera shooting distance.When the apparent size is small,it is difficult to see the object ,then higher lighting lighting level is required.To view the importance details of the players(e.g arm,leg etc movement) from a longer distance demands higher light level.

c. Speed of action: Sports can be classified into three groups A,B and C characterized mainly by speed of action occurring during camera shots as stated below.This is an important parameter in determining vertical illuminance.

i. Group A- In this group of sports,movement of playing object is along the the direction of view,so requires less illumination level as compared to Group B and C. Archery,athletics,billiards,bowling,darts,horse jumping,swimming etc.

ii. Group B- In this group of sports,although the players movement may not be faster ,but the direction of play changes frequently and rapidly,which calls for quick reaction on the part of the spectators and cameraman as well as the players.Badminton,baseball,basketball,hockey comes under this group.

iii. Group C- In this group of sports,the object of play is small and travels at high speed e.g Table tennis,squash or,where there is action involving split second judgement,such as slip catch or,boxing,these all involve high speed of movement and requires higher illumination level.

• Each of these groups is subdivided into three subsection according to maximum shooting distance and vertical illuminance recommended as given in a Table[Table1].

Table 1: Maximum Shooting Distance

Sl. No	Maximum Shooting distance	25m	75m	150m
i)	Group of Sport A	500	700	1000
ii)	Group of Sport B	700	1000	1400
iii)	Group of Sport C	1000	1400	-

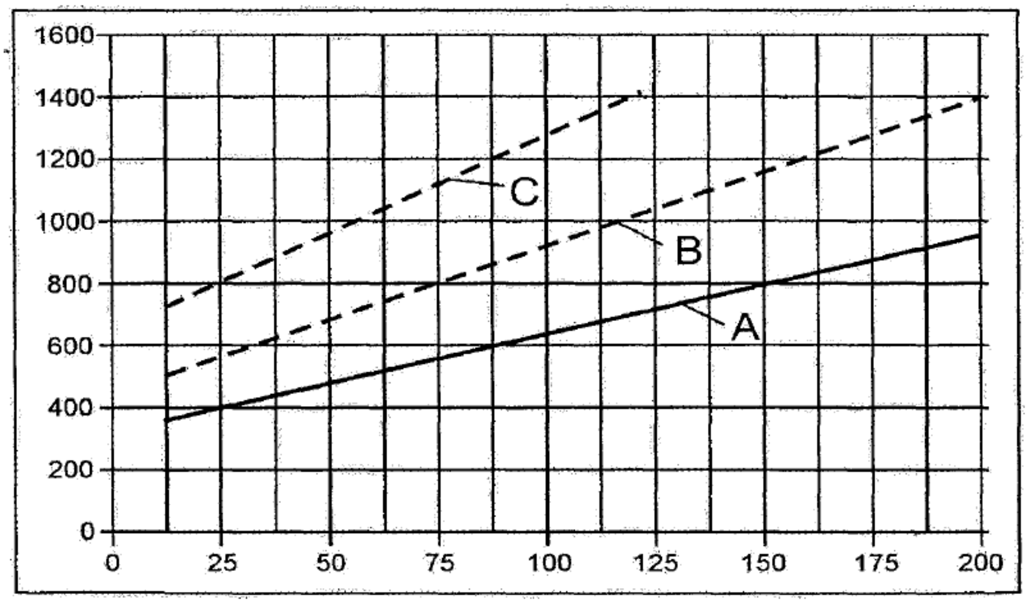


Figure 5: Recommended Vertical Illuminances Related to Camera Shooting Distance(*NLC 2010*)

Recommended vertical illuminance for various groups of play and camera shooting distances are given in [Figure5]

- The lighting design parameters for stadium lighting are as follows-

a. Horizontal illuminance[Eh] : The illuminated playing surface takes up a major part of the field of view for anyone in a sporting venue, whether players, officials or spectators. Horizontal illuminance (Eh) represents the illuminance on this horizontal plane at ground level. It serves primarily to create a stable visual background against which the eye can discern players and objects.
Standard specifies the average horizontal values(Eh(avg)).

b. Vertical illuminance[Ev] : The athletes in any particular sporting event, as well as the ball they are using, can be understood as vertical surfaces. This means that we need to keep vertical illuminance (Ev) primarily in mind when we light them.
To guarantee an optimal view and make it possible for the human eye to

identify players from every direction, we should generally measure Ev at a height of 1.5 meters, which corresponds approximately to the faces of the players.The planes normal to the four principal directions of the playing field at a height are considered as shown in [Figure6] and [Figure7].

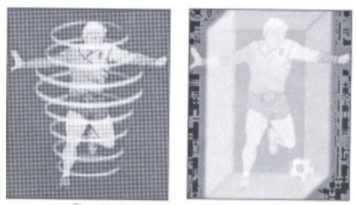


Figure 6: Vertical planes surroundings players(*Sportslighting-Fundamentals & Design Concepts.*)

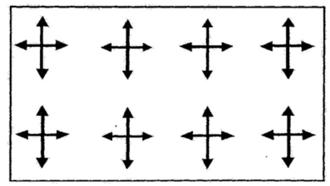


Figure 7: Vertical illuminance towards North-South-East-West(*NLC 2010*)

c. Vertical illuminance with respect to camera : It represents the illuminance at a point in vertical plane facing camera location,i.e.the vertical plane is normal to the line joining the point of measurement and the center of camera aperture.So in most of the cases the plane is inclined rather than perpendicular to the playing ground[Figure8].

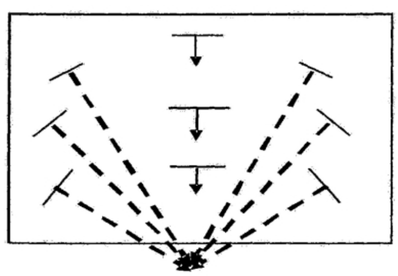


Figure 8: Vertical Illuminance with respect to Camera(*NLC 2010*)

The vertical illuminance required for players and spectators will usually be obtained if the requirements regarding the horizontal illuminance are fulfilled.Vertical illumnance at 1.5 mtr above ground level facing towards main/secondary camera forms the basis of the lighting requirement for CTV and Filming.Apart from recognition of players and spectators,the vertical illuminance also has be such as to ensure that ball flight above the playing

field can be easily followed by the players,spectators and cameras.
Standard specifies the average vertical illuminance values with respect to camera direction(Ev_{avg}).

d. Uniformity of illuminance : Good illuminance uniformity in the horizontal and vertical planes is important in order to avoid adaptation problems for players and spectators, and adjustment problems for cameras, respectively, for different directions of view.ifthe uniformity is not good enough, there is a certain risk (especially with television cameras) that the ball or a player will not be seen clearly at certain positions on the field.
Uniformity is expressed as
• the ratio of the lowest to the highest illuminance ($U1 = E_{min}/E_{max}$).
• the ratio of the lowest to the average illuminance ($U2 = E_{min}/E_{avg}$).

e. Horizontal illuminance gradient : Illuminance gradient means change in iluminance over distance.It is important to focus that Horizontal illuminance level should not change rapidly during the lighting design process.
Too high rate of change of illuminance can cause sudden losses of picture brightness,for television and photographic system while panning the camera over the field.Not only that,if the illuminance uniformity gradient is very high,then the player may miss judge the actual speed of playing object and hence may lead to miss-fielding/miss-passing.

f. Uniformity on Vertical planes over four directions at grid a point : Vertical illuminance values in four directions (North-South-East-West) at a grid point should not differ too much from each other.
Fulfilment of this requirement will ensure,in the case of one or more main camera locations across the field,that the vertical planes facing individual camera locations will have sufficiently high illuminance.It also enables secondary cameras to make shots at arbitrary position within limited area around the field.Fulfilment of these requirement guarantees adequate modelling of the sportsman on the field.
It is recommended that the ratio between minimum values to maximum values of illuminance over four directions on a point should be better than 0.30.

g. Ratio between average horizontal and vertical Illuminance[Eh_{avg}/Ev_{avg}] **:** The players and playing objects becomes comfortably visible against the

background of illuminated playing ground when proper contrast is maintained between objects and their background.This contrast is depends on the ratio between average horizontal illuminanace and average vertical illuminance. To have comfortable viewing condition and good picture quality,it is recommended that there should be a balance between horizontal illuminance to vertical illuminance.
The recommended value of the ratio is-

$$0.5 < [Eh_{avg}/Ev_{avg}] < 2.0$$

h. Glare restriction : Glare has a disturbing effect on the visual comfort of both players and spectators. Glare can be minimised by paying careful attention to the aiming of the floodlights relative to the main direction of view for the sport or sports that is considered.In sports lighting applications usually discomfort glare is evaluated by Glare rating for a number of significant observer locations looking towards each and every grid points of the field.
• The glare rating evaluation is dependent upon two lighting parameters-

i) the veiling luminance produced by the luminaires: Lvl; and
ii) the veiling luminance produced by the environment: Lve .

• The following interrelationship between these two parameters describes the degree of glare rating (GR) possessed by the installation for a certain observer position and viewing direction-

$$GR = 27 + 24log[Lvl/(Lve)^{0.9}]$$

Here GR stands for Glare Rating for Floodlighting. The lower the GR, the better the glare restriction.
• The assessment scale given below corresponds with the values of the glare rating GR,

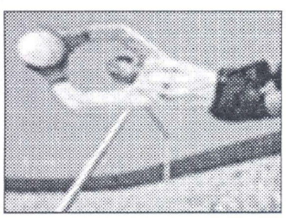
GR	Interpretation
90	unbearable
80	
70	disturbing
60	
50	just admissible
40	
30	noticeable
20	
10	unnoticeable

- For sports lighting acceptable GR values lies within 50.

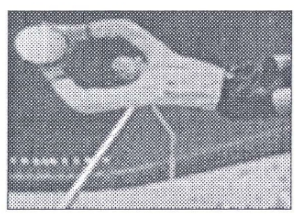
i. Modelling and shadows : Modelling refers to lighting's ability to reveal form and texture. Modelling ability is particularly important in providing a pleasant overall impression of the athletes and objects in the field of play, not to mention of the spectators in the stands.The effectiveness of modelling is dependent upon the direction from which the light comes and the number and type(Narrow beam/wide beam/indirect lighting) of light source used.Good quality television pictures demand good modelling from the lighting. An installation where light comes from only one direction will result in harsh shadows and poor modelling.

j. Colour properties : The color properties of luminaires have two important aspects-
(i)The colour appearance of the light. This is the colour impression of the total environment that the light source creates.
(ii)The colour rendering properties of the light source used, or the CIE Colour Rendering Index (CRI). This describes how faithfully a light source can reproduce a range of colours.
An indication of a lamp's color appearance can be obtained from its correlated colour temperature as measured in degrees Kelvin (K), which vary mainly between 2000 and 6500 K. The lower the color temperature, the "warmer" the color impression of the light is; the higher the color temperature, the "cooler" or more bluish the impression of the light is.
Sports lighting generally requires a color temperature of between 4000 and 6500 K.
The color rendering properties of a light source can be indicated by its Colour

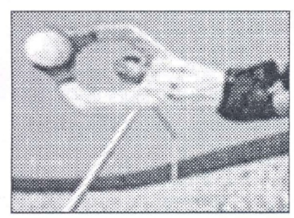
Rendering Index, expressed as a numerical value between 0-100. A light source with a CRI of 100 will represent scene colors faithfully, with daylight as the standard of comparison. Colour perception is highly relevant in most sports applications.While some of the color distortions that artificial lighting causes are acceptable for non-televised activities, TV broadcasting requires highly accurate color rendition.
he transition from conventional lighting to LED lighting gave rise to a discussion of whether CRI remains the correct color fidelity metric for television broadcasting. It was developed based on the human eye response curve and for a set of pastel colors, and is not necessarily appropriate for sports broadcast cameras that transmit images rich in saturated colors.
To ensure a lamp with good colour rendering index(viz. 80-90)was quite acceptable a decade ago which were capable to reproduce the true colour of ball,dresses of the player quite well.But nowadays for colour matching(advertising hoarding)-colour rendering index of more than 90 is preferable.



(a) Natural Colour(Under daylight)



(b) Poor Colour Rendering(Artificial lighting)



(c) Good Colour Rendering(Artificial lighting)

Figure 9: Changes of Colour of Players and ball according to Colour Rendering.(*Sportslighting-Fundamentals & Design Concepts*)

k. Flicker : A particular problem for super slow-motion cameras is a 50 Hz flicker, due to the phasing of the light.Cameras perceive light level changes due to the uneven ratio between the camera scanning frequency and the alternating amplitude of artificial lights powered by mains frequency. This effect, which is visible only during slow-motion replay, is called the flicker effect.
• Sports federations have started to incorporate a so-called flicker factor

into their lighting recommendations.To avoid any visible slow-motion image flicker, a flicker factor of less than 3 percent is recommended.

l. Lighting the spectator areas : Adequate horizontal illuminance is key to ensure spectators safety movement when they enter or leave the stands and other premises.
A stadium must be equipped with an emergency lighting system approved by relevant local authorities for use in the event of a general lighting failure in any part of the stadium to which the public or staff can access.
• European norm EN 12193 recommends a minimum value of 10 lux in the spectator area, to ensure spectator comfort.

m. Continuity of lighting : It is important for the sports federations or organizing committees to ensure that an event should continue even if a power failure occurs.
• Therefore,it is important for the professional competitions that a primary power supply disruption automatically trigger a secondary power supply in a way that creates no disruption to the lighting of the field of play.
The main points to consider are-
(i) The time delay involved in switching from one power source to another, taking into account luminaire's re-strike times.
(ii) The need to maintain a lighting level sufficient to maintain broadcasting continuity.

n. Controlling of spill light : Stray light from outdoor lighting installations can disturb people in the vicinity i.e. drivers on adjacent roads,inhabitants of nearby houses etc.That is why Spill light outside the field boundary is also called light pollution.Lighting design should be such that it should fulfil the design criteria on the field and upto the spectator gallery and at the same time it should limit the spill light to a minimum.
To control the spill light,floodlight luminaires used for big stadium should have an internal mechanism to control the light spill-in the form of internal baffle.

2.2 Light source and Luminaire used in Sports Lighting

1.Light Source : Depending upon the level of competition and location of the event (i.e indoor or outdoor),following lamps are used in Sports sports lighting-
i. Tabular fluorescent lamp.
ii.High pressure Sodium Vapour Lamp(SON).
iii.Metal Halide(MH) Lamp.
iv. LED Lamp.
• The lamp selection parameter are mainly basd on Colour properties(i.e. CCT and CRI)of the lamp.For top level competition (Category-I)suitable for CTV transmission metal halide lamps should be used for indoor and outdoor events.Because of its good CCT and CRI,metal halide lamps give top quality white light, which is crucial for the illumination of both indoor and outdoor night games.
• For non televised Category-II and III,use of high pressure sodium vapour lamp offers better solution in perspective of energy and usage as luminous efficacy of SON is much higher than MH lamp.
• For Indoor venues club/recreational level lighting can be achieved by fluorescent lamps.The physical length of these lamps and its rather low luminous flux make it unsuitable for floodlighting.
• Incandescent(tungsten and tungsten halogen)lamps are used for providing emergency/anti panic lighting in stadiums because of its instantaneous start-up.
• Now a days,LED lamps are used in both indoor and outdoor sport.Both in Televised(Class-I) and Non-Televised(Class-II and Class-III) events,LED Lamps are used because of its own advantages.More energy efficiency,low maintenance costs,superior light quality,less environmental impact compared to older lighting system such as halide or sodium-vapour lamps makes LED to use in any Sports event.
• The following table[Table2] shows different lamp parameters-

In the above table-
• TF indicates Tungsten filament,similarly TH,TbF,SON,MH and LED indicates Tungsten Halogen,Tubular Fluorescent,Hight pressure Sodium,Metal Halide and Light Emitting Diode respectively.

Table 2: Lamp selection parameters

Lamp	Rating	Efficacy	CCT	CRI	RUT	RST	Life(hr)
TF	15-500	8-17	2700	E	Instant	Instant	1000
TH	75-2000	13-25	2900-3200	E	Instant	Instant	2000-3000
TbF	15-140	50-104	2700-6500	M to E	Instant	Instant	5000-18000
SON	50-1000	66-138	2000	P	3-5 min	1-2 min	15000
MH	70-2000	79-95	4000-6700	G to E	3-5 min	10 min	10000
LED	70-80	110-130	5000-7000	G	Instant	Instant	50000

• Rating is in Watt(W) and Efficacy is in lm/W.
• CCT-Co-related colour Temperature, CRI-Colour Rendering Index.
• In CRI column E,M,G and P indicates Excellent,Moderate,Good and Poor respectively.
• RUT and RST indicates Run-up time and Re-strike time respectively.
• Life(hr) means total burning hours of a lamp.
• In my thesis work,I used only MH and LED lamps for design,so the brief discussion about these two lamp are only my consideration .

2.2.1 Metal Halide(MH) Lamp

In the year 1912 Charles P. Steinmetz was the first to use halide salts in a mercury vapour lamp. In the year 1960 Robert Reiling developed the first reliable MH lamp. Reiling built on the work of Steinmetz to complete his work. The MH lamp became more popular and decades later the price of the lamp became more affordable. MH is very popular due to its good quality white light and good lamp efficacy as compared to other older lamps(Tabular fluorescent lamp,High pressure Sodium Vapour Lamp(SON),Incandescent etc).

• **Constructional details of Metal Halide Lamp-** The constructional details of Metal Halide Lamps are as follows[Figure10]-

1. It consists of two glass tubes, two main electrodes, one auxiliary electrode, a ballast and a capacitor.
2. Outer glass tube is made up of Borosilicate glass which is used for insulation as well as to block the UV radiation coming from the arc.

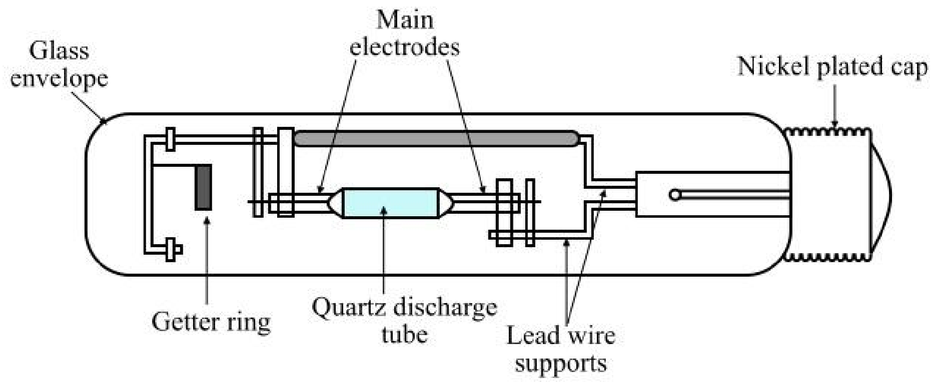


Figure 10: Metal Halide lamp main parts

3. Inner tube (discharge) is made up of quartz or hard glass and contains a starting gas (usually argon), mercury and MH salts.
4. Filaments are made up of tungsten treated with radioactive Thorium.
5. Molybdenum is used in sealing discharge tube as it does not expand even under extremely high temperatures.
6. Molybdenum is highly resistant to corrosion and is also used in high strength steel, armour and electrical contacts.
7. MH lamps have a coated finish on the inside of the bulb that diffuses the light.
8. Often a phosphor coat is used in diffusing light as well as changing the lamp's colour properties.
9. Choke is provided to develop a high voltage at the time of starting and to limit the current after discharge.
10. Capacitor is connected across the supply to improve the power factor.

• **Operation Of Metal Halide Lamp-** The operation of Metal Halide lamp is as follows-
1. When the lamp is cold, the halides and mercury are condense on the fused quartz tube (discharge tube).
2. When supply is switched 'ON', current passes through the starting electrode and jumps to a short distance leading to the main electrode.
3. Argon is used to start discharge in the lamp and argon gas strikes and initiates an arc at low temperature.
4. After the arc initializes, the tube heats up and the mercury is vaporized.

5. The initialized arc activates to work through the resistance of the gas, during this period, more molecules of the gas become ionized.
6. This creates more electric current to pass through the tube, allowing the arc to become wider and hotter.
7. This heat produced by the arc in the tube vaporizes the solid mercury and travels through the mercury vapour to reach the other main electrodes.
8. There is less resistance on this path now and current stops flowing through the starting electrode.
9. After a mercury vapour arc strikes and heats, the halides vaporize and gets separated.
10. The metal atoms diffuse away from the arc to cooler areas and recombine with the halogen before they damage any part of the electrodes and the lamp is now fully warmed up and produce its white light.

Types of Metal Halide Lamps- A variety of shapes are available
(i) Elliptical
(ii) Tubular
(iii) Double Ended and (iv) Compact Pin ended and reflector.

Advantages: The advantages of Meal Halide lamps are as follows-
1. More pure white light than the traditional lamps because of good Colour Rendering Index(60 - 90 depends on brand and chemical compositions).
2. More energy efficient than mercury vapour lamp.
3. Lumen per wattage range from 65 to 115.
4. Life time is 20,000 hrs for mounted base up and 10,000 hrs for horizontal mounted lamps.

Disadvantages- The disadvantages of Meal Halide lamps are-
1. Very high manufacturing cost.
2. The light is very bright and it produces much more light pollution than HPS lamps, since the whites from an MH lamp are closer to daylight in frequency.
3. Warm up time is 1 - 15 minutes.

Applications- As one of the most efficient sources of high Colour Rendering Index(CRI) white light,it is used in wide area overhead lighting applications for commercial,industrial and public spaces,such as parking lots,sports arenas,factories and retail store.

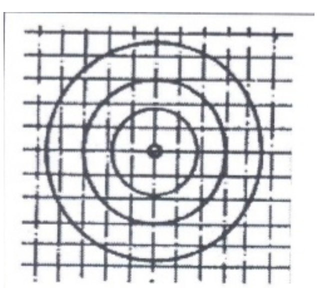
2.2.2 LED Lamp

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons (Energy packets). The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device. An LED lamp or LED light bulb is an electric light that produces light using lightemitting diodes (LEDs). LED lamps are significantly more energy-efficient than equivalent incandescent lamps and can be significantly more efficient than most fluorescent lamps. The most efficient commercially available LED lamps have luminous efficacy of 200 lumen per watt (lm/W). Commercial LED lamps have a lifespan many times longer than incandescent lamps. LED lamps require an electronic LED driver circuit to operate from mains power lines, and losses from this circuit means that the efficiency of the lamp is lower than the efficiency of the LED chips it uses. The driver circuit may require special features to be compatible with lamp dimmers intended for use on incandescent lamps. Generally the current waveform contains some amount of distortion, depending on the luminaires' technology. LEDs come to full brightness immediately with no warm-up delay. Frequent switching on and off does not reduce life expectancy as with fluorescent lighting. Mixing red, green, and blue sources to produce white light needs electronic circuits to control the blending of the colors. Since LEDs have slightly different emission patterns, the color balance may change depending on the angle of view, even if the RGB sources are in a single package, so RGB diodes are seldom used to produce white lighting. Nonetheless, this method has many applications because of the flexibility of mixing different colors, and in principle, this mechanism also has higher quantum efficiency in producing white light. Electro-luminescence (The p–n junction in any direct band gap material emits light when electric current flows through it. This is electroluminescence. Electrons cross from the n-region and recombine with the holes existing in the p-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes is lower than the energy levels of the electrons. Some portion of the energy must be dissipated to recombine the electrons and the holes. This energy is emitted in the form of heat and light. As indirect band gap materials the electrons dissipate energy in the form of heat within the crystalline silicon and germanium diodes, but in gallium arsenide phosphide (GaAsP) and gallium phosphide (GaP) semiconductors, the electrons dissipate energy by emitting photons. If the semiconductor is translucent, the junction becomes the source of light, thus becoming a light-emitting diode) as a phenomenon was discovered in 1907 by the English experimenter H. J. Round of Marconi Labs, using a crystal of silicon carbide and a cat's-whisker detector. Russian inventor Oleg Losev reported creation of the first LED in 1927. His research was distributed in Soviet, German and British scientific journals, but no practical use was made of the discovery for several decades. In September 1961, while working at Texas Instruments in Dallas, Texas, James R. Biard and Gary Pittman discovered near-infrared (900 nm) light emission from a tunnel diode they had constructed on a GaAs substrate. By October 1961, they had demonstrated efficient light emission and signal coupling between a GaAs p-n junction light emitter and an electrically isolated semiconductor photodetector. The first blue-violet LED using magnesium-doped gallium nitride was made at Stanford University in 1972 by Herb Maruska and Wally Rhines, doctoral students in materials science and engineering. Even though white light can be created using individual red, green and blue LEDs, this results in poor color rendering, since only three narrow bands of wavelengths of light are being emitted. The attainment of high efficiency blue LEDs was quickly followed by the development of the first white LED. LEDs work on the principle of Electroluminescence. On passing a current through the diode, minority charge carriers and majority charge carriers recombine at the junction. On recombination, energy is released in the form of photons. As the forward voltage increases, the intensity of the light increases and reaches a maximum. Like an ordinary diode, the LED diode works when it is forward biased. In this case, the n-type semiconductor is heavily doped than the p-type forming the p-n junction. When it is forward biased, the potential barrier gets reduced and the electrons and holes combine at the depletion layer (or active layer), light or photons are emitted or radiated in all directions. A typical figure below shows the light emission due to electron-hole pair combining on forward biasing. Mixing white LEDs with different color temperature will produce a bouquet of white light, and luminous flux of this mixed white light is the sum of white LEDs with different color temperatures. Spectral distribution curve of the mixed white light is the sum of spectral power distribution curve of different color temperature white LED, which determines the color temperature of mixed white light. By changing LED drive current, we can change their luminous, which also changes spectral power distribution curves of different LEDs. The new spectral power distribution generated by different color temperature LED results in dynamic tunable white light.

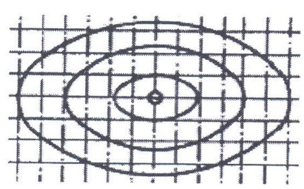
2.2.3 Luminaires

Proper luminaire selection and their mounting are the of the vital issues to achieve the desired quality lighting over the sports arena.Luminaire mounting includes both their layout on the head frame and aiming towards the playing ground.Selection of proper luminaire is based on Indoor or outdoor event.Luminaire photometry,layout of high mast with respect to playing ground,Electrical safety,cost etc.Out of these luminaire photometry is most important.

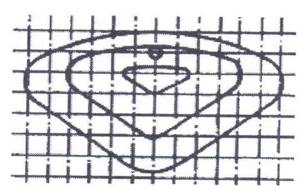
Luminaire Photometry- Mainly three types of light distribution in space,are used in indoor as well as outdoor lighting applications.
a. Symmetric-Circular shaped luminaires with discharge tube(DT)at focus of the reflector[Figure11a].
b. Asymmetric-rectangular shaped with DT at central line of reflector[Figure11b].
c.Double asymmetric-rectangular shaped with DT at off-central line of reflector [Figure11c].The typical isocandela diagram for the above three luminaire are as follows-



(a) Axially symmetric



(b) Asymmetric

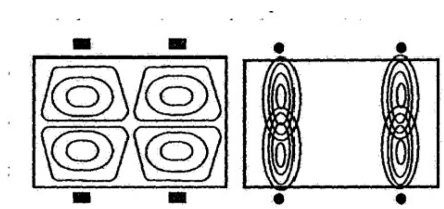


(c) Double Asymmetric

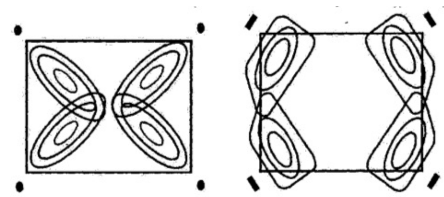
Figure 11: Iso-candela diagram of luminaires used in sports lighting(*Sportslighting-Fundamentals & Design Concepts*)

- To ensure efficient floodlight,beam shape plays a important role-

a. The rectangular floodlight offers the advantages over the circular unit when mounted closely spaced along the sides of a playing field, the normal arrangement for a small field, of giving a more uniform light distribution and less wastage of light shown in [Figure12a].
b. The circular floodlight however is more efficient than the rectangular unit when used in the four comer, diagonal arrangement provided several units per mast are used[Figure12b].



(a) Side Mounted Luminaire



(b) Corner Mounted Luminaire

Figure 12: Side and Corner Mounted Luminaire photometry(*NLC 2010*)

2.3 Dimming

Dimming means reducing the output of a lamp on lighting fixture. As a lamp or fixture is dimmed its lumen output decreases.All conventional light sources can not be dimmed but all LED can be dimmed though it is not always simple.The dimming of a LED lamp or a lighting fixture depends on the driver that is been used to control it.The main function of a driver is to run the LEDs at the correct voltage and current,converting the mains AC supply(in India 240 volt,50 Hz)to usually 12-24 volt DC.This is necessary because LEDs don't operate on mains.LEDs work at low voltages on DC.

The driver can be separated from the LED or integrated with the LEDs.

Dimming driver- It acts as a driver as well as a dimmer.As a driver it converts mains AC supply to low voltage DC and as a dimmer it raises and lowers the amount of electrical energy flowing out to the LEDs.Now a days mainly Pulse Width Modulation(PWM) or Amplitude Modulation(AM)are being used to carry out this function.

Sealed in Drivers- With most LED lamps the driver is sealed inside.So,there is no means of delivering any dimming control signal to the driver.Therefore,if dimming is required,it must be done by fitting an external dimmer.

There are several ways to control a driver or instruct it what to do.The most common methods of controlling a driver are Digital Addressable Lighting Interface(DALI),Digital Multiplex(DMX),1-10 V analog control etc.DALI is the most wide spread communications protocol for commercial lighting control.A DALI signal is delivered to the LED driver via two wires that are in addition to the wires delivering the mains supply.On the other hand 1-10 V analog control is an analog communication protocol.Like DALI,it is delivered to the driver on two wires that are in addition to the main wires.DMX512 is a standard for digital communication networks that are commonly used to control lighting and effects.It is widely used for colour changing applications such as facade lighting.In recent years there are several wireless technologies available for communicating with LED drivers including Zigbee and bluetooth.

2.3.1 Methods of Dimming Control:

Drivers may use either of two techniques to reduce the amount of energy flowing to the LEDs-

i. PWM- An LED driver that dims by using PWM is switching the power to the LED s on and off.The longer the on pulses the brighter the LEDs will appear to be and vice-versa,provided this takes place at a frequency greater than about 200 Hz any flickering will not be visible to the human eye and the brain will average the perceived level of brightness.

ii. AM- Here the driver simply increase or decreases the output currents to the LEDs.The risk of flicker is eliminated,but some LEDs change colours slightly if their current is altered,especially at low level.
Some LED driver manufacturer use a combination of PWM and AM to achieve an optimal performance.

2.3.2 Types of LED dimmer:

The most common LED dimmers are phase-cutting dimmers.The two types of this is given below-

i.Leading Edge phase cutting dimmer/Triac dimmer : These work by switching the current off at the zero crossing point and on again later in the same main cycle.The amount of energy flowing to the LEDs depends on the duration of the off period.The longer the off period the dimmer the LEDs will appear to be.

ii. Trailing Edge Phase cutting Dimmer : These work by switching the current at the zero crossing point and off later in the mains cycle.Usually this is done using Isolated Gate Bipolar Transistor(IGBT).The amount of energy flowing to the LEDs depends on the duration of the off period.The longer the off period the dimmer the LEDs will appear to be.

2.4 Badminton Court

2.4.1 History of Badminton Court

The modern history of badminton began in India with a game known as poona. Poona was a competitive sport that British Army officers learned and brought back to England, but more about that part of badminton's history in a moment.Poona developed from a children's game called battledore and shuttlecock. The object of this game was to see how long a group could volley the shuttlecock by hitting it with the battledore, or paddle. This co-operative, non-competitive game was originally played without a net. The shuttlecock is often called a bird because its made out feathers. Today, some models are made of plastic, but competition shuttlecocks consist of 16 real feathers. Experts claim the very best shuttles are made from feathers taken from the left wing of a goose. In fifth century China, ti jian zi was played by kicking a shuttle into the air. By the 1600s, people in Europe were playing jeu de volant, a game that used a racket rather than feet to volley the shuttle.By the time British officers stationed in India encountered poona the game was a fast-paced competitive sport. These officers took the equipment for poona back to England in the early 1870s.

• It was the Duke of Beaufort who officially introduced the game to England.

In 1873, guests at a lawn party on his country estate, Badminton, played a game of poona. The game was a hit and soon became popular among the British elite. People began calling the new party sport " the Badminton game."

• The game was played both indoors and outdoors on a court with an hourglass shape. It has been suggested that this unusual shape developed so the game could be played in Victorian salons, large rooms with doors that opened inward on both sides. In 1901, the official badminton court became rectangular.

• By 1893, badminton had grown to the point where 14 clubs joined to form the Badminton Association.This group was instrumental in standardizing the laws of the sport and in starting the earliest and most prestigious badminton tournament, the All-England Badminton Championships.

• The International Badminton Federation was created in 1934 as badminton was spread to more countries, and today has its headquarters in Kent, England. Canada,Denmark,England,France, Ireland,The Netherlands,New Zealand,Scotland and Wales were the members of 'IBF'.Today, the IBF has more than 150 member nations. The American Badminton Association was formed in the United States in 1936 and joined the IBF in 1938. In 1978 the ABA changed its name to the U.S. Badminton Association.

2.4.2 Size of the Badminton Court

The Badminton court is a rectangular field and divided into halves by a net. There are two standard sizes of tennis courts-

i. Single Badminton court- Its standard size is 13.4 meters(44 feet) in length and 5.18 metres (17.0 feet)in width.

ii. Double Badminton court- Its standard size is 13.4 meters(44 feet)in length and 6.1 meters(17.0 feet) in width.

• The net is 1.55 metres (5 feet 1 inch) high at the edges and 1.524 metres (5.00 feet) high in the centre. The net posts are placed over the doubles sidelines, even when singles is played.

• A standard size Badminton court and its dimensions for both Single court and Double court are given in the below figure[Figure13].

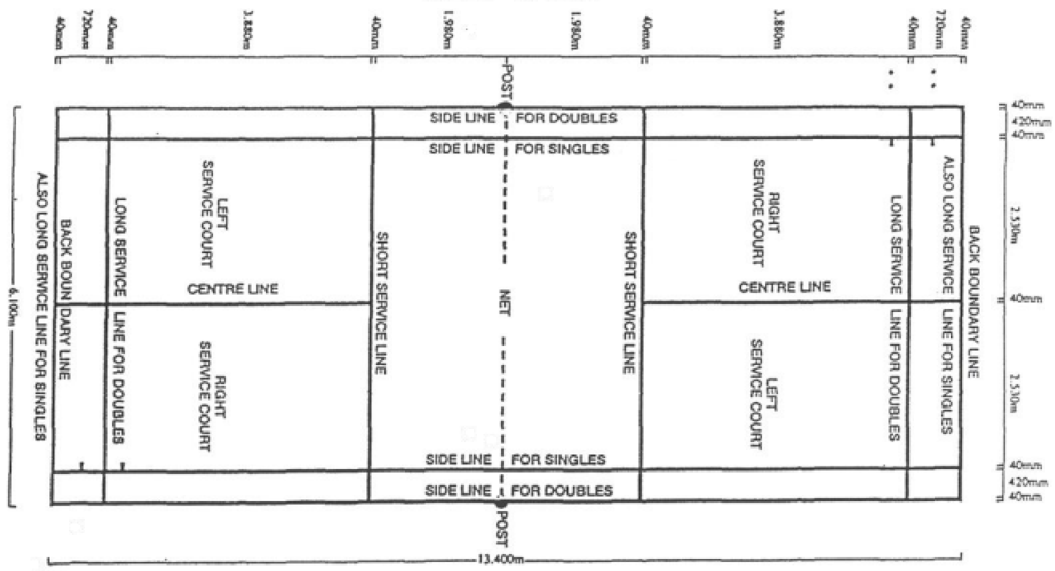


Figure 13: A standard size Badminton Court

2.4.3 Badminton court flooring types

The design of mainstream Badminton court ground focuses mostly on the safety and prevention of injuries of the players, regardless of the material of the floor.Badminton courts can be divided into two categories-Indoor and Outdoor.The different types of flooring for Indoor and Outdoor Badminton court are as follows-

1. Wooden Badminton Court : A Wooden flooring is the best choice to have as a badminton court flooring because it is area elastic floor surface.
• In fact, the Badminton World Federation (BWF) itself recommends wooden flooring. According to BWF's official handbook, "It is desirable to have a wooden sprung floor together with approved non-slip court mats." Wood has a natural tendency to absorb pressure without being too hard on the body. This makes for a great playing surface. However, not all wooden surfaces are for badminton,Certain varieties are susceptible to get slippery while others may not be as durable.
• The most recommended types of wooden badminton court flooring are hardwood.

2. Synthetic Badminton Court Flooring : Synthetic Badminton court floorings have artificial materials as its source. They are designed keeping in mind the specific needs of the games modern format and are extremely player-friendly.
There are predominantly two types of synthetic badminton court flooring-

a. PVC Badminton Court Flooring- PVC synthetic courts are popular to provide decent anti-slip properties. They are available in the form of mats, making it easy to lay and store them. These mats further segregated into surface, middle and lower mats. While the surface mats provides durability, anti-slip and abrasion resistance properties, the middle mats add stability. Ideally these should be installed above wooden flooring.

b. Acrylic Badminton Court Flooring - The most special features about acrylic badminton court flooring is that they come in several colors and types as well as most economical sport flooring. They have anti-slip characteristics that can be used for multi-purpose games.

3. Modular tiles (Outdoor): Modular tiles are a revolution in the Badminton court flooring space because they get the best of Wooden and PVC floorings. The features of Elite modular tiles are as follows:
i. Excellent slip and water resistance
ii. Antibacterial and anti-fungal.
iii. Easy to clean and maintain and
iv. Excellent cushion and durability.

4. Rubber Mat Flooring : This is the new Product for indoor Sport floorings.It is a natural rubber cushioned surface and can be used for multiple sport floorings that protects floor and reduces sports injuries and fatigue.Main Features of Rubber mat flooring are-
i. Non-toxic.
ii.Easy to maintain
iii.Good Shock absorption and
iv.Easy to install and uninstall.

2.4.4 Famous International Badminton Tournaments

There are many famous Badminton tournaments happening all over the world in different countries. These Badminton tournaments attract good numbers of spectators every time. Among the many international Badminton tournaments six famous grand-slams are-

1. BWF Thomas Cup : BWF Thomas Cup is the biggest, oldest and most prestigious badminton tournament in the world.This tournament is also known as Also Men's Teams World Championship.It is the International competition between Men's team of BWF country members.

• The first event was held in 1948, followed by a tournament every three years till 1982.After 1982,it started happening in every two years.Outside Asia, England was the only country to host the tournament. Indonesia has won more than 48 percent of the 29 tournaments ever held, China won 21 percent , and Malaysia, 17.2 percent.Japan and Denmark each won one tournament.

2. BWF Uber Cup : The Uber Cup or Women's World Team Championships was added for the first time in 1956-57.When it was first started, the Thomas Cup took place every three years and this was the sports first major international tournament. The idea for the competition and the donation of the trophy was made by the first President of the world governing body, Sir George Thomas, legendary player (21 All England Championship titles) and administrator of the sport.

3. BWF Sudirman Cup : Surdirman Cup is the mixed teams world championship. It takes place every two years, each time in a different BWF country member. The first tournament was held in Indonesia, in 1989.
There is no cash prize in this tournament. Athletes play for the prestige of their respective countries and to earn points in the BWF world ranking.

4. BWF World Championship : BWF World Championship also does not offer cash prizes, but it is the one that provides more ranking points. They receive the title of world champions and gold medals.

• It was started in 1977 and happened every three years until 1983, promoted by the IBF (International Badminton Federation).After BWF started promoting the event, in 1985, with the same goals, BWF defined its periodicity for every two years, and, from 2006, every year. It is held in different WBF countries members.

5. BWF World Juniors Championship : BWF Wold Juniors Championship aims to reward the best youth players (under-19) in the world.
• The first tournament was held in 1992, in Indonesia, where after 25 years, in 2017, hosted the event again. Initially was held once every two years, and became an annual event after 2006.

6. World Grand Prix Finals : World Grand Prix Finals took place for the first time in Indonesia, in 1983, having been promoted annually until 2001, each year in a different Asian country, associated with the International Badminton Federation (IBF).
• The goal is to reward the best players of the year. Only the top 8 in the world ranking are invited to play. This tournament was no longer promoted after 2001.

Chapter 3

3 Lighting design using MH floodlight

This thesis task is entirely simulation based, and hence this does not involve any physical site visit, data collection such as measurement of dimension, lux audit etc. The design has been performed in DIALux 4.13 software. DIALux 4.13 is a very popular and widely used lighting design software. Performance of both Indoor and Outdoor type of designs is very feasible in this software. In this chapter, the methodology for designing a lighting system of a Badminton court, both for non-televised and televised event using this software has been performed. In the later part, the analytical comparison of the results achieved after simulating the design with the values prescribed in NLC 2010 has been carried out.

3.1 Methodology

In this section,the lighting design for three different Non-televised class and Televised lighting has been discussed in step by step.

3.1.1 Design for Non-Televised Event

First of all,according to the required illuminance level in Class
1) To perform the design of an indoor Badminton court, a " New Exterior Project" has been incorporated at the very beginning and the project name has been given.
2) The luminaire Light Loss Factor which is Maintenance Factor for DIAlux has been taken as 0.7.
3) A typical model of Badminton court has been inserted into the Ground Element from the available sports sites.Any sports site is divided into two parts-Total Playing Area (TPA) and Principal Playing Area (PPA).PPA is the amount of area where the game-play happens.In most of the sports sites, this area is separately marked.TPA includes an additional safety area along with the playing area.According to NLC 2010,the required parameter has to achieve in Total Playing Area(TPA).
4) The dimension of the "Badminton Court" is kept as the default values(TPA=18 m* 10.5 m) and dimension of the ground element is adjusted

accordingly.
5) The Centre point of the "Badminton Court" and Ground Element is placed at same point.
6) According to the required illuminance for Class-I lighting,the number of luminaire is calculated from the Lumen formula.The Lumen formula for average illuminance is-

$$E_{avg} = \frac{N*\phi*COU*MF}{A}$$

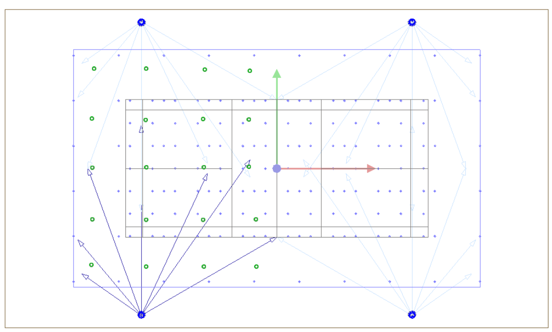
Where,

N=Number of luminaires
$\phi = Lumenpackage$
COU=Coefficient of utilization
MF=Maintenance Factor
A=Receiving Area

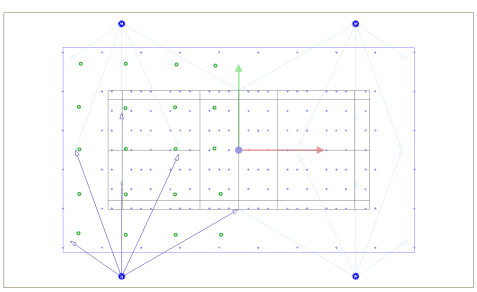
By using the the above formula,the no of luminaire required for Class-I Non-Televised Event can be calculated from the available data.Once,the luminaire required for Class-I lighting is obtained,then luminaire required for Class-II and Class-III lighting can be calculated mathematically according to their required illuminance level.
7) In the Luminaire arrangement tab,"Floodlight Arrangement" has been selected and the particular luminaire is selected.During the placement of Luminaire it is important to focus on Luminare photometry either the luminaire is suitable for Corner mounting or Side mounting which is discussed in Light and source and Luminaire used in sports lighting section of Chapter2.
8)According to the required no of luminaire,1/4 th value of the number has been given in Floodlight Arrangement and mirrored them horizontally and vertically to create a 4 pole structure having same number of luminaire in each pole.
9) Split the Floodlight Arrangement and placed each Floodlight in (C0,γ0)plane.Then add each floodlight arrangement into different Control group.In each control group,four luminaires are there with mirrored horizontal and vertical position with each other with respect to centre point of the playing Arena.Once the control group are formed,add all these control group into a Light scene to control ON/OFF or Dimming of the luminaire.
10) The aiming points or Beam Angles are adjusted for each of the luminaire for getting uniform illuminance into the playing ground.

11) Calculation Grid for the Total Playing Area (TPA) and Principle Playing Area (PPA) are already created by DIALux software automatically.The "Display Values" option is selected,so that the illuminance at each grid point can be seen along with average illuminance and uniformity.For small playing area grid size 1 m*1 m or 2 m* 2m can be considered.
12) The aiming points are adjusted until the required illuminance level and uniformity is achieved.During Beam Angle adjustment, first adjust the Beam Angle of particular luminaires required for Class-III.This is followed by class-II and class-I.
13) To Check the Glare Rating,GR observer are placed at different different position of the playing ground.
14) After designing,simulated result is obtained which attached in Annexure I.A.

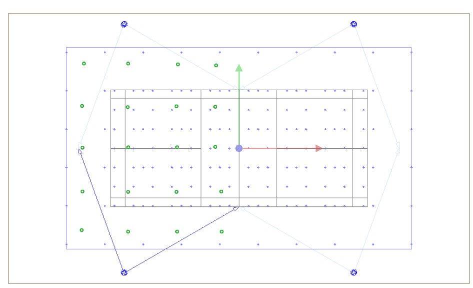
• The luminaires aiming for three different Class[II, II and III] non-televised events are [Figure14a],[Figure14b] and [Figure14c] respectively.



(a) Luminaire Aiming of Class-I



(b) Luminaire Aiming of Class-II



(c) Luminaire Aiming of Class-III

Figure 14: Luminaire Aiming of three Non-Televised Event using MH

The flowchart for lighting design using any lighting design software is [Figure15]-

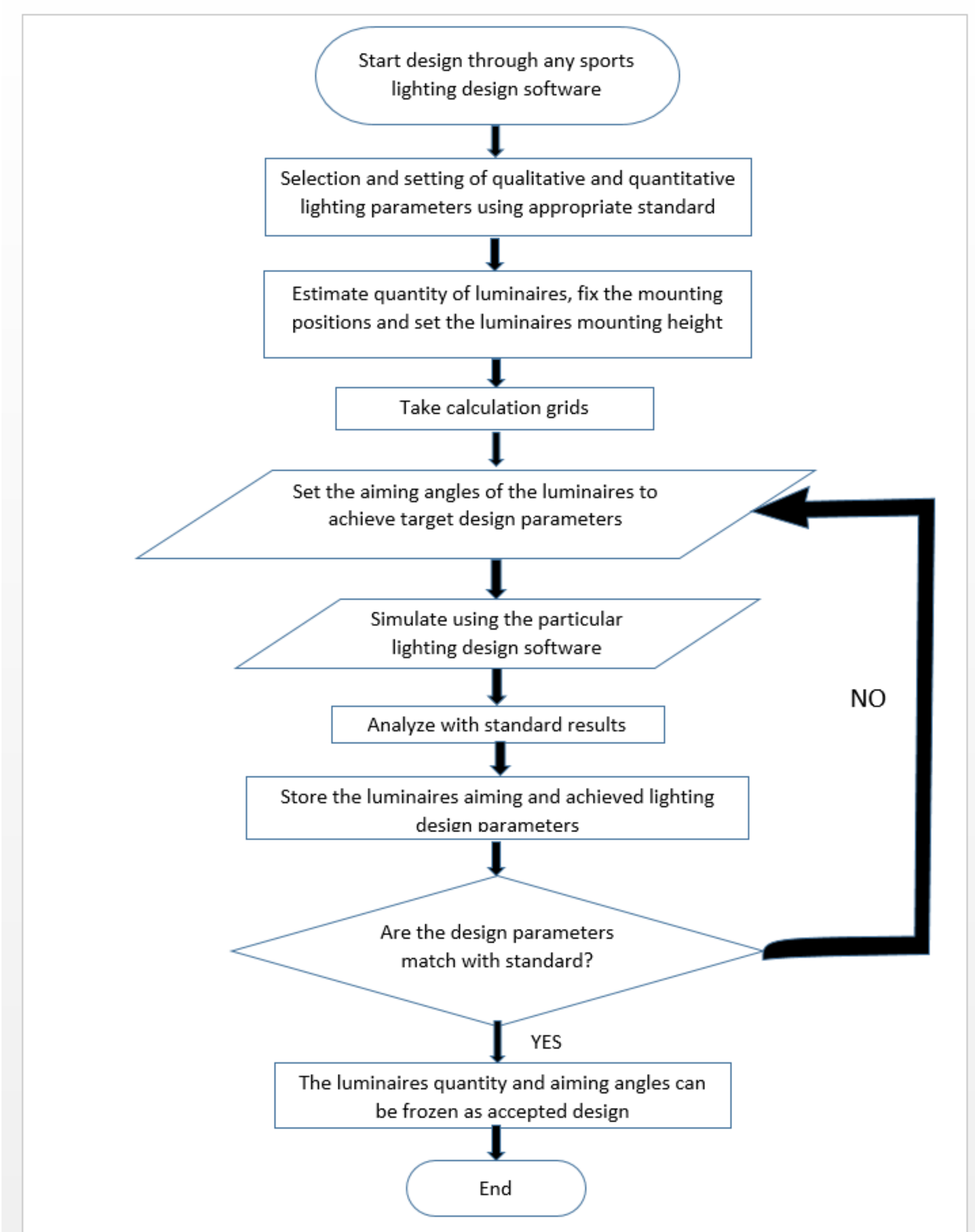


Figure 15: Flowchart for lighting design

3.1.2 Design for Televised Event :

For the Televised case of design a cameras has been utilized for the simulation of camera vertical illuminance. This primary camera is placed at a height of 6.00 m. The vertical illuminance is measured at a height of 1.00 m. by the camera. The luminaire aiming for the televised design is shown in [Figure16]-

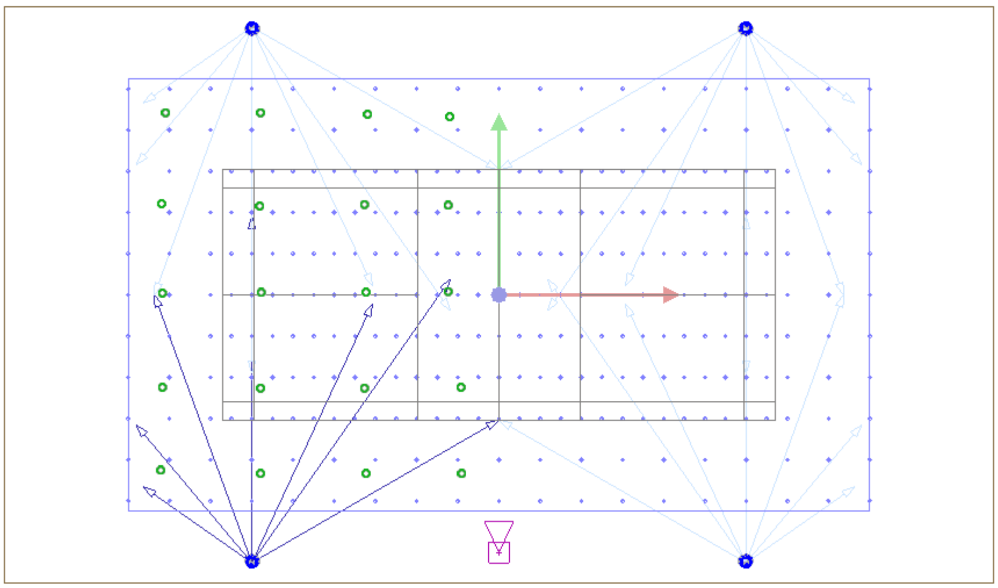


Figure 16: Luminaire Aiming of Televised Badminton Court using MH

3.1.3 Switching between Non-Televised and Televised Lighting Designs-

It is often hard to arrange separate sporting arenas for televised and non-televised games, due to availability if spaces, funds , manpower etc. So There might be cases where a single venue is used for both televised and non-televised events. For example,before happening of a televised game, the players play practice matches or warm up games in the same venue. Quite necessarily and obviously those sessions will not be broadcast by TV camera but requirement of artificial lights may still be there.Although the amount of light required will obviously be lesser compared to that of Televised event but it must comply with the values in NLC 2010.Hence proper control scheme

must be there to illuminate the field as per requirement.
Similar idea has been incorporated here in this design too. With the use of dimming method in the televised event court design, the horizontal average illuminance value has been reduced to match with the Non-televised event standard of NLC 2010. This method has been applied to achieve the Class I values of Illumination for Non-televised events from the televised one.

3.2 Technical Data for Selected Luminaires :

The lighting design has been performed here using Side Arrangement of Poles or luminaires instead of Corner Arrangement because the selected luminaire is double asymmetric which is explained properly through figure 8(a) and 8(b) in Light and Luminaire section of Chapter-2. Both the televised and non-televised designs have been performed using a LED having two beam angles.The beam angles are 20 degree and 80 degree,one in C0-C180 plane and the other one in C180- C270 plane.These beams are comes under wide beam.For Badminton Court,the playing area is small as compared to other playing ground,so wide beam is used.In other sports Medium beam,Narrow beam or combination of two or three can be used. The type of game-play and corresponding luminaires used has been tabulated below

Type of game-play	No of luminaires used
Non-televised Class I	28
Non-televised Class II	20
Non-televised Class III	8
Televised Event	28

Details of the Luminaire- 28 Pieces PHILIPS MWF 330/ 400W[Figure17], [SYMMETRIC], CLOSED
Luminous flux (Luminaire): 22807 lm
Luminous flux (Lamps): 30500 lm
Luminaire Wattage: 433.0 W Luminaire classification according to CIE: 100
CIE flux code: 69 92 99 100 75
Fitting: 1 x HPI T 400W (Correction Factor 1.000).

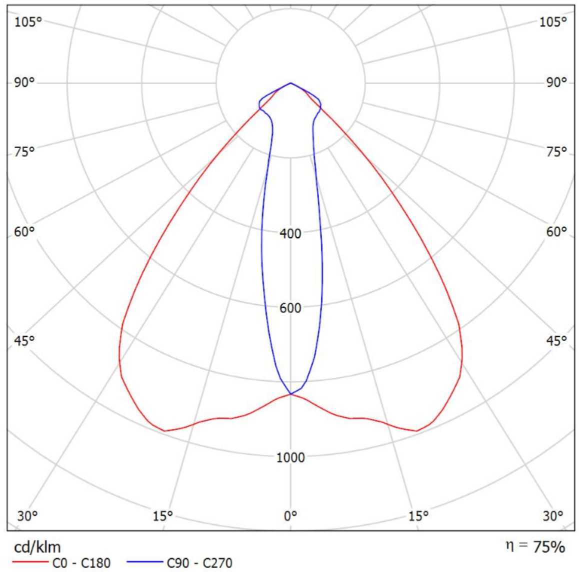


Figure 17: polar Curve of used MH Luminaire

3.3 Result Analysis

Non-Televised Class-I Event- The required lighting design parameters for Class-I Non-Televised lighting design are as follows-

$$\text{Average Illuminance, } E_(avg) >= 750lx;$$
$$\text{Uniformity } (\frac{E_(min)}{E_(avg)}),\ U_0 >= 0.7;$$
$$\text{Glare Rating, } GR < 50.$$

The DIALux simulated result using MH lamp for Class-I Non-Televised Event is given below in Tabulated form[Table3].

Table 3: DIALux simulated result of Clas-I lighting

Area	E_{avg} (lx)	E_{min}(lx)	E_{max}(lx)	U0	U1	GR (Maximum)
TA	751	549	1060	0.73	0.52	20
PA	769	708	856	0.92	0.83	20

In the above table GR,E_{avg},E_{min} and E_{max} are Glare Rating,Average,Minimum and Maximum horizontal illuminance. All these illuminance parameters are in Lux(lx) here.
$U1 = E_{min}/E_{max}$,is also called transverse uniformity.
According to NLC 2010 guideline,the required parameter has to achieve in Total Playing Area(TPA).Once the parameter are obae obtained in TPA region,the the parameters are automatically obtained in PPA region.
The isoline line diagram for TPA(TA in DIALux) after DIALux simulation is shown in [Figure 18]-

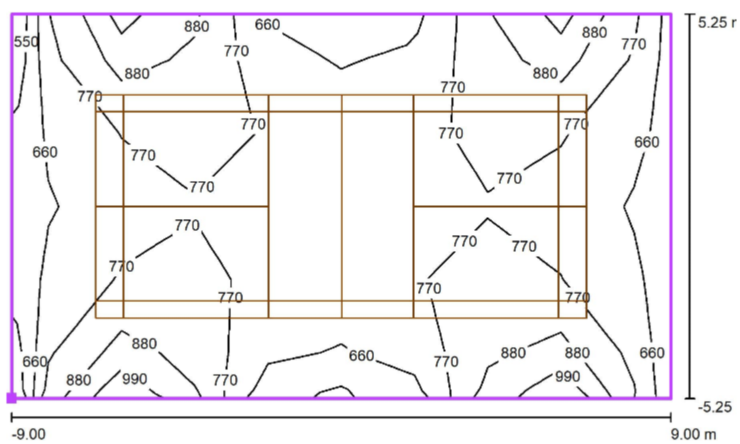


Figure 18: Isoline Diagram of Horizontal Illuminance for Class I

Non-Televised Class-II Event- The required lighting design parameters for Class-II Non-Televised lighting are as follows-

$$\text{Average Illuminance, } E_(avg) >= 500lx;$$
$$\text{Uniformity } (\frac{E_(min)}{E_(avg)}),\ U_0 >= 0.7;$$
$$\text{Glare Rating, } GR < 50.$$

The DIALux simulated result result for Class-II Non-televised lighting is given in [Table4].

The Isoline diagram of TPA for Class-II lighting after DIALux simulation is as follows[Figure19]-

Table 4: DIALux simulated result of Class-II lighting

Area	E_{avg} (lx)	E_{min}(lx)	E_{max} (lx)	U0	U1	GR (Maximum)
TA	555	414	780	0.75	0.53	21
PA	560	458	671	0.82	0.68	21

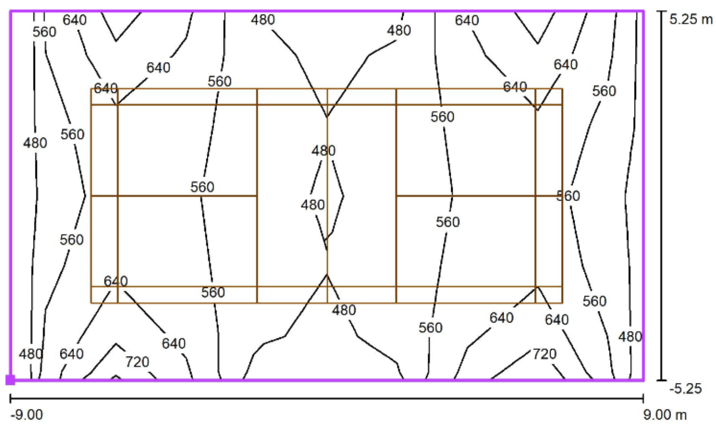


Figure 19: Isoline Diagram of Horizontal Illuminance for Class-II

Non-Televised Class-III Event- The required lighting design parameters for Class-II Non-Televised lighting are given below

$$\text{Average Illuminance, } E_(avg) >= 200lx;$$
$$\text{Uniformity } (\frac{E_(min)}{E_(avg)}),\ U_0 >= 0.7;$$
$$\text{Glare Rating, } GR < 50.$$

THe DIALux simulated result for Class-III Non-televised lighting is given in tabulated form[Table5].

Table 5: DIALux simulated result of Class-III lighting

Area	E_{avg}(lx)	E_{min}(lx)	E_{max}(lx)	U0	U1	Glare (Maximum)
TA	239	169	300	0.71	0.56	25
PA	227	200	267	0.88	0.75	25

The Isoline diagram of TPA for Class-III lighting after DIALux simulation is as follows[Figure20]-

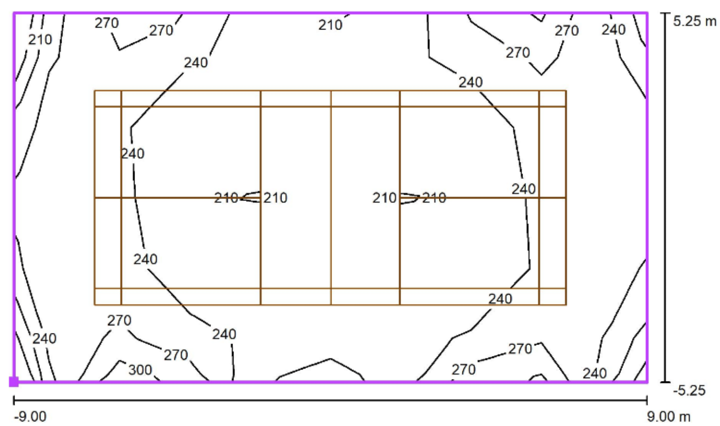


Figure 20: Isoline Diagram of Horizontal Illuminance for Class-III

Televised Lighting Event- For Televised event,vertical illuminance level is more important than the horizontal.The estimated vertical illuminance is obtained from the graph between vertical illuminance versus Maximum camera shooting distance in Figure-1.Their required parameters for Televised lighting Event are-

$$U1 >= 0.5$$
$$U2 >= 0.7$$

and Average Horizontal to Average Vertical illuminance ratio shold be within 0.5 to 2.

where, $U1 = E_{min}/E_{max}$ and $U2 = E_{min}/E_{avg}$.

The DIALux simulated result for Televised Badminton court is given in the below table[Table6].

Where, Eh_{avg} =Average horizontal illuminance

Ev_{avg} =Average vertical illuminance

Table 6: DIALux simulated result of Televised lighting

Type	E_{avg}(lx)	E_{min}(lx)	E_{max}(lx)	U2	U1	Eh_{avg}/Ev_{avg}
Horizontal	751	549	1060	0.73	0.52	NA
Camera	587	469	903	0.80	0.52	1.28

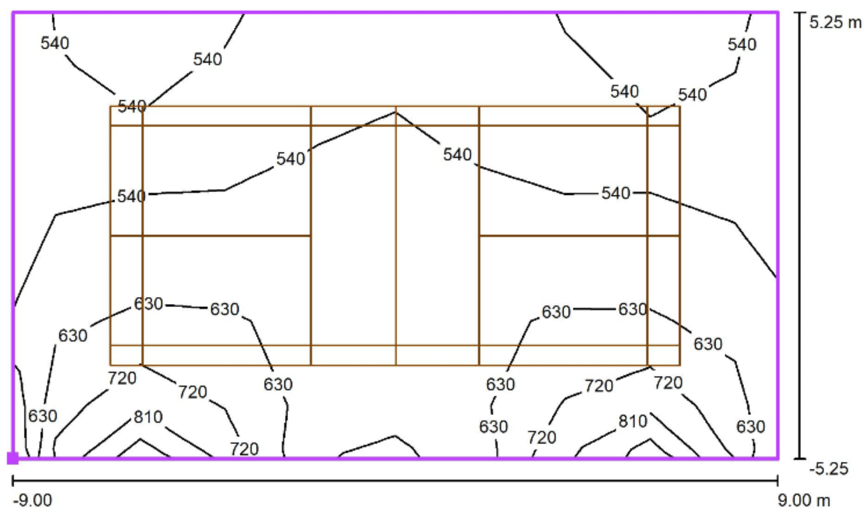


Figure 21: Vertical Isoline diagram of Televised Event

The vertical Isoline diagram for Televised Event is shown in above figure [Figure21].

• From the above discussion, it is clear that the values of Average Illuminance, Uniformity ratio and Glare were matched with the values given in NLC 2010 for Non-Televised Event.For Televised case, the values of Minimum Illuminance and Maximum Illuminance and their ratio,average horizontal to average vertical ratio has been looked after, since there is specific recommendation in NLC 2010 on the same if the game is shot with a camera for the purpose of broadcasting.Reasonable percentage of Upward Light Ratio (ULR) or Upward Light Output Ratio (ULOR) in both Non-Televised and Televised design has been observed. The Upward Light Output Ratio has also been checked. For non televised case it is calculated as 1 percent, 1.5 percent and 1.5 percent for class I, II, and III respectively. For televised it is 1 percent.

3.4 Design of Power supply system of a Televised Badminton Court using MH

In the previous chapters it has been explained and shown that Lighting design of a Badminton court or any sports facility is not an easy task, especially when the case is for Televised game-play. The lighting designer of the facility is mostly concerned with the achievement of the photometric parameters as per the standard value. But another complex yet indispensable system runs behind for the achievement of these parameters is the Electrical Power Distribution system. The primary electrical load for any sports facility is the lighting load of the same. Generally, for both outdoor and indoor sports, towers are involved consisting the lamps, but now a days indoor facilities are often designed with downlight also.Generally, lighting designers are not concerned with this electrical system. It is the job of the Electrical Engineers to take care of this.

3.4.1 Maintenance Work of a System

Maintenance work of building, electrical installation or machines is a function of availability of funds. Hence shortage of funds often causes curtail of proper maintenance.But such limitations are not involved in Sports Lighting, since the facilities are mostly used for National and International level of game play, which is why sufficient funds is always available.
The role of a maintenance engineer or team mainly comprises of three folds of responsibilities. The first is to get the job done within and utilizing the existing system. The second is to try to make the existing system better or improve. The third being Energy management. Among these three the second one is no doubt the toughest one. This requires great knowledge, leadership and Hard work.
Basically Maintenance Management is an IMM which may be depicted as a system to ensure the optimum service availability and stability of the installation at the lowest possible cost maintaining good relation among the different wings of the service providing and different service utilizing department.
Figure[Figure22] shows a brief overview of how the entire maintenance work of any electrical system is performed.

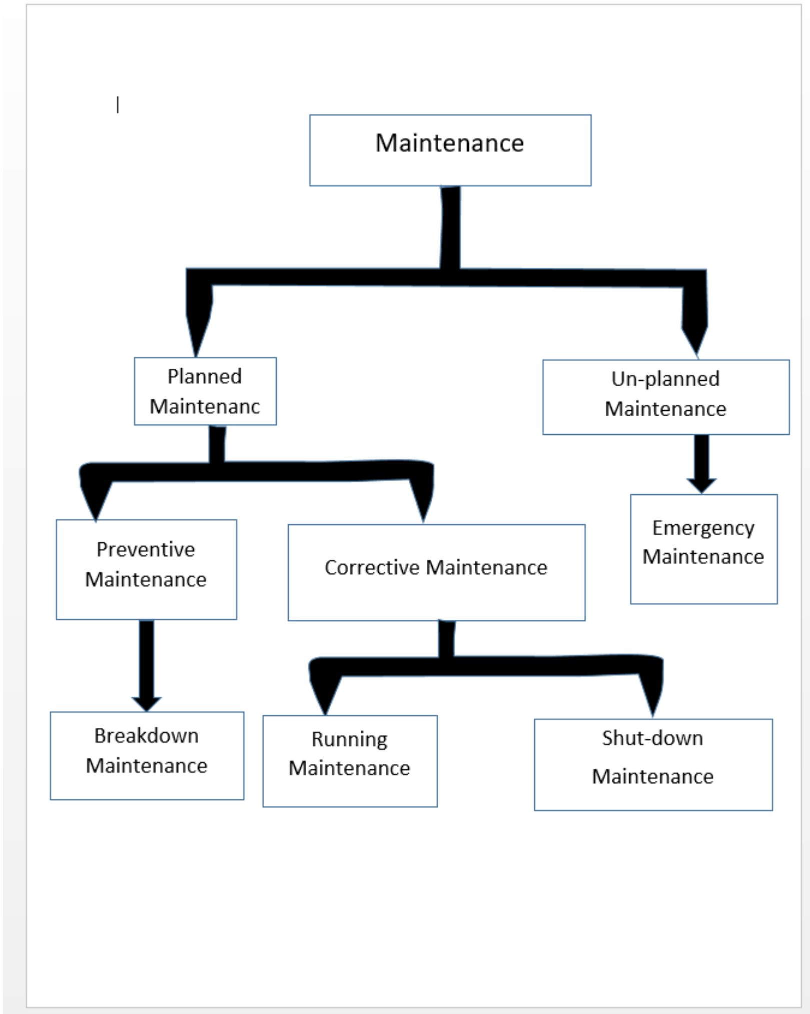


Figure 22: Block diagram of Maintenance Work

3.4.2 Design Procedure of Power Supply Scheme

Component Required : The illumination of any sports facility, Badminton court to be precise for this thesis work, comprises of a number of equipment. This does not include only the lamp and the electrical system, but also few other auxiliary things. A list of items involved in the illumination process directly and indirectly are as follows-

i. High mast with fixed head frame.

ii. Detachable man rider unit for accessing the flood light.
iii. Floodlight fixture suitable for 400 W meal halide lamp.
iv. Main Lighting Distribution Board (MLDB).
v. Sub-Lighting Distribution Board (SLDB).
vi.Distribution Board (DB).
vii.Power and Control Cables.
viii. Distribution Transformer.
ix. Control Gear Racks.
x. Earthing Equipment.
xi. Anti Panic Lighting System and Power Sources(UPS)
xii. Mimic cum Local Control Panels- Part of Control Scheme.
• For the sake of relevance and compactness of this thesis, the discussion has been kept limited within the Lamps and Electrical Equipment only.

Design Procedure : Since this thesis work does not include any physical sports site visit, the design procedure is based upon some assumptions, which might vary slightly from the actual scenario. Here,the design of the power supply scheme refers to drawing of a SLD and wiring diagram consisting some typical components, listed above, that are necessary to power mostly all Badminton facility lighting design and installation.
The electrical system has been designed for the purpose to supply power to the lighting arrangement of a Televised Badminton Court only.
The following discussion is moved forward with the explanation of the Single Line Diagram , shown in Figure , of the designed system. Although the ratings of the equipment are mentioned here but the related calculations has been shown in further section.

a. Incomer : Incomer is the Electrical Transmission Line of 11kV, 50 Hz AC. The Distribution Transformer is connected to this through a 63A Triple Pole Molded Case Circuit Breaker (TPMCCB).

b. Three Phase Distribution Transformer : The Distribution Transformer is required to step down the 11 kV transmission line voltage to distribution voltage of 415 V.The primary winding of the transformer is connected as Delta(Because the Transmission Line is Star Connected) and the secondary side is connected as Star with Neutral.
The transformer is connected to the transmission line with a circuit breaker

of rating 63A TPMCCB because there may be cases where the transformer or the supply system needs to be isolated from the transmission line, for example - during the maintenance work of the system or the transformer itself. The transformer power rating is decided as per the power consumption of the system.Here a rating of 20kVA has been taken.

c. Main Lighting Distribution Board (MLDB): The Main Lighting Distribution Boards are indoor floor mounted, metal enclosed, single front, vermin proof, IP52 protected as per IS247. The bus bars are air insulated and made up of electrolytic graded Aluminium. Bus bars shall be Polyvinyl chloride (PVC) sleeved having red, yellow, blue and black coloured strips arranged according to IS375.
Incomer to the bus-bar includes Four Pole Molded Case Circuit Breaker (FPMCCB) with a current rating of 63A. Rating of this decided as per the connected load due to the floodlighting system. Incomer MCCB also contains overload and short circuit releases along with ammeter and voltmeter with selector switch, kW meter, Power factor meter and frequency meter. The incomer also have one set of red, yellow and blue phase indicating lamps with control fuses and ON/OFF/Trip indicating lamps.
Outgoings of the busbar of MLDB consists of 63 A FPMCCB. The number of feeders will be decided as per the illumination design and load distribution. Each outgoing MCCB is provided with 70A Three Pole contactor, and ON delay timer. Switching arrangement is made to keep required number of lamps "ON" according to the level of match-"Practice", "National", "International". Apart from these, there is one outgoing feeder eith 32A FPMCCB to feed panel for small power requirement of the mast control room.

d. Sub-Lighting Distribution Board (SLDB) : These are metal enclosed wall mounted type. The incomer to SLDB are 63A FPMCCB. Outgoings contain 32A FPMCCB.Each outgoing feeders supply power to DB and the number depends on the load distribution.

e. Distribution Board (DB) : Distribution Boards have 32A FPMCCB as incoming and the outgoings with 16A Four Pole Molded Case Circuit Breaker (FPMCCB).The outgoings go directly to the Flood light luminaire through the driver circuit. Each floodlight circuit is connected with Current

Transformer for sensing current and decide the ON/OFF status of the lamp and the output status is fed to the LED display of the Mimic Cum Control Panel.

f. Mimic Cum Control Panel : One Mimic cum local control panel is provided with distribution boards so that the ON/OFF status of the lamps can be monitored and controlled stage-wise basis. Each floodlight circuit is provided with CT to sense the current for the indication purpose.
Mimic cum control panel is quiped with a set f push buttons for switching control. The number of push buttons indicates the corresponding number of level of game-play- International, National, Practice or any other level if required any. The system works in the following way- if a push button of corresponding level is pressed, it actuates required numbers of contactors of the outgoing feeders of the Main Lighting Distribution Board (MLDB). This in turn will switch on corresponding lighting panels in stages depending on the time delay set. Tine delay set is given to restrict the heavy inrush of current due to switching on of floodlights together.

g. MH Floodlights : For the design of the lighting system of the typical televised Badminton court, MH floodlights has been chosen with power 400W.

h. Cables : There are two types of cables used in the power supply schems- Power Cables and Control Cables.
The cable distribution are as follows -
i. From Transmission Line Supply to Primary Side of the Distrbution Transformer.
ii. From Transformer secondary side to Main Lighting Distribution Board(MLDB).
iii. From Main Lighting Distribution Board (MLDB) to Sub-Lighting Distribution Boards(SLDB).
iv. From Sub-Lighting Distribution Boards (SLDB) to Distribution Boards(DB).
v. From Distribution Boards (DB) to control gear racks where driver circuits are kept and interconnection between Distribution Boards(DB).
vi. From Control gear racks to flood lights.
vii. Interconnected control cables form mimic cum control panel to MLDB for actuating the contactors and from control gear racks to mimic cum con-

trol panel for LED display.
Out of these above mentioned cables , (vii) is control cable and all other cables are cables are Power Cables. The ratings of the all the cables has been calculated and discussed later.

i. Anti-Panic Lighting system : It is a normal practice to provide backup flood lights at the top of the masts so that minimum visibility can be achieved in case of complete power failure of normal supply.
• These floodlights can be powered by suitably rated UPS (Uninterrupted Power Supply) located in the control room.

j. Earthing : High mast towers is to be earthed at two separate point by means of two numbers of earth pits with 600*600*6mm Gl earth plate with required accessories and connected by 50*6 mm Gl flat. Equipment in the control room shall be earthed using suitable Gl flat connected to the existing earth grid of the control room.
The equipment discussed above has been mentioned with their ratings. Now in the following discussion the calculation of those ratings has been discussed. Also, the total cable length required approximately will also be shown. To do so, help of the wiring diagram. To move forward with the calculation, the following assumptions has been made in the diagram.

Assumptions : As per the wiring diagram given in figure,approximate distance between-
i. Distribution transformer to Main Lighting Distribution Board (MLDB)= 60 m.
ii. MLDB to each Sub Lighting Distribution Board(SLDB) = 20 m.
iii. SLDB1 to Tower1 and Tower3= 60 m.
iv. SLDB2 to Tower2 and Tower4= 50 m.
v. Distribution Board(DB) to Corresponding Tower= 10 m.
vi. DB1 and DB3 = 35 m.
vii. DB2 and DB4 = 15 m.
viii. MLDB to Tower2 and Tower4 = 60 m.

Cable Length Calculation : The above distances are approximated as point by point distance. But when the cable will be installed either through

ground or through air, it will require extra length due to bending and exact distance. Hence, while designing it is safe to keep some extra length in the cables of all segment. Here an additional length of 10 m. plus extra 10of total segment length is kept as spare cable length. Due to that, the following cable lengths are required.
i. Distribution transformer to MLDB = (60+10)*1.10 = 80 m(approx).
ii. MLDB to each SLDB = (20+10)*1.10 = 35m (approx).
iii. SLDB1 to DB2 and SLDB2 to DB4= (50-10+10)*1.10 = 55 m.(approx).
iv.SLDB1 to DB1 and SLDB2 to DB3 = (60+10)*1.10 = 80 m.
v. DB1 to DB3 = (35+10)*1.10 = 50 m.
vi. DB2 to DB4 = (15+10)*1.10 =30 m.
vii. DB to corresponding tower = (10+10) = 25 m.

Current Calculation : As per the output planning data of Televised Badminton court by using Metal Halide floodlighting system,the power consumed by the system is 12124 W.
Thus, active power consumed by each pole = 3031 W.
Current consumption by each tower due to floodlighting loads is calculated by the following equation-

$$\sqrt{3} * V_{line} * I_{line} * powerfactor = ActivePowerConsumed$$

In the above equation,putting $V_{line} = 415V$ and power factor=0.65

$$I_{line} = 7Amp\text{(approx)}$$

The 7 lamps in each tower is distributed in 3+2+2 in each phase respectively. This 7 A current is drawn by each phase also, since the Distribution secondary is Star Connected with Neutral wire, hence $I_{phase} = I_{line}$.Therefore, this 7 A current flows through
i. Distribution Board to Each phase of Tower and each Sub-Lighting Distribution Board to Distribution Board.
ii. Therefore, the current flowing between, Main Lighting Distribution Board and each Sub-Lighting Distribution Board =(7+7)= 14 A.
iii. Similarly, the current flowing between Transformer secondary to Main Lighting Distribution Board = 14+14 = 28 A.
During the Power System design process,it is important to consider the case

of failure/fault.The case of failure occurrence may happen in the following three possible path-
i. Cable between Main Lighting Distribution Board to any one of the Sub-Lighting Distribution Boards.
ii. At any one of the Sub-Lighting Distribution Boards.
iii. Cable between Sub-Lighting Distribution Board to connected Distribution Boards.
By considering the the fault,it is important to design backup connection. There will be a changes in current flow in the faulty system than the healthy system. Therefore,the rating of the electrical equipment must be calculated on the basis of situation of fault/failure. Consider a fault occurs between MLDB and either DB1 or DB2. Thus the total current drawn by the system will follow the following path-
MLDB → SLDB2 → DB3 → i. Tower3 and ii. Tower1 through Changeover Switch and DB1.
MLDB → SLDB2 → DB4 → i. Tower4 and ii. Tower2 through Changeover Switch and DB2.
It is quite clear from the above current flow path, at the time of power failure, any electrical equipment connected between the MLDB and the DBs of healthy part of the system, the bottom part of the system, will encounter double the current flow in normal condition of the system. Similar thing will happen when the failure occurs MLDB and either DB3 or DB4 of the system.
• Now, to calculate the ratings of different electrical equipment, a Safety Factor of 1.25 has been considered.
• Thus, the current Rating of the equipment like cables, MCCB, switches etc. will be as follows-
i. Distribution Board to Tower and Each phase of the lamp =7*1.25= 9 Amp (approx).According to market availability,this current rating can be consider as 10 Amp.
ii. Sub-Lighting Distribution Board to Distribution Board =(10+10)= 20 Amp.
iii. Main Lighting Distribution Board to Each Sub-Lighting Distribution Board = (20+20) = 40 Amp.

Selection Of Cables : There are two type of cables that has to select during the cable selection process.These are-

i. Power Cables : It is assumed that, cables at all the segments, except DB to Lamps are laid underground and cable between DB to Lamp are laid in air.
In order to select cables that can tolerate the currents, discussed above, the standard IS-7098(Part-1) and for market availability of required cables, a catalogue from Havells India Limited has been consulted. According to both, the following specification of the power cables has been selected-
• 1.1kV, Four Core, Aluminium Conductor, XLPE insulated, Armoured Cable.
• Different cross sections of the same power cable is required at different parts of the designed system, due to different amount of flow of current.The differenr cables and their cross section are as follows-
a. Distribution Transformer Secondary to Main Lighting Distribution Board :10sq.mm.[Because it has the current tolerance capacity is 50 Amp and rated current is 40 Amp(approx)a here].
b. Sub-Lighting Distribution Board to each Distribution Board : 4 sq.mm.
c. Distribution Board to Tower/Lamp : 4 sq.mm.
d. Back-Up Cable : 4 sq.mm.

ii. Control Cables : Apart from the above specification of the power cables, control cables complying the standard IS-1554(Part-1) with following specification can be used -
• Four-core, 1.5sq.mm., Copper Conductor PVC/XLPE insulated flexible cables.

Selection Of Distribution Transformer : For the purpose of selecting the distribution transformer required to give supply to the entire system, a standard IS-1180 and catalogue of Shree Krishna Technology has been consulted for market availability checking.
The selected Distribution Transformer has the following specification-
• 3 phase, 11/0.415 KV, 25 kVA, 50Hz, Copper Wound.
• The transformer should be suitable for working with following power supply variations - i. Voltage : -12 to +12 percent, ii. Frequency : ± 3 percent (48.5 Hz to 51.5 Hz), iii. Power Factor - Zero (Lag) – Unity – Zero (Lead).

• Percentage Impedance - 4 percent.
• Cooling Type : Oil Cooled.
• Length - H 652mm x W 905mm x L 906mm.
• Maximum Ambient Air Temperature - 50 degree Centigrade.
• Minimum Ambient Air Temperature - -5 degree Centigrade.
• Average Daily Ambient Air Temperature - 38 degree Centigrade.
• Relative Humidity - 15 to 85 percent.

Selection Of Circuit Breakers : For the selection of MCCBs at different parts of the supply system, IS/IEC-60898-1 :2002 standard and a catalogue of ABB has been referred, to check market available ratings of the same. The circuit breakers connected at different parts of the system are as following-

• Between Transmission Line and Transformer Primary : 63A, 3 Pole MCCB.
• Between Transformer Secondary and MLDB Busbar : 63A, 4 Pole, MCCB.
• At outgoing of MLDB and incoming of SLDB : 63A, 4 Pole, MCCB.
• Between outgoing of MLDB and incoming of panel for mast control room : 32A,4 Pole, MCCB.
• At outgoing of SLDB and incoming of DB : 32A, 4 Pole, MCCB.
• At outgoing of SLDB, i.e.- feeder of each lamp : 16A, 2 Pole, MCCB.

3.5 Single Line Diagram for Televised Event :

The wiring diagram for televised badminton court by using MH floodlighting is as follows-

The Single Line diagram for televised badminton court by using MH floodlighting is given in the below figure24-

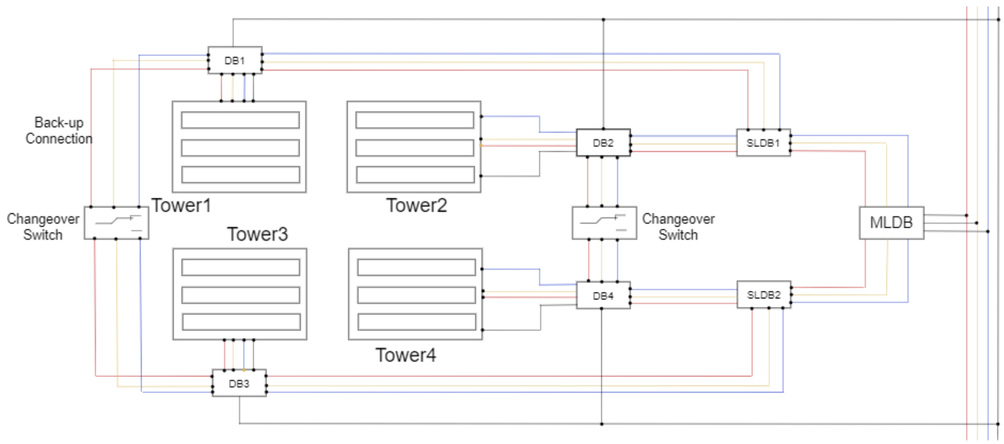


Figure 23: Wiring Diagram of The Power Supply scheme

Chapter 4

4 Lighting design using LED floodlight

This thesis work is entirely simulation based, and hence this does not involve any physical site visit, data collection such as measurement of dimension,lux audit etc. The design has been performed in DIALux 4.13 software. DIALux 4.13 is a very popular and widely used lighting design software. Performance of both Indoor and Outdoor type of designs is very feasible in this software. In this chapter, the methodology for designing a lighting system of a Badminton Court for both non-televised and televised event using LED has been performed in DIALux 4.13 software. In the later part, the analytical comparison of the results achieved after simulating the design in DIALux 4.13 with the values prescribed in NLC 2010 has been carried out.

4.1 Methodology-

To perform the design of an outdoor Badminton Court, a " New Exterior Project " has been incorporated at the very beginning. A typical model of Badminton court is taken from available sports sites. As per the NLC 2010 any sports site is divided into two parts Total Playing Area (TPA) and Principal Playing Area (PPA). PPA is the amount of area where the gameplay happens. In most of the sports sites, this area is separately marked. TPA

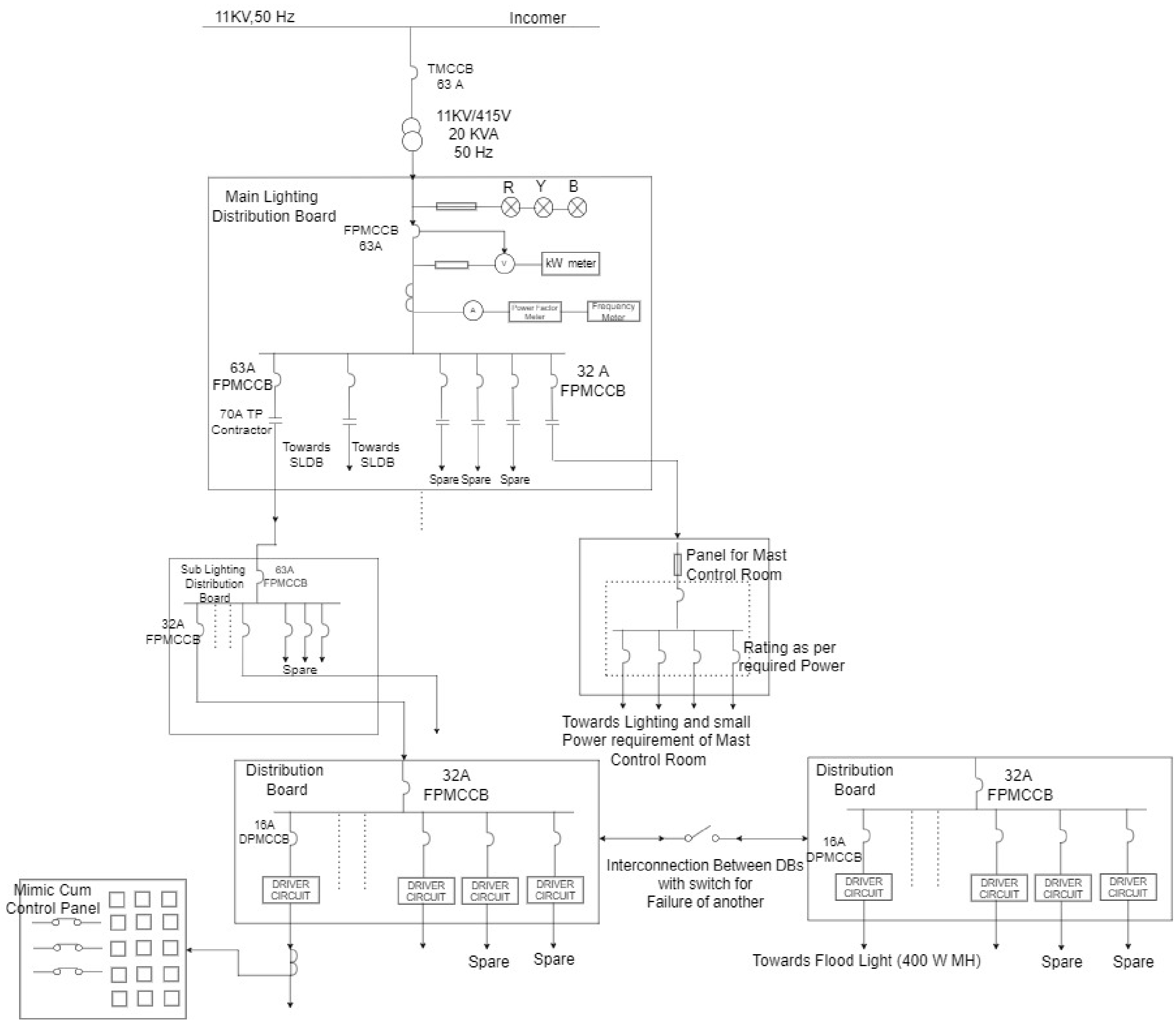


Figure 24: Simplest Single Line Diagram of the Designed Power Supply Scheme

includes an additional safety area along with the playing area. In DIALux 4.13 this TPA is named as TA, where the PPA is named as PA. In the Badminton Court design process,the default value of the total playing(TA) and principal playing area has been considered.The default value of the TA and PA are 18 m * 10.5 m and 13.4 m * 6.1 m respectively. The ground element has been adjusted accordingly. To keep a similarity with grass court of Badminton Court, the colour of the court is taken green. Since the design has been simulated using LED luminaires the light loss factor has been taken 0.8.

4.1.1 Design for Non-Televised Event-

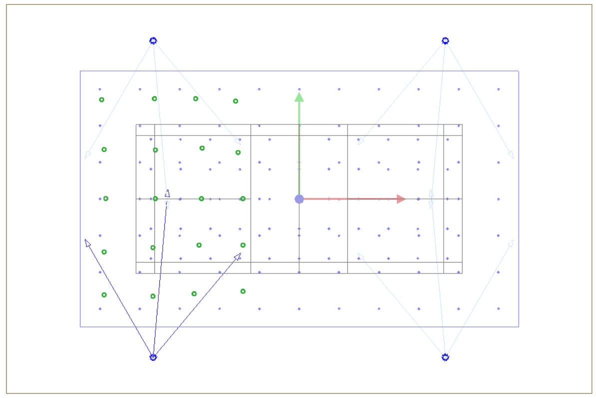
While performing the non-televised event court design, switching and Dimming phenomena has been used with the help of Control Group and Light Scene options in DIALux 4.13. The design of class III has been done at first with minimum number of luminaires, aimed at particular points.This is followed by class II and class I. Extra luminaires are added to the previous class but the aiming angles of previous class's luminaires are kept unaltered. The idea behind that is, in practical cases, changing of luminaire aiming angles for every class of game-play is actually impossible. The design should be and is made keeping in mind such that only the required number of luminaires are switched on/ff and dimmed according to the level of game-play.The luminaire aiming of the three classes has been shown in Figure 9(a),9(b)and 9(c).

4.1.2 Design for Televised Event-

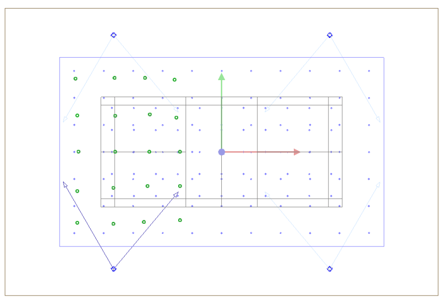
For the Televised case of design a camera has been utilized for the simulation of camera vertical illuminance. This primary camera is placed at a height of 6.00 m. The vertical illuminance is measured at a height of 1.00 m. by the camera.The luminaire aiming for the televised design is shown in Figure . The flow chart of the adopted methodology has been given in Figure-10.For Televised Lighting design,main goal is to achieve the required vertical illuminance.The required vertical illuminance is obtained from from vertical illuminance versus maximum camera shooting distance curve[Figure-1].Once the vertical illuminance is achieved,then required horizontal illuminance is automatically obtained.

4.1.3 Switching between Non-Televised and Televised Lighting Designs-

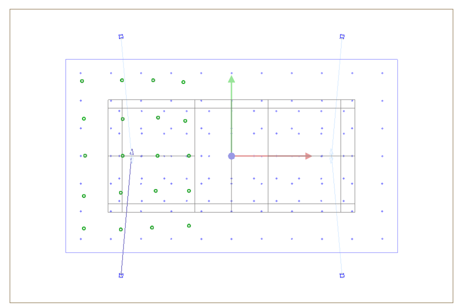
It is often hard to arrange separate sporting arenas for televised and non-televised games, due to availability if spaces, funds , manpower etc. So



(a) Luminaire Aiming of Class-I



(b) Luminaire Aiming of Class-II



(c) Luminaire Aiming of Class-III

Figure 25: Luminaire Aiming of three different Class Non-Televised Event

There might be cases where a single venue is used for both televised and non-televised events. For example,before happening of a televised game, the players play practice matches or warm up games in the same venue. Quite necessarily and obviously those sessions will not be broadcast by TV camera but requirement of artificial lights may still be there.Although the amount of light required will obviously be lesser compared to that of Televised event but it must comply with the values in NLC 2010.Hence proper control scheme must be there to illuminate the field as per requirement.
Similar idea has been incorporated here in this design too. With the use of dimming method in the televised event court design, the horizontal average illuminance value has been reduced to match with the Non-televised event standard of NLC 2010. This method has been applied to achieve the Class I

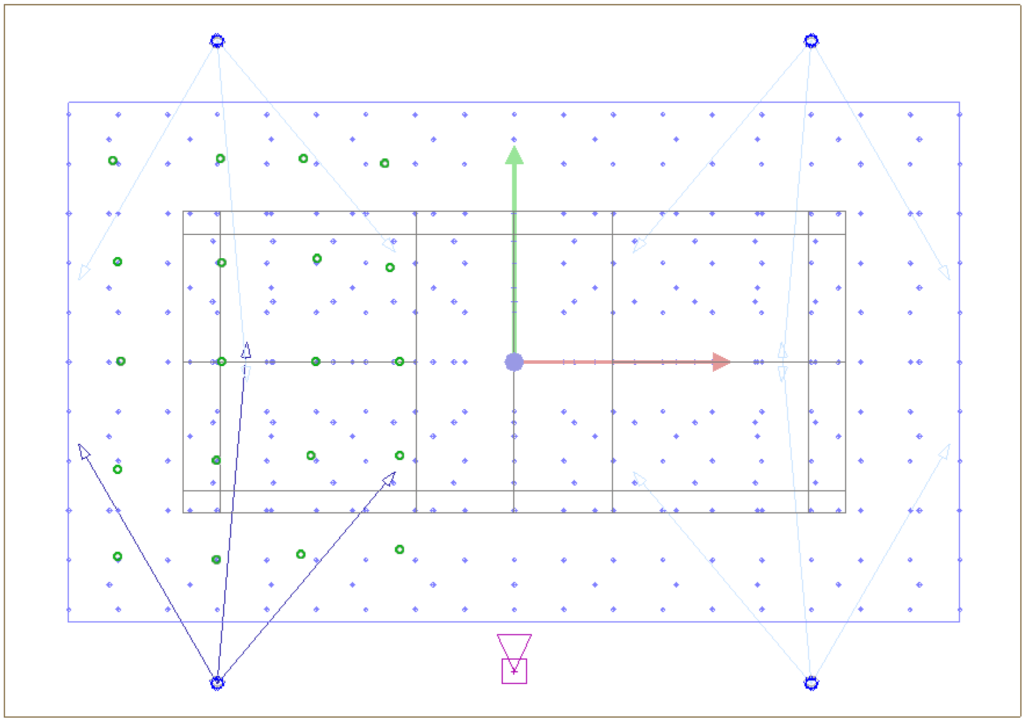


Figure 26: Luminaire Aiming of Televised Badminton Court

values of Illumination for Non-televised events from the televised one.

4.2 Technical data for Luminaire Selection :

The lighting design has been performed here using Side Arrangement of Poles or luminaires instead of Corner Arrangement because the selected luminaire is double asymmetric which is explained properly through figure 8(a) and 8(b) in Light and Luminaire section of Chapter-2. Both the televised and non-televised designs have been performed using a LED having two beam angles.The beam angles are 60 degree and 90 degree,one in C0-C180 plane and the other one in C180- C270 plane.These beams are comes under wide beam.For Badminton Court,the playing area is small as compared to other playing ground,so wide beam is used.In other sports Medium beam,Narrow beam or combination of two or three can be used. The type of game-play and corresponding luminaires used has been tabulated below

Type of game-play	No of luminaires used
Non-televised Class I	12
Non-televised Class II	8
Non-televised Class III	4
Televised Event	12

Details of the Luminaire-

12 Pieces INTEGRATED POWER FL FLA400BL5KN05
Article No.: FL
Luminous flux (Luminaire): 55007 lm
Luminous flux (Lamps): 54969 lm
Luminaire Wattage: 440.0 W
Luminaire classification according to CIE: 100
CIE flux code: 76 97 100 100 100
Fitting: 1 x User defined (Correction Factor 1.000).

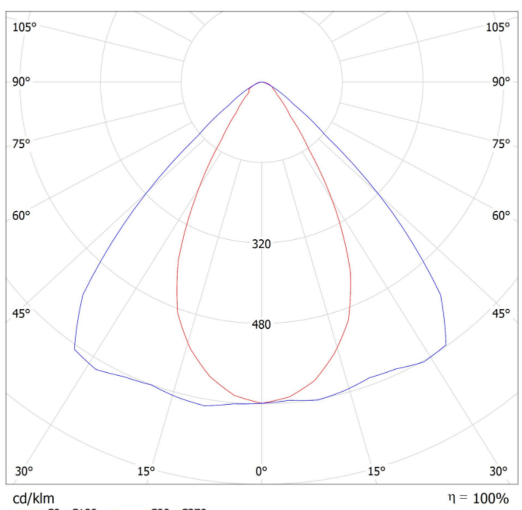


Figure 27: polar Curve of used LED Luminaire

4.3 Result Analysis

In non-televised lighting design, a default grid size has been taken.In televised design an extra calculation grid of grid size of 1.0 m * 1.0 m has been taken to simulate the design.After performing the design in DIALux 4.13 software,the values of Average Illuminance, Uniformity ratio and Glare has been analysed to see whether these required parameter are matched with the values given in NLC 2010 or not.For the televised case, the values of Minimum and Maximum horizontal Illuminance and their ratio,Average Horizontal to Vertical illuminance ratio has been observed,since there is specific recommendation in NLC 2010 on the same if the game is shot with a camera for the purpose of broadcasting. The Upward Light Output Ratio has also been checked. For non televised case it is calculated as 0.5 percent, 0.5 percent and 0.5 percent for class I, II, and III respectively. For televised it is 0.5 percent.
The recommended lighting design parameter and the DIALux simulated results for different class Non Televised event and Televised events are given below-

Non-Televised Class-I Event- According to NLC 2010, the recommended lighting design parameters for non televised Class-I event are as follow-

Table 7: Required value of Lighting Design parameters for Class-I

Class	E_{avg} (lx)	Uniformity (U0)	GR (Maximum)
Class I	750	0.7	50

In the above table,E_{avg} =Average hoizontal illuminance

$$U0 = E_{min}/E_{avg}$$

The DIALux simulated result is as follows-

In the above table,E_{avg},E_{min} and E_{max} are Average,Minimum and Maximum horizontal illuminance. All These parameters are in Lux(lx) here.
$U1 = E_{min}/E_{max}$,is also called trnsverse uniformity.

Table 8: DIALux simulated result of Clas-I lighting

Area	E_{avg}(lx)	E_{min}(lx)	E_{max}(lx)	U0	U1	Glare (Maximum)
TA	758	575	908	0.76	0.63	34
PA	832	744	908	0.89	0.82	34

According to NLC 2010 guideline,the required parameter has to achieve in Total Playing Area(TPA).Once the parameter are obae obtained in TPA region,the the parameters are automatically obtained in PPA region.
The isoline line diagram for TPA after DIALux simulation is-

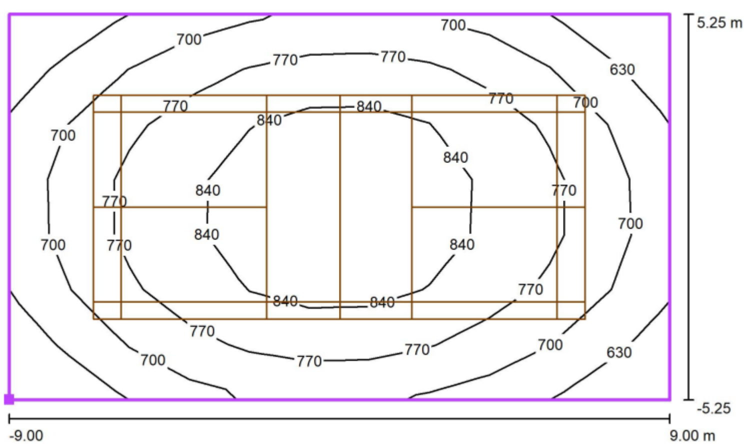


Figure 28: Isoline Diagram of Horizontal Illuminance for Class I

Non-Televised Class-II Event- The required lighting design parameters for Class-II Non-Televised lighting are given below in Table[9].

Table 9: Required value of Lighting Design parameters for Class-II

Class	E_{avg}(lx)	Uniformity (U0)	GR (Maximum)
Class II	500	0.7	50

The DIALux simulated result result for Class-II Non-televised lighting is given in Table[10].

Table 10: DIALux simulated result of Class-II lighting

Area	E_{avg}(lx)	E_{min}(lx)	E_{max}	U0	U1	GR (Maximum)
TA	510	396	611	0.78	0.65	33
PA	556	499	611	0.90	0.82	33

The Isoline diagram of TPA for Class-II lighting after DIALux simulation is as follows[Figure29]-

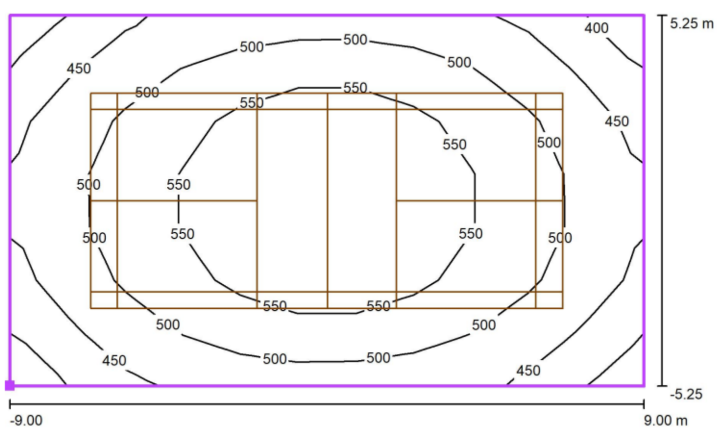


Figure 29: Isoline Diagram of Horizontal Illuminance for Class-II

Non-Televised Class-III Event- The required lighting design parameters for Class-II Non-Televised lighting are given below[Table11] .

Table 11: Required value of Lighting Design parameters for Class-III

Class	E_{avg} (lx)	Uniformity(U0)	GR (Maximum)
Class III	200	0.7	50

The DIALux simulated result result for Class-III Non-televised lighting is given below [Table12].

Table 12: DIALux simulated result of Class-III lighting

Area	E_{avg}(lx)	E_{min}(lx)	E_{max}(lx)	U0	U1	GR (Maximum)
TA	210	149	247	0.71	0.60	35
PA	233	206	247	0.89	0.83	35

The Isoline diagram of TPA for Class-III lighting after DIALux simulation is as follows[Figure30]-

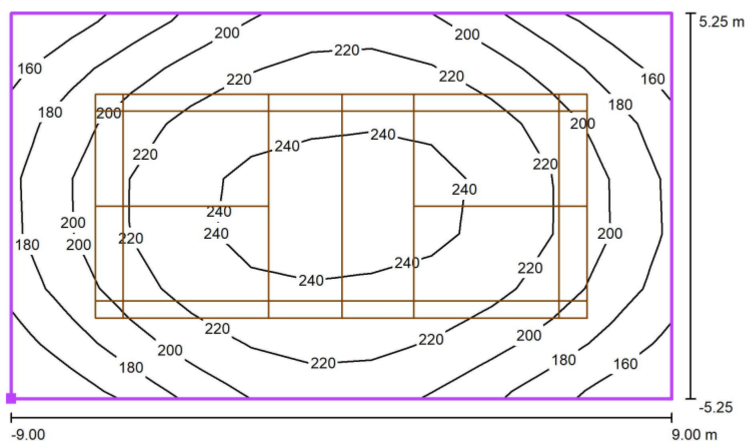


Figure 30: Isoline Diagram of Horizontal Illuminance for Class-III

Televised Lighting Event- For Televised event,vertical illuminance level is more important than the horizontal.The estimated vertical illuminance is obtained from the graph between vertical illuminance versus Maximum camera shooting distance Figure-1.Their required parameters for Televised lighting Event are-

$$U1 >= 0.5$$
$$U2 >= 0.7$$

and Average Horizontal to Average Vertical illuminance ratio shold be within 0.5 to 2.
where,$U1 = E_{min}/E_{max}$ and $U2 = E_{min}/E_{avg}$.

The DIALux simulated result for Televised Badminton court is given in the below table[Table13].

Table 13: DIALux simulated result of Televised lighting

Type	E_{avg}(lx)	E_{min}(lx)	E_{max}(lx)	U2	U1	Eh_{avg}/Ev_{avg}
Horizontal	758	575	908	0.76	0.63	NA
Camera	614	511	752	0.83	0.68	1.24

The isoline diagram for Televised LED Floodlight system is as shown in[Figure31].

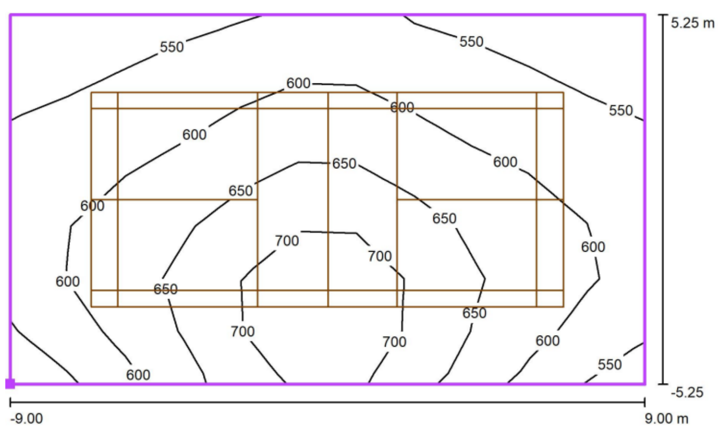


Figure 31: Vertical Isoline diagram for Televised Event

• From the above discussion, it is clear that the values of Average Illuminance, Uniformity ratio and Glare were matched with the values given in NLC 2010 for Non-Televised Event.For Televised case, the values of Minimum Illuminance and Maximum Illuminance and their ratio,average horizontal to average vertical ratio has been looked after, since there is specific recommendation in NLC 2010 on the same if the game is shot with a camera for the purpose of broadcasting.Reasonable percentage of Upward Light Ratio (ULR) or Upward Light Output Ratio (ULOR) in both Non-Televised and Televised design has been observed.

4.4 Design of Power Supply Scheme :

The power supply scheme of LED and Metal Halide Floodlight system is same except the rating of different the electrical equipments are different. So,the design process and the process of drawing the Single Line Diagram is not discussed here[As it is discussed in Power Supply scheme part of Chapter 3].The required electrical equipment to design the lighting system and their ratings are discussed here.

Current Calculation : As per the output planning data of Televised Badminton court by using LED floodlighting system,the power consumed by the system is 5280 W.
Thus, active power consumed by each pole = 1320 W.
Current consumption by each tower due to floodlighting loads is calculated by the following equation-

$$\sqrt{3} * V_{line} * I_{line} * powerfactor = ActivePowerConsumed$$

In the above equation,putting $V_{line} = 415V$ and power factor=0.8

$$I_{line} = 2.5Amp(\text{approx})$$

The 3 lamps in each tower is distributed in 1+1+1 in each phase respectively. This 2.3 A current is drawn by each phase also, since the Distribution secondary is Star Connected with Neutral wire, hence $I_{phase} = I_{line}$.
The process of selection of MCCB are same as that of Metal Halide Lamp [Discussed in Power Supply scheme part of Chapter 3].

Selection of Distribution Transformer For the purpose of selecting the distribution transformer required to give supply to the entire system, As per BIS and BEE Standards and catalogue of Electromech has been consulted for market availability checking.
The selected Distribution Transformer has the following specification-

• 3 phase, 11/0.415 KV, 10 kVA, 50Hz, Copper Wound.
• The transformer should be suitable for working with following power supply variations - i. Voltage : -12 to +12 percent, ii. Frequency : ± 3 percent (48.5 Hz to 51.5 Hz), iii. Power Factor - Zero (Lag) – Unity – Zero (Lead).
• Percentage Impedance - 4 percent.
• Cooling Type : Oil Cooled.
• Length - H 266.70 mm x W 139.70 mm x L 130.302mm.
• Maximum Ambient Air Temperature - 50 degree Centigrade.
• Minimum Ambient Air Temperature - -5 degree Centigrade.
• Average Daily Ambient Air Temperature - 38 degree Centigrade.
• Relative Humidity - 15 to 85 percent.

Selection Of Circuit Breakers : For the selection of MCCBs at different parts of the supply system, IS/IEC-60898-1 :2002 standard and a catalogue of Schneider Electric India has been referred, to check market available ratings of the same. The circuit breakers connected at different parts of the system are as following-
• Between Transmission Line and Transformer Primary : 40A, 3 Pole MCCB.
• Between Transformer Secondary and MLDB Busbar : 40A,4 Pole, MCCB.
• At outgoing of MLDB and incoming of SLDB : 40A, 4 Pole, MCCB.
• Between outgoing of MLDB and incoming of panel for mast control room : 16A,4 Pole, MCCB.
• At outgoing of SLDB and incoming of DB : 16A, 4 Pole, MCCB.
• At outgoing of SLDB, i.e.- feeder of each lamp : 6A, 2 Pole, MCCB.

Selection of Cables : The method of selecting power and control cables are discussed in Power Supply scheme part of Chapter 3.

Power Cables - The power cable required for different part of the power supply system are as follows- • Distribution Transformer Secondary to Main Lighting Distribution Board : 10sq.mm.
• Main Lighting Distribution Board to each Sub-Lighting Distribution Board : 4sq.mm.
• Sub-Lighting Distribution Board to each Distribution Board : 4 sq.mm.
• Distribution Board to Tower/Lamp : 4sq.mm.
• Back-Up Cable : 4sq.mm.

Control Cables - Control cables complying the standard IS-1554(Part-1) with following specification can be used -
• Four-core, 1.5sq.mm., Copper Conductor PVC/XLPE insulated flexible cables.

4.5 Single Line Diagram for Televised Event

The wiring diagram for the LED based lighting system is as follows[Figure**??**

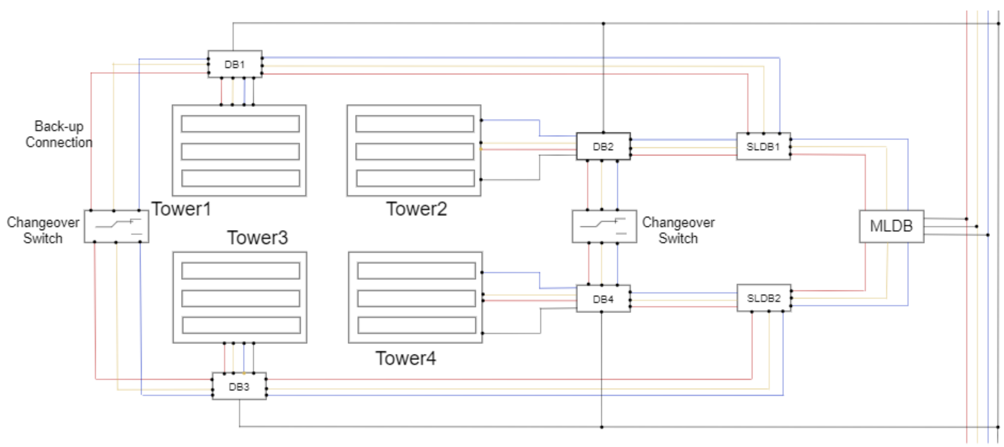


Figure 32: Wiring Diagram of The Power Supply scheme(LED)

The single line diagram for LED floodlighting system is as follows-

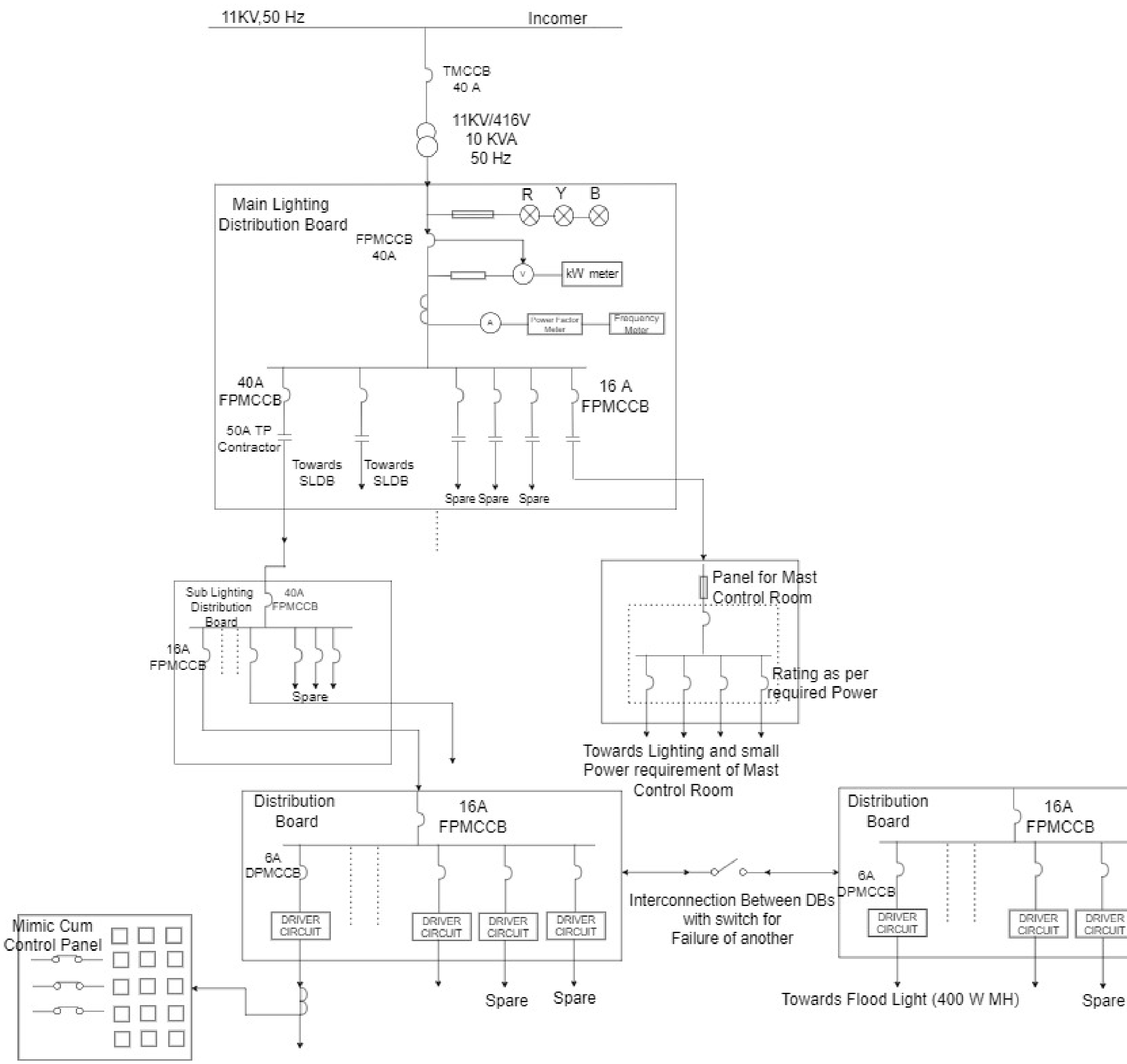


Figure 33: Simplest Single Line Diagram of the Designed Power Supply Scheme(LED)

Chapter 5

5 Comparison study between MH and LED floodlight system

5.1 comparison of the Lighting parameters

The different comparison parameters for MH and LED floodlight are as follows-

a. Correlated Colour Temperature(CCT) : LEDs are available in a wide range of color temperatures that generally span from 2200K-6000K (ranging from " warm " yellow to light or " cool " blue).
Metal halide lamps generate a very cool white light. They are available in color temperatures as low as 3000K. Some metal halides are available with extremely cool color temperatures up to 20,000K.

b. Colour Rendering Index(CRI) : CRI for LED is highly dependent on the particular light in question. That said, a very broad spectrum of CRI values is available ranging generally from 65-95.
Metal halides are the best source of high CRI of white light on the market.

c. Cycling (Turning On/Off) : LEDs are an ideal light for purposely turning on and off because they respond rather instantaneously (there is no warm up or cool down period). They produce steady light without flicker.
Metal Halide lights require a notoriously long warm up period. Many stadiums have traditionally relied on metal halide lights but the bulbs can take 15-30 minutes to get to full operating power.

d. Dimming : LEDs are very easy to dim and options are available to use anywhere from 100 percent of the light to 0.5 percent. LED dimming functions by either lowering the forward current or modulating the pulse duration. LED lights are not compatible with traditional incandescent dimmers (which lower the voltage sent to the light) so you need to purchase LED dimmer switches as well if you want to dim.
Metal halide lights can be dimmed through the use of different electric or

magnetic ballast but the process changes the voltage input to the light and can consequently alter the light characteristics. Generally speaking metal halide lights are less efficient when run at less than full power. In some cases dimming can also cause the light to prematurely expire.

e. Directionality : LEDs emit light for 180 degrees. This is typically an advantage because light is usually desired over a target area (rather than all 360 degrees around the bulb).We can read more about the impact of directional lighting by learning about a measurement called "useful lumens" or "system efficiency."
Metal Halide lights are omnidirectional meaning they emit light for 360 degrees. Much of these emissions must be reflected and/or redirected which means losses and lower overall system efficiency.

f. Efficiency : LEDs are very efficient relative to every lighting type on the market and extremely efficient relative to incandescent bulbs. Typical source efficiency ranges 37 and 120 lumens/watt. Where LEDs really shine, however, is in their system efficiency (the amount of light that actually reaches the target area after all losses are accounted for). Most values for LED system efficiency fall above 50 lumens/watt.
Metal Halide lights have average efficiency (75-100 lumens/watt source efficiency). They lose out to LEDs principally because their system efficiency is much lower (¡30 lumens/watt) due to all of the losses associated with omnidirectional light output and the need to redirect it to a desired area.

g. Efficiency Droop : LED efficiency drops as current increases. Heat output also increases with additional current which decreases the lifetime of the device. The overall performance drop is relatively low over time with around 80 percent output being normal near the end of life. Recent advances by researchers who have identified the reasons for droop in LEDs look to reduce losses even further.
Metal Halide lights also experience efficiency losses as the device ages and additional current is required to achieve the same lighting output. Efficiency losses are greater than LEDs and the degradation time shorter in the case of Metal Halides.

h. Emissions (In Visible Spectrum) : LEDs produce a very narrow spectrum of visible light without the losses to irrelevant radiation types (IR, UV) or heat associated with conventional lighting, meaning that most of the energy consumed by the light source is converted directly to visible light.
Metal Halide lights produce relevant amounts of both IR and UV radiation.

i. Ultraviolet and Infrared : LEDs - NONE
Metal Halide lights emit IR radiation which is a waste of energy for the purposes of regular illumination.
Metal Halide lights emit UV radiation and require a filter built into the bulb to keep these emissions from being radiated into the atmosphere. These filters are required to prevent fading of dyed surfaces exposed to metal halide light otherwise serious damage can occur to light fixtures or even human beings and animals (e.g. serious sunburn or arc eye).

j. Failure Characteristics : LEDs fail by dimming gradually over time. Because LED lights typically operate with multiple light emitters in a single luminaire the loss of one or two diodes does not mean failure of the entire luminaire.
Metal Halide lights exhibit an end-of-life phenomenon known as cycling where the lamp goes on and off without human input prior to eventually failing entirely. For this reason in many applications (such as a sporting stadium) metal halide lamps must be changed out prior to the end of their useful life.

k. Foot Candles : Foot candle is a measure that describes the amount of light reaching a specified surface area as opposed to the total amount of light coming from a source (luminous flux).
LEDs are very efficient relative to every lighting type on the market. Typical source efficiency ranges 37 and 120 lumens/watt. Where LEDs really shine, however, is in their system efficiency (the amount of light that actually reaches the target area after all losses are accounted for). Most values for LED system efficiency fall above 50 lumens/watt.
Metal halide lights are very efficient compared to incandescent lights (75-100 lumens/watt source efficiency). They lose out to LEDs principally because their system efficiency is much lower (¡30 lumens/watt) due to all of the losses associated with omnidirectional light output and the need to redirect it to a desired area.

l. Heat Emissions : LEDs emit very little forward heat. The only real potential downside to this is when LEDs are used for outdoor lighting in wintery conditions. Snow falling on traditional lights like HID will melt when it comes into contact with the light. This is usually overcome with LEDs by covering the light with a visor or facing the light downward towards the ground.
Metal halide bulbs emit a significant amount of heat (roughly 10-15 percent of the total energy consumed is emitted as heat). In some circumstances this could be beneficial, however, it is a generally a bad thing as heat losses represent energy inefficiencies. The ultimate purpose of the device is to emit light, not heat.

m. Life Span : LEDs last longer than any light source commercially available on the market. Lifespans are variable but typical values range from 25,000 hours to 100,000 hours or more before a lamp or fixture requires replacement.
Metal Halide lights have an better lifespan relative to old technology like incandescent lights but they have a short lifespan compared to LED. Typical lifespan values range from 6,000 hours to 15,000 hours before a bulb requires replacement. Note: sometimes metal halide lights need to be changed out before the end of their useful life to preempt serious degradation effects like color changes or cycling.

n. Lifetime Cost : LED lighting has relatively high initial costs and low lifetime costs. The technology pays the investor back over time (the payback period). The major payback comes primarily from reduced maintenance costs over time (dependent on labor costs) and secondarily from energy efficiency improvements (dependent on electricity costs).
Metal halide lights are relatively cheap to purchase but they are relatively expensive to maintain. Metal halide bulbs will likely need to be purchased several times and the associated labour costs will need to be paid in order to attain the equivalent lifespan of a single LED light.

o. Maintenance Costs : As a result of the operational lifetimes of LEDs and the frequency with which bulbs have to be changed out, LEDs are by far the best on the market in regards to lifetime costs.
Metal halide bulbs require regular relamping and ballast replacement in ad-

dition to the labor cost to monitor and replace aging or expired lights several times within the typical lifespan of a single LED.

p. Upfront Costs : LED light costs are high but variable depending on the specifications. The typical 100W-equivalent LED light costs somewhere between $10 and 20$.
A 100W Metal Halide light costs somewhere between $10 and 30$ per bulb depending on the specifications.

q.Shock Resistance : LEDs are solid state lights (SSLs) that are difficult to damage with physical shocks.
Metal halide bulbs are relatively fragile. Perhaps more importantly, broken metal halide bulbs require special handling and disposal due to hazardous materials like mercury inside of many lights.

r. Size : LEDs can be extremely small (less than 2mm in some cases) and they can be scaled to a much larger size. All in all this makes the applications in which LEDs can be used extremely diverse.
Metal halide bulbs can be small but typically aren't produced below roughly a centimeter in width. The size of the lamps is limited by the wattage and light output required for a given application.

s. Cold Tolerance : LEDs - Minus 40 Degrees Celsius (and they will turn on instantaneously).
Metal halide - Minus 40 degrees Celsius.

t. Heat Tolerance : 00 Degrees Celsius. LEDs are fine for all normal operating temperatures both indoors and outdoors. They do, however, show degraded performance at significantly high temperatures and they require significant heat sinking, especially when in proximity to other sensitive components.
We couldn't find any objective data on metal halide bulb performance in high temperature situations. If you have any information please contact us.

u. Warm Up Time : LEDs have virtually no warm-up time. They reach maximum brightness near instantaneously.
Metal Halide lamps require a noticeable warm-up time that varies depending

on the light. Metal halide lights for sporting stadiums might take 15-20 minutes to arrive at maximum brightness.

5.2 Bill of Quantitiy Comparison of the Lighting System :

Table 14: BOQ comparison table of Lighting System

Components	MH (Qty*Price/Luminaire)	LED
luminaire for Sports Lights	28*4500	12*14000

- High Mast for both the Lighting System is same.so,this is not included in the comparison table.

- From the above table it can be concluded that, the initial cost to implement LEDs are higher than that of MH.

5.3 BOQ Comparison for Power DT and CB :

Table 15: BOQ comparison table of DT and CB

Components	MH(qty*cost/unit)	LED
Distribution Transformer	70,000	51,500
MCCB(2 pole)	28 * 1020(16 Amp)	12 * 950 (6 amp)
MCCB(4 pole)	9 * 2500 (32 Amp)	9 * 1020 (16 Am)
MCCB(4 pole)	5 * 9890 (63 Amp)	5 * 9870(40 Amp)
MCCB(3 pole)	1 * 12440 (63 Amp)	1 * 7800(40 Amp)

Here, the costing for LED is less than that of MH.

5.4 BOQ Comparison of Cable Installation :

Here, also we can observe that the cost for cable installation is lesser in the case of LED than in the case of MH.

Table 16: BOQ Comparison of Cable Installation

Cable location	MH (length*cost/m)	LED
SLDB-DB and DB-Tower(450)	450 * 170(4 sq.mm)	450 * 170(4 sq.mm)
MLDB-SLDB(150 m)	150 * 242(10 sq.mm)	150 * 170(4 sq.mm)
Control Cable(100 m)	100 * 102(1.5 sq.mm)	100 * 102(1.5 sq.mm)

Chapter 6

6 Overall conclusion and future scope

When Considering a new Technology,cost is normally the main topic of investigation.Not only should one consider the up-front cost,but also the accumulative operational cost associated with maintenance and powering a lighting system.It is important for the owner to understand that investing in LED lighting does not result in immediate saving when we replace the Metal Halide luminaire with LED,due to high initial cost.,but promotes significant savings over time.The previously installed metal halide floodlight system,used approximately 300 percent the power consumed by the newly installed LED lighting system and over an extend ,this will result in dramatic energy savings.The payback period of the system is 3 years.If we replace the whole Electrical system of metal halide with LED,the rating of different electrical equipment like Distribution Transformer,Cable,MCCB will reduce.Hence,the cost of the new system will reduce as compared to old system but the owner has to invest initially.
In brief,LED floodlights can replace conventional lamps for sports application in many cases.Newly developed LED technology provides an economical solutions featuring less power consumption and less maintenance.The barrier to mass application is mainly results from high initial cost and limited lumen output.Therefore the resulting data from the case study should increase the awareness and urge more sports establishment owner to change their lighting system.

Some improvements that can be made in this study are as follows,
(1) Integrating Human Centric lighting(HCL) with this study so that the players can receive biologically effective lights and this can also neutralize the jet lag when they are travelling from one time zone to another.

(2) In this study, we haven't considered the aspects of age of the players involved in the game. We know that, there can be many changes in human body with age. So, the players' age will play a vital role for the lighting design. This aspect can be incorporated in this study for better design.

7 References

(1) A. C. McNAMARA, CARL R. SNYDER, & JOIN T. OLIVER. (IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 1A-10), NO. 5, SEPTEMBER/OCTOBER 1974). High wattage HID Lamp Fixture Coordination Vertical Versus Horizontal Versus Somewhere in Between.

(2) Alexis Polycarpou, Ioulia Yiannou, & Nicholas Christofides. Comarison of MH and Led performance for Sport Lighting Application.

(3) Ashwathi Suresh, Shailesh K.R & Jane Preema Salis. Lighting Optimization to save energy in an Indoor Sports Facility

(4) D Nath, S Mazumdar, JK Chandra & AK Bag. A rough set-based method for aiming angle tuning of luminaires for outdoor sports lighting.

(5) Dongyan Zhang, Weiping Zhang, Yuanchao Liu, & Xuesun Zhao. High Power-High Frequency Resonant Mode Electronic Ballast for Metal Halide Lamps.

(6) HD Einhorn. (THE TRANSACTIONS OF THE SA INSTITUTE OF ELECTRlCAL ENGINEERS)GLARE IN SPORTS LIGHTING. (Page 8-12)

(7) https://www.tutorialspoint.com/what-is-a-metal-halide-lamp

(8) https://www.philipslighting.com

(9) https://www.havellslighting.com

(10) https://www.abb.com

(11) https://wwww.dlgsc.wa.gov.au/sports-and-recreation/sports-dimensions-

guide/badminton

(12) Jaime Paul Ayala, Jos´e Luis Rojo & Roberto Gutierrez. Adaptive and Predictive Control for Operating an Electronic Ballast HID-MH Lamp System without Acoustic Resonances.

(13) Jane Preema Salis, Ashwathi Suresh, & Shailesh K.R (Manipal Institute of Technology). Lighting Design Of An Indoor Sports Facility- A Case Study.

(14)Kevin William Houser, Minchen Wei, & Michael Royer. Illuminance Uniformity of Outdoor Sports Lighting.

(15) K. Houser, M. Royer, and R. Mistrick, “Light loss factors for sports lighting,” LEUKOS, vol. 6, no. 3, pp. 183–201, 2010.

(16) M. Di Pede, F. Leccese, G. Salvadori, E. Di Ciolo, &S. Piccini. On the vertical illuminance in indoor sport facilities (Innovative measurement procedure to verify international standard requirements in fencing halls).

(17) Milind Nagraj.(35th annual Number-SEEAWB). Sports Lighting-Associated System Design and Commissioning.

(18) Mr. Ashim Datta & Dr. Biswanath Roy.(35th Annual Number-SEEAWB). Sportslighting-Fundamentals & Design Concepts.

(19) Muhammad Wasif Umar, Norzaihar B Yahaya, Zuhairi B Baharuddin. PWM Dimming Control for High Brightness LED Based Automotive Lighting Applications.

(20) National Lighting Code 2010.(SP72:2010)

(21) Philips Lighting. Sports Lighting: Key Considerations for illuminating the field of play and the spectator Zones.

(22) P. S. Bhimbra, Generalized Theory of Electrical Machines, 5th ed. Khanna Publishers, 2007.

(23) R. H. Simons and A. R. Bean, Lighting Engineering Applied calcu-

lations, 1st ed. Architectural Press, 2001. (24) ROBIN C. ALDWORTH. The Development and Application of Metal Halide Lamps for Color Filming and Television.

(25) Safaa Alaa Eldeen Hamza, Dr. Amin Babiker A, & Nabi Mustafa. The use of Pulse Width Modulation “PWM” Technique in LED Lighting Systems.

(26) Shady S. Refaat, Haitham Abu-Rub, Omar Ellabban, & Mladen Kezunovic. A Novel Smart Energy Management System in Sports Stadiums.

(27) Sport England. Design Guidance Note (Artificial Sports Lighting Updated guidance for 2012).

(28) S. U. K. Basu, “Operation and maintenance of sports lighting - power distribution,” 35th Annual Number, pp. SF39–SF48

(29) Wei Han, Kwok T. Chau, Chaoqiang Jiang, Wei Liu, & W. H. Lam. High-Order Compensated Wireless Power Transfer for Dimmable Metal Halide Lamps.

(30) Xuan Hao Lee & Ching Cherng Sun. An LED-based luminaire for badminton court illumination.

8 Annexures

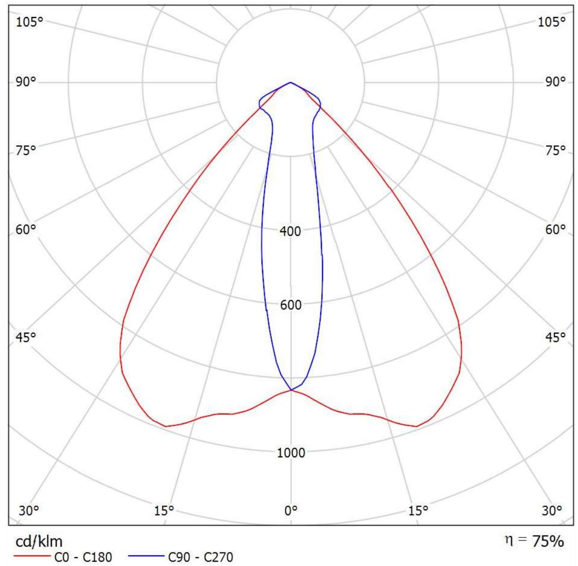
Here, the detailed design results from the DIALux software are given for each cases of MH and LED. In the first part for each case, non-televised design results are given and in the last part, the televised design are shown. As, here we have achievedthe required parameter for televised case through non-televised class-I design, so, the other designs have not been shown here. So, only the summary and isolines are shown here. These are as follows,

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



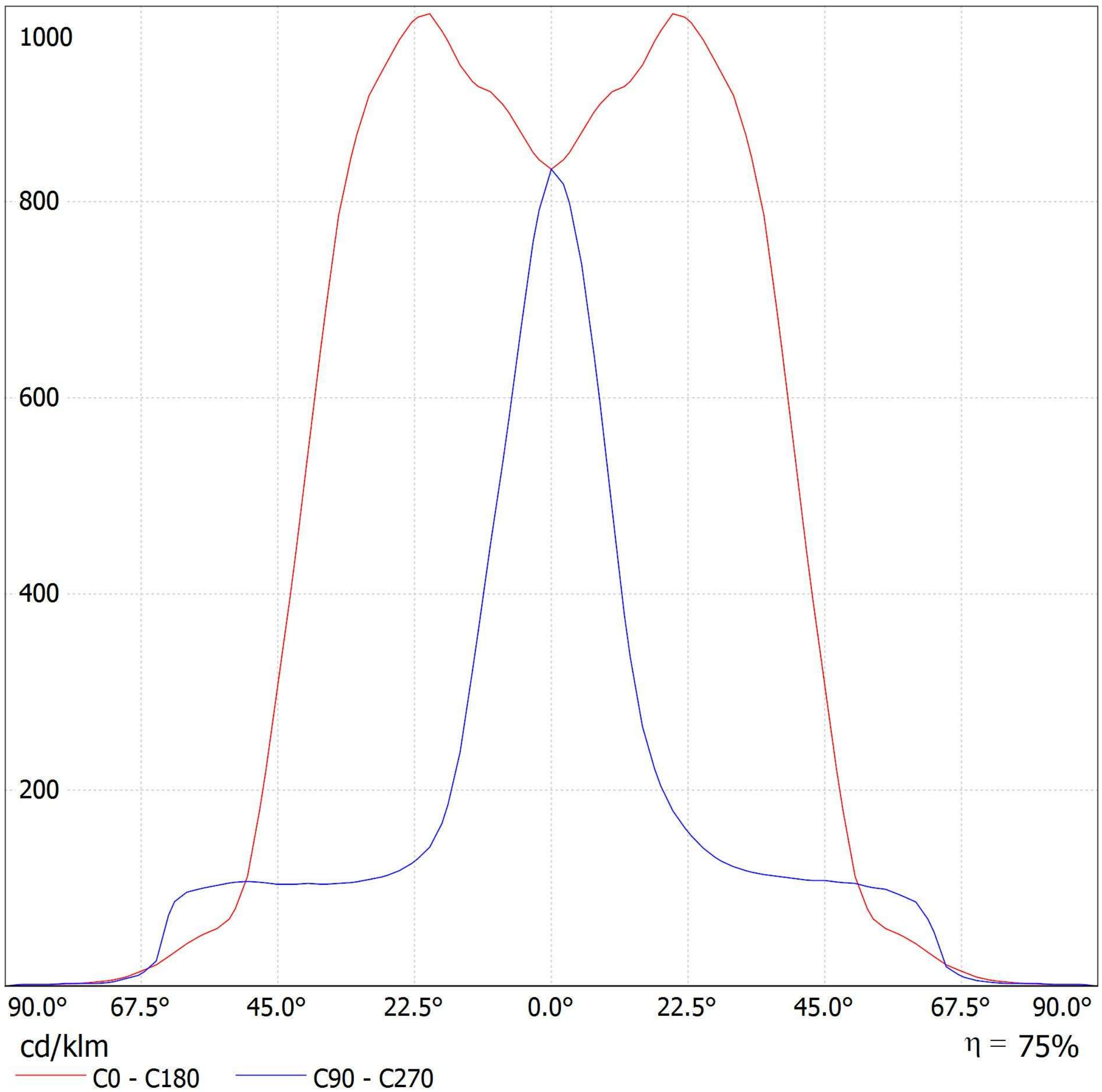
Luminaire classification according to CIE: 100
CIE flux code: 69 92 99 100 75

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

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED / LDC (Linear)

Luminaire: PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED
Lamps: 1 x HPI T 400W

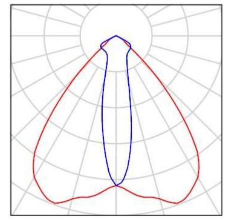


Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Luminaire parts list

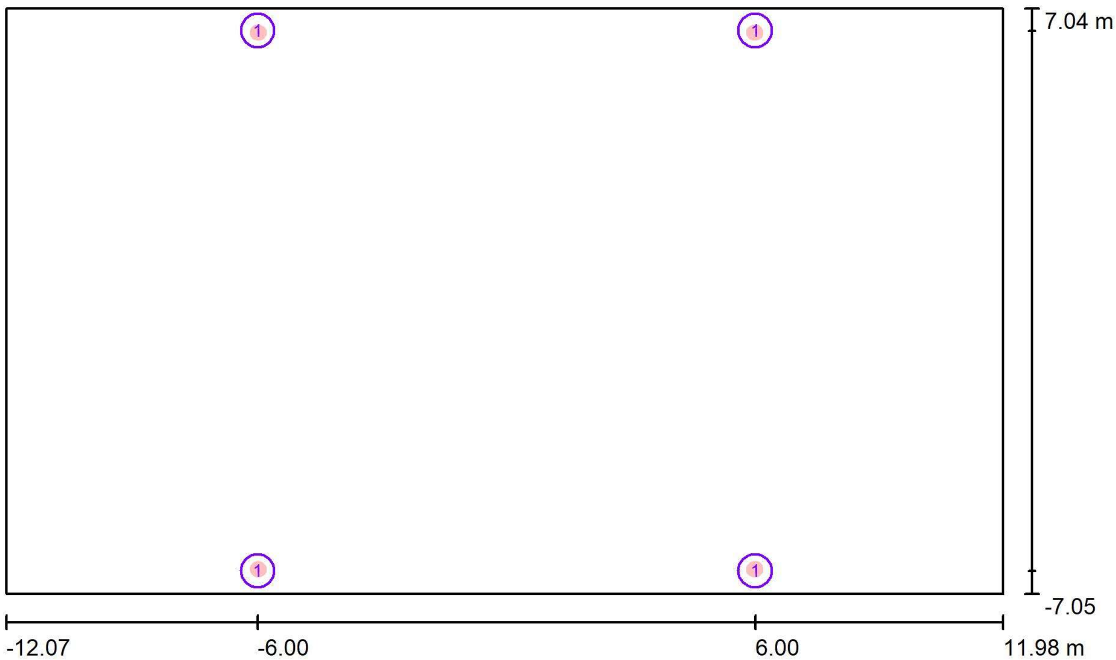
28 Pieces PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED
Article No.:
Luminous flux (Luminaire): 22807 lm
Luminous flux (Lamps): 30500 lm
Luminaire Wattage: 433.0 W
Luminaire classification according to CIE: 100
CIE flux code: 69 92 99 100 75
Fitting: 1 x HPI T 400W (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Luminaires (layout plan)



Scale 1 : 172

Luminaire Parts List

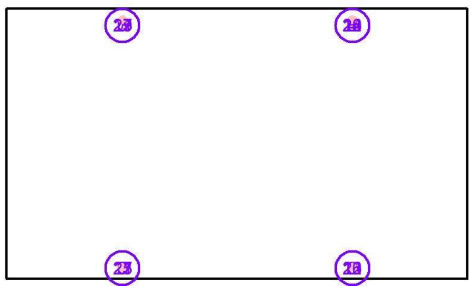
No.	Pieces	Designation
1	28	PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Luminaires (coordinates list)

PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED

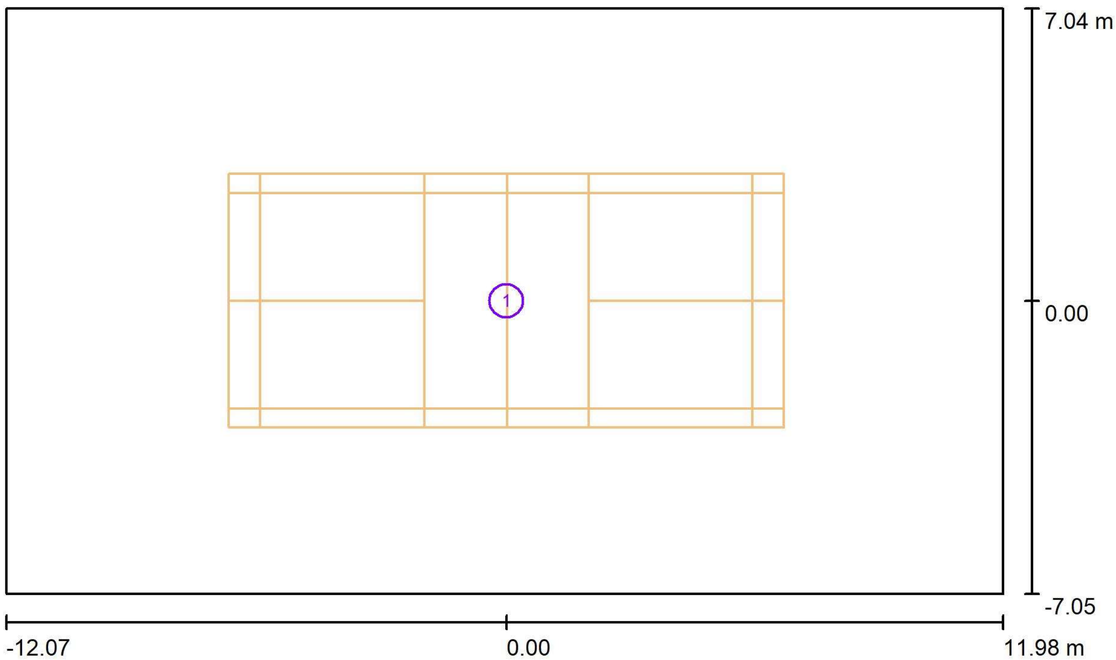
22807 lm, 433.0 W, 1 x 1 x HPI T 400W (Correction Factor 1.000).



No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
1	-6.000	-6.500	12.000	0.0	-30.0	30.0
2	6.000	-6.500	12.000	0.0	-30.0	150.0
3	-6.000	6.500	12.000	0.0	-30.0	-30.0
4	6.000	6.500	12.000	0.0	-30.0	-150.0
5	-6.000	-6.500	12.000	0.0	-35.0	55.0
6	6.000	-6.500	12.000	0.0	-35.0	125.0
7	-6.000	6.500	12.000	0.0	-35.0	-55.0
8	6.000	6.500	12.000	0.0	-35.0	-125.0
9	-6.000	-6.500	12.000	0.0	-30.0	65.0
10	6.000	-6.500	12.000	0.0	-30.0	115.0
11	-6.000	6.500	12.000	0.0	-30.0	-65.0
12	6.000	6.500	12.000	0.0	-30.0	-115.0
13	-6.000	-6.500	12.000	0.0	-35.0	90.0
14	6.000	-6.500	12.000	0.0	-35.0	90.0
15	-6.000	6.500	12.000	0.0	-35.0	-90.0
16	6.000	6.500	12.000	0.0	-35.0	-90.0
17	-6.000	-6.500	12.000	0.0	-30.0	110.0
18	6.000	-6.500	12.000	0.0	-30.0	70.0
19	-6.000	6.500	12.000	0.0	-30.0	-110.0
20	6.000	6.500	12.000	0.0	-30.0	-70.0
21	-6.000	-6.500	12.000	0.0	-20.0	130.0
22	6.000	-6.500	12.000	0.0	-20.0	50.0
23	-6.000	6.500	12.000	0.0	-20.0	-130.0
24	6.000	6.500	12.000	0.0	-20.0	-50.0
25	-6.000	-6.500	12.000	0.0	-15.0	145.0
26	6.000	-6.500	12.000	0.0	-15.0	35.0
27	-6.000	6.500	12.000	0.0	-15.0	-145.0
28	6.000	6.500	12.000	0.0	-15.0	-35.0

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Sport Sites (layout plan)



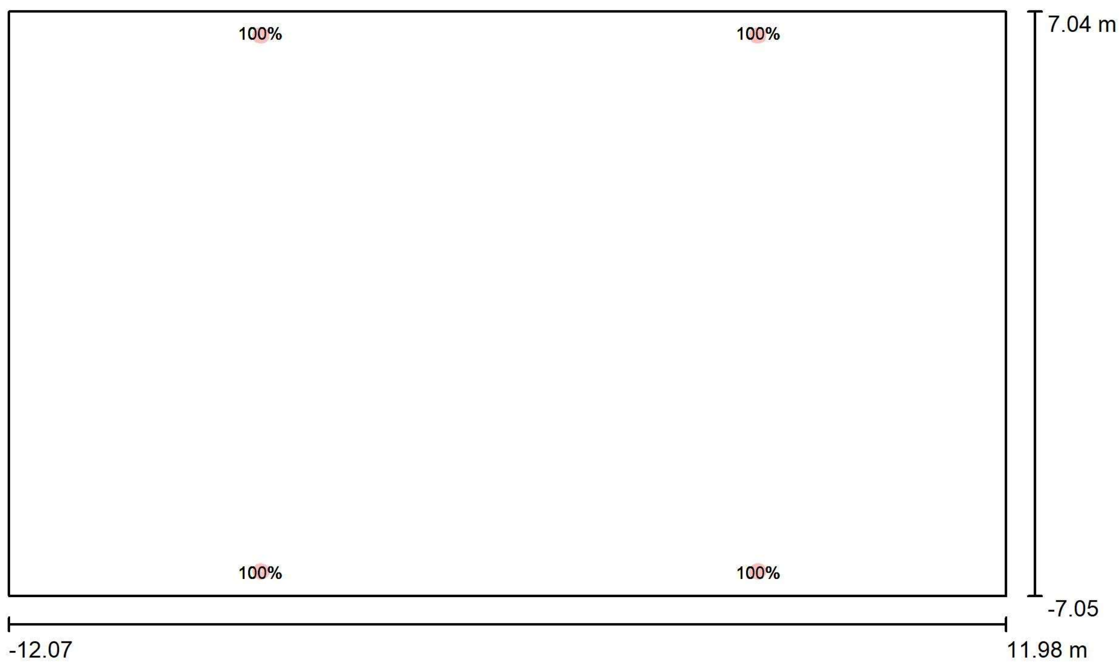
Scale 1 : 172

Sport Site Parts List

No.	Pieces	Designation
1	1	Badminton

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Planning data

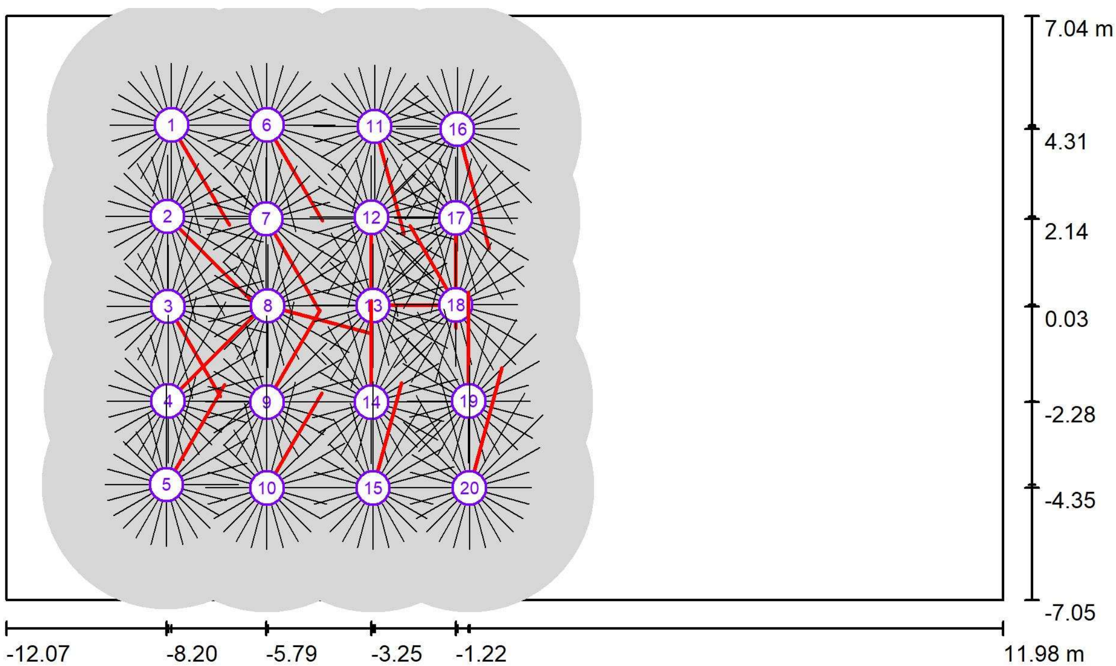


Scale 1 : 172

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	Control group 1 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
2	Control group 2 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
3	Control group 3 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
4	Control group 4 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
5	Control group 5 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
6	Control group 6 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
7	Control group 7 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
	All other luminaires	0

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / GR Observer (Results Overview)



Scale 1 : 172

GR Observerlist

No.	Designation	Position [m] X	Y	Z	Viewing sector [°] Start	End	Increment	Slope angle	Max
1	GR Observer 1	-8.080	4.406	1.500	0.0	360.0	15.0	-2.0	19 [2)]
2	GR Observer 2	-8.177	2.198	1.500	0.0	360.0	15.0	-2.0	19 [2)]
3	GR Observer 3	-8.158	0.029	1.500	0.0	360.0	15.0	-2.0	17 [2)]
4	GR Observer 4	-8.158	-2.257	1.500	0.0	360.0	15.0	-2.0	19 [2)]

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / GR Observer (Results Overview)

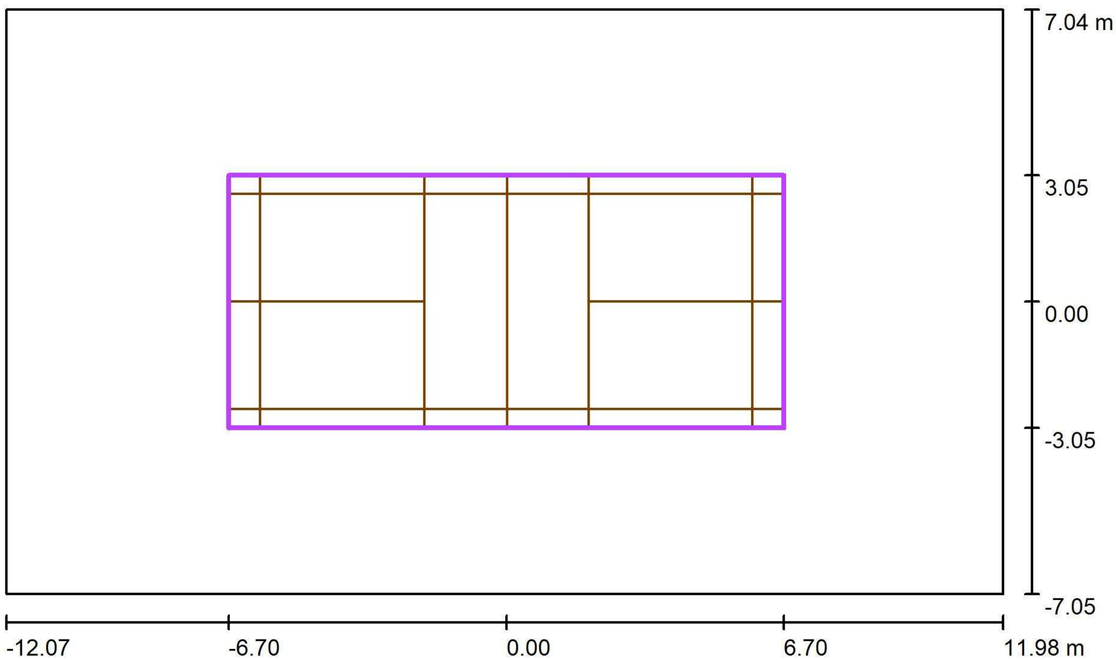
GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
5	GR Observer 5	-8.197	-4.269	1.500	0.0	360.0	15.0	-2.0	19 [2)]
6	GR Observer 6	-5.774	4.406	1.500	0.0	360.0	15.0	-2.0	18 [2)]
7	GR Observer 7	-5.794	2.140	1.500	0.0	360.0	15.0	-2.0	17 [2)]
8	GR Observer 8	-5.759	0.044	1.500	0.0	360.0	15.0	-2.0	17 [2)]
9	GR Observer 9	-5.774	-2.276	1.500	0.0	360.0	15.0	-2.0	17 [2)]
10	GR Observer 10	-5.774	-4.348	1.500	0.0	360.0	15.0	-2.0	18 [2)]
11	GR Observer 11	-3.175	4.367	1.500	0.0	360.0	15.0	-2.0	18 [2)]
12	GR Observer 12	-3.253	2.179	1.500	0.0	360.0	15.0	-2.0	17 [2)]
13	GR Observer 13	-3.214	0.049	1.500	0.0	360.0	15.0	-2.0	15 [2)]
14	GR Observer 14	-3.253	-2.276	1.500	0.0	360.0	15.0	-2.0	16 [2)]
15	GR Observer 15	-3.214	-4.348	1.500	0.0	360.0	15.0	-2.0	18 [2)]
16	GR Observer 16	-1.182	4.309	1.500	0.0	360.0	15.0	-2.0	20 [2)]
17	GR Observer 17	-1.221	2.159	1.500	0.0	360.0	15.0	-2.0	18 [2)]
18	GR Observer 18	-1.221	0.068	1.500	0.0	360.0	15.0	-2.0	15 [2)]
19	GR Observer 19	-0.909	-2.257	1.500	0.0	360.0	15.0	-2.0	18 [2)]
20	GR Observer 20	-0.889	-4.348	1.500	0.0	360.0	15.0	-2.0	20 [2)]

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 14 x 7 Points
Belongs to the following sport arena: Badminton 1

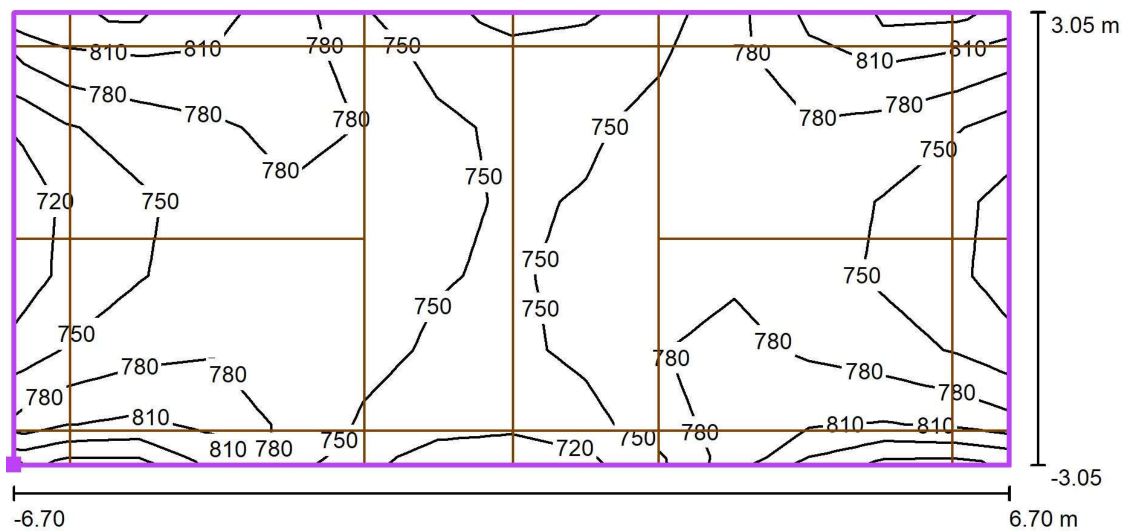
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	769	708	856	0.92	0.83	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

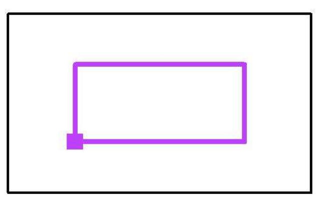
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

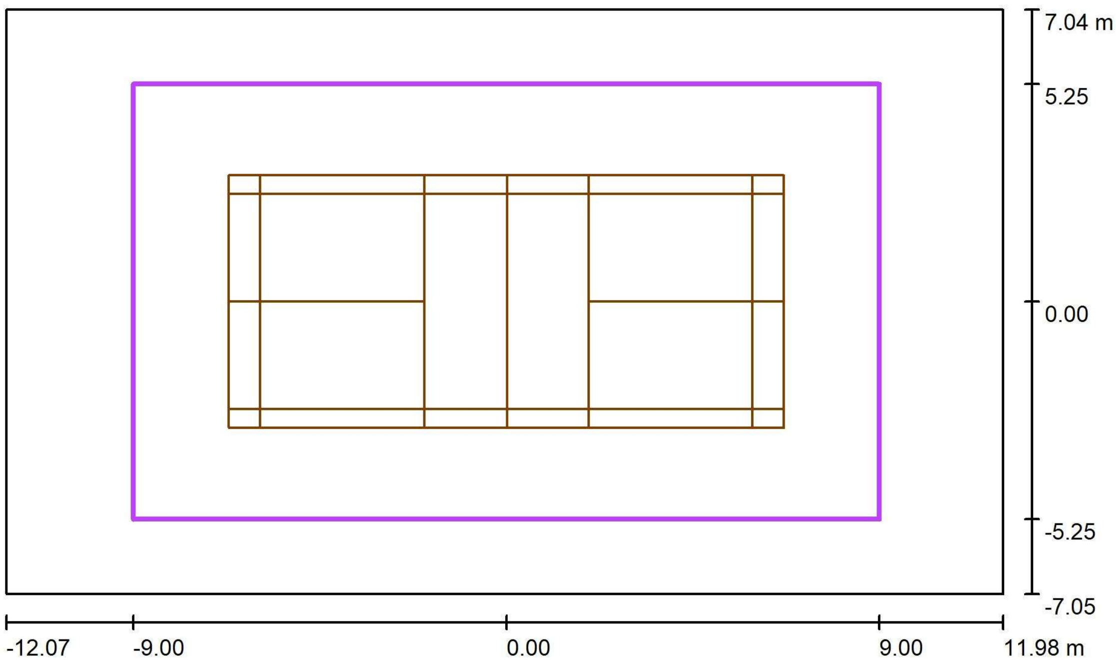


Grid: 14 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
769	708	856	0.92	0.83

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 10 x 6 Points
Belongs to the following sport arena: Badminton 1

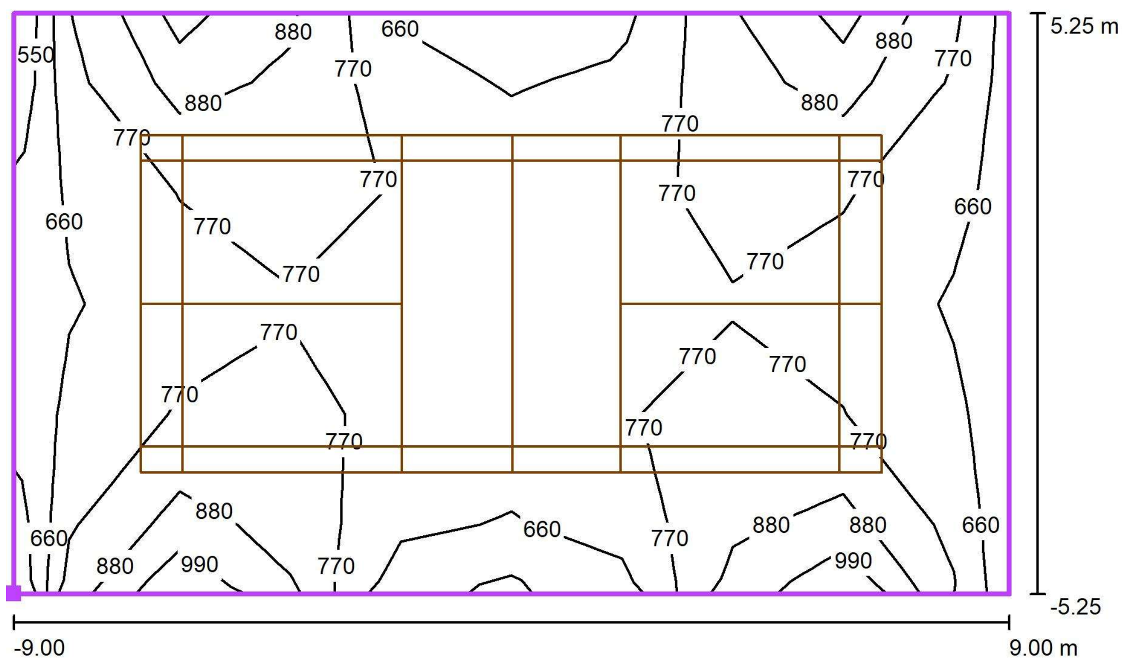
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	751	549	1060	0.73	0.52	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

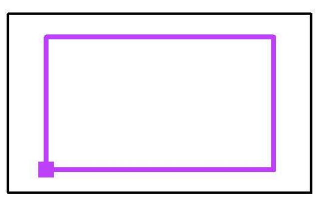
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

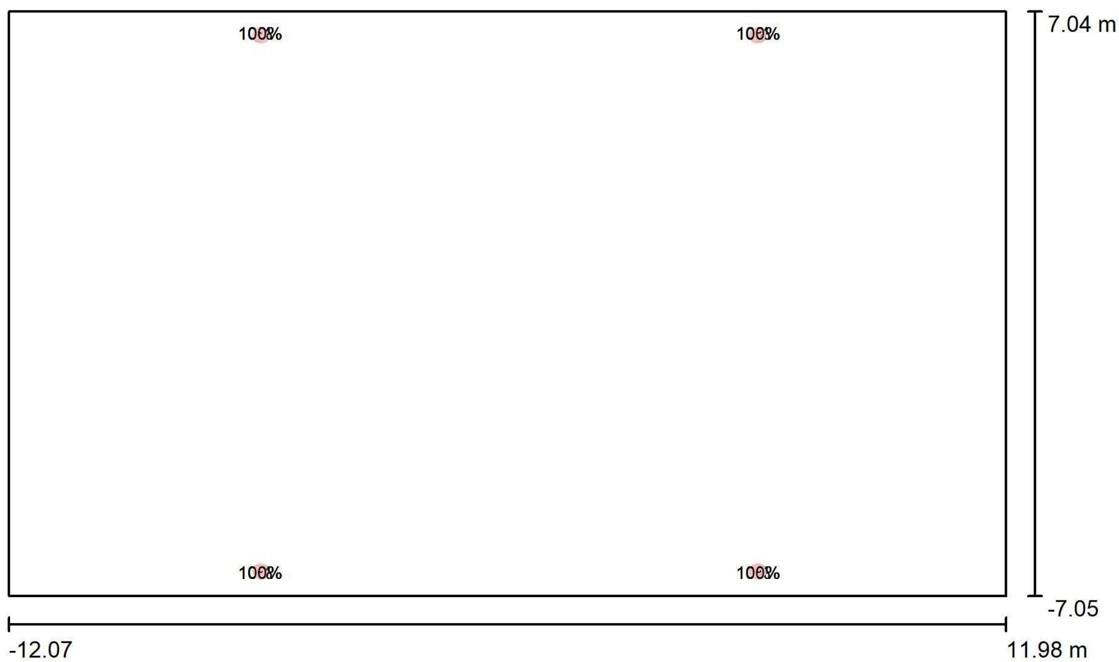


Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
751	549	1060	0.73	0.52

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / Planning data

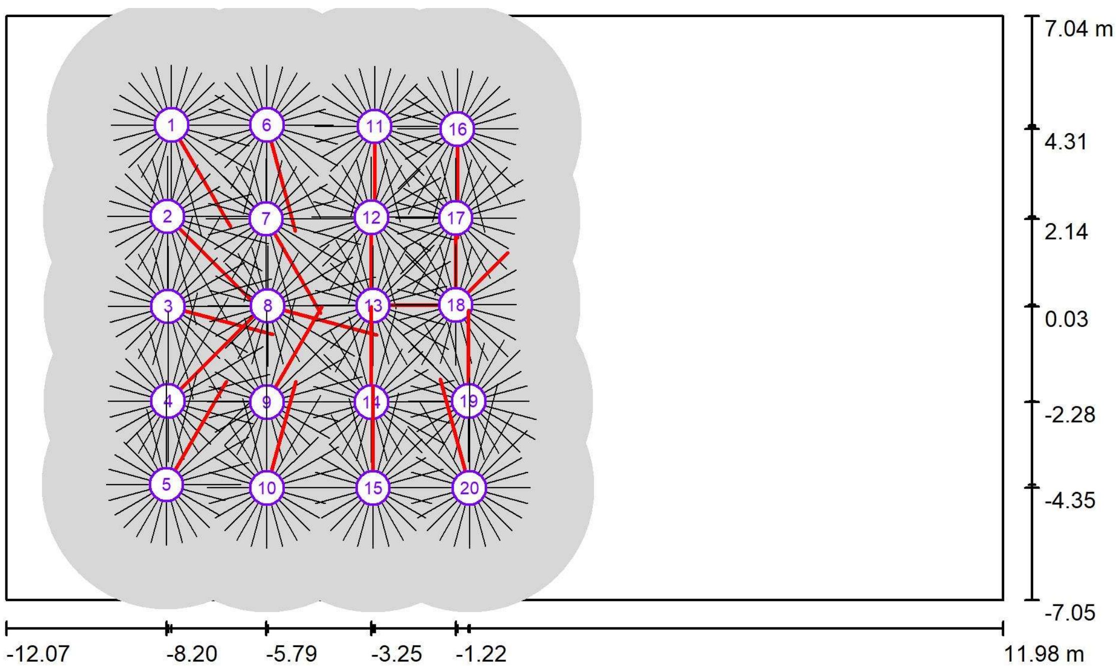


Scale 1 : 172

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	Control group 1 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
2	Control group 2 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
3	Control group 3 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
4	Control group 4 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
5	Control group 5 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
6	Control group 6 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
7	Control group 7 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
	All other luminaires	0

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / GR Observer (Results Overview)



Scale 1 : 172

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-8.080	4.406	1.500	0.0	360.0	15.0	-2.0	20 [2)]
2	GR Observer 2	-8.177	2.198	1.500	0.0	360.0	15.0	-2.0	21 [2)]
3	GR Observer 3	-8.158	0.029	1.500	0.0	360.0	15.0	-2.0	18 [2)]
4	GR Observer 4	-8.158	-2.257	1.500	0.0	360.0	15.0	-2.0	21 [2)]

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / GR Observer (Results Overview)

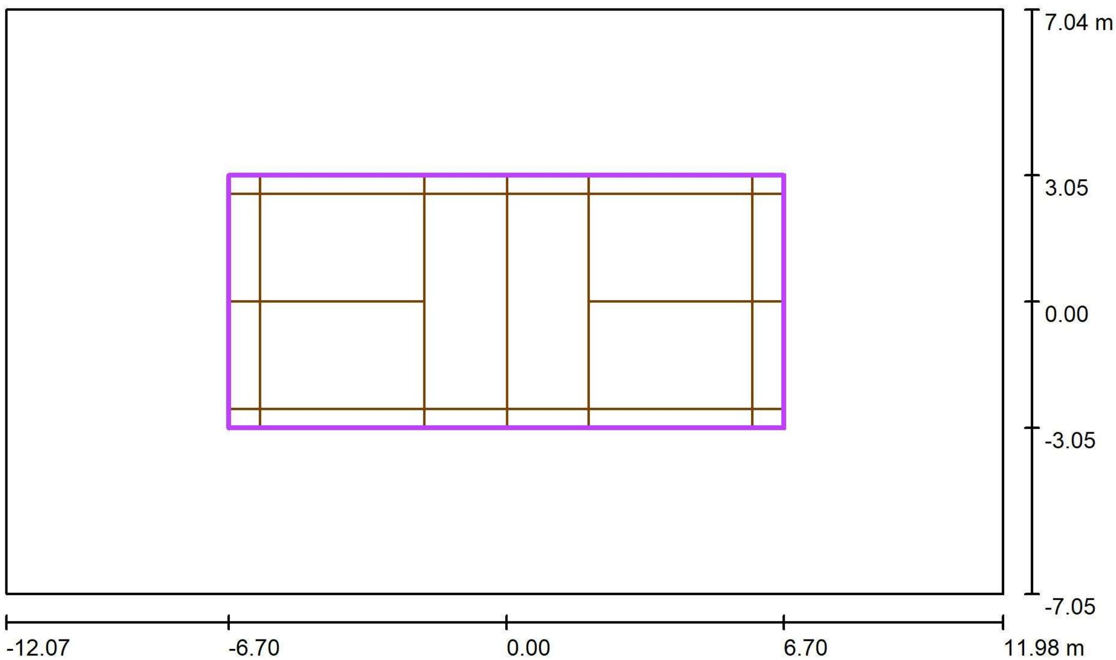
GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
5	GR Observer 5	-8.197	-4.269	1.500	0.0	360.0	15.0	-2.0	20 2)
6	GR Observer 6	-5.774	4.406	1.500	0.0	360.0	15.0	-2.0	18 2)
7	GR Observer 7	-5.794	2.140	1.500	0.0	360.0	15.0	-2.0	18 2)
8	GR Observer 8	-5.759	0.044	1.500	0.0	360.0	15.0	-2.0	19 2)
9	GR Observer 9	-5.774	-2.276	1.500	0.0	360.0	15.0	-2.0	18 2)
10	GR Observer 10	-5.774	-4.348	1.500	0.0	360.0	15.0	-2.0	18 2)
11	GR Observer 11	-3.175	4.367	1.500	0.0	360.0	15.0	-2.0	17 2)
12	GR Observer 12	-3.253	2.179	1.500	0.0	360.0	15.0	-2.0	16 2)
13	GR Observer 13	-3.214	0.049	1.500	0.0	360.0	15.0	-2.0	16 2)
14	GR Observer 14	-3.253	-2.276	1.500	0.0	360.0	15.0	-2.0	16 2)
15	GR Observer 15	-3.214	-4.348	1.500	0.0	360.0	15.0	-2.0	17 2)
16	GR Observer 16	-1.182	4.309	1.500	0.0	360.0	15.0	-2.0	18 2)
17	GR Observer 17	-1.221	2.159	1.500	0.0	360.0	15.0	-2.0	15 2)
18	GR Observer 18	-1.221	0.068	1.500	0.0	360.0	15.0	-2.0	12 2)
19	GR Observer 19	-0.909	-2.257	1.500	0.0	360.0	15.0	-2.0	15 2)
20	GR Observer 20	-0.889	-4.348	1.500	0.0	360.0	15.0	-2.0	19 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 14 x 7 Points
Belongs to the following sport arena: Badminton 1

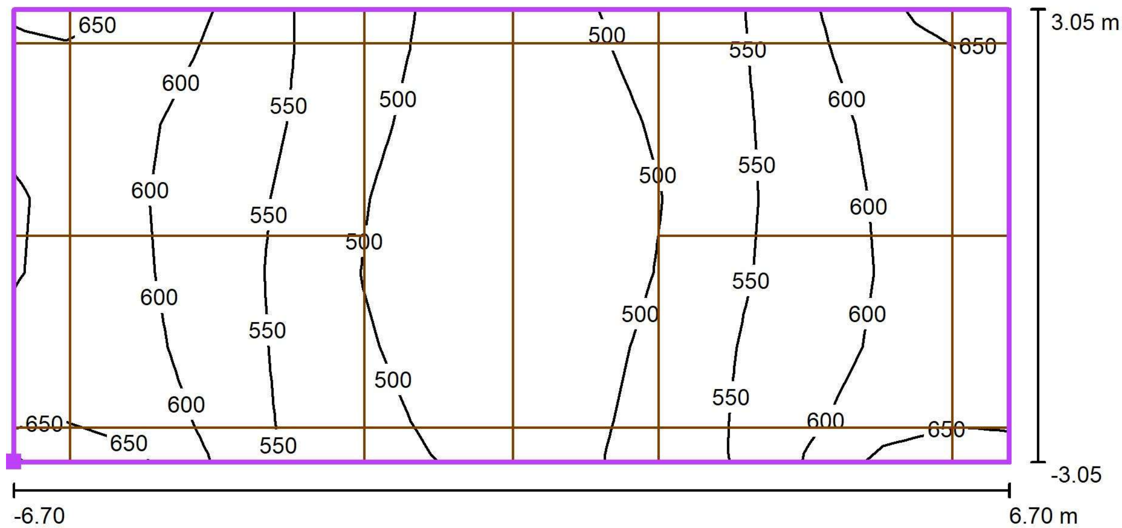
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	560	458	671	0.82	0.68	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

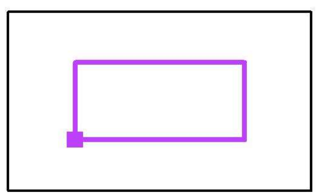
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

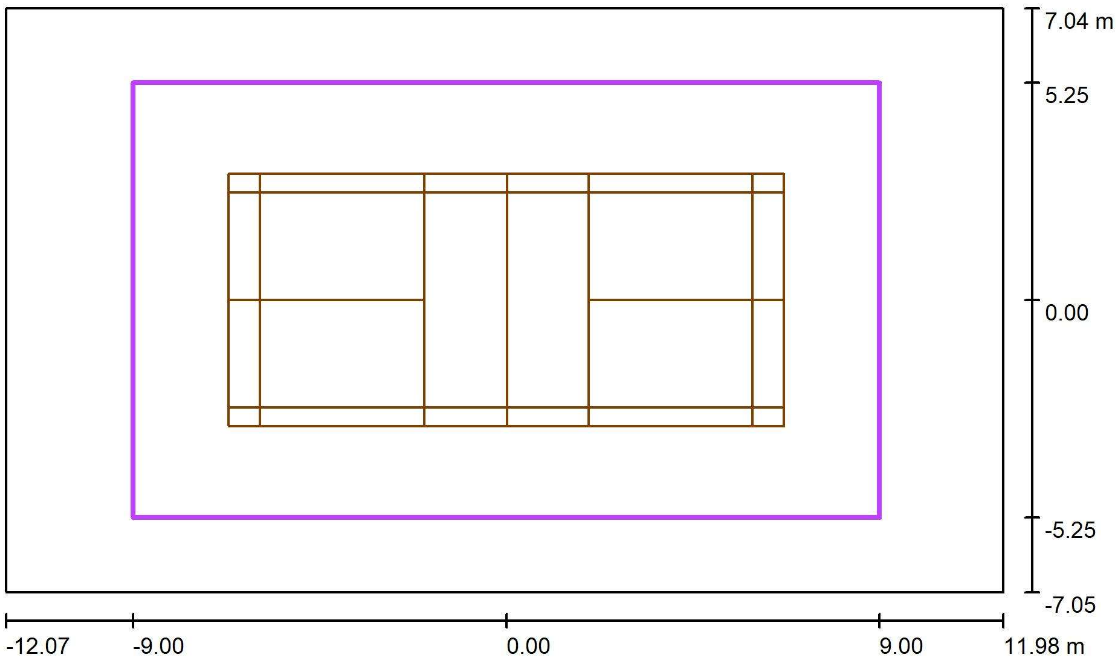


Grid: 14 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
560	458	671	0.82	0.68

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 10 x 6 Points
Belongs to the following sport arena: Badminton 1

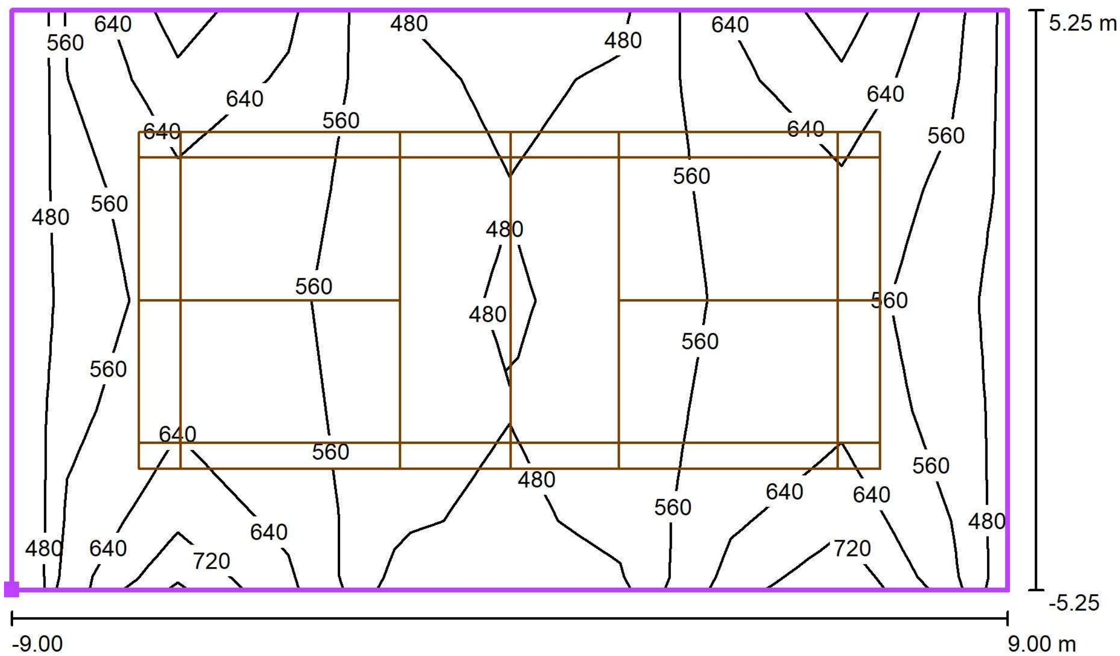
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	555	414	780	0.75	0.53	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

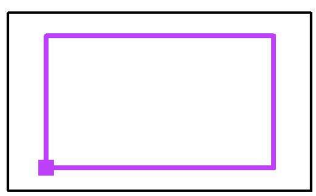
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

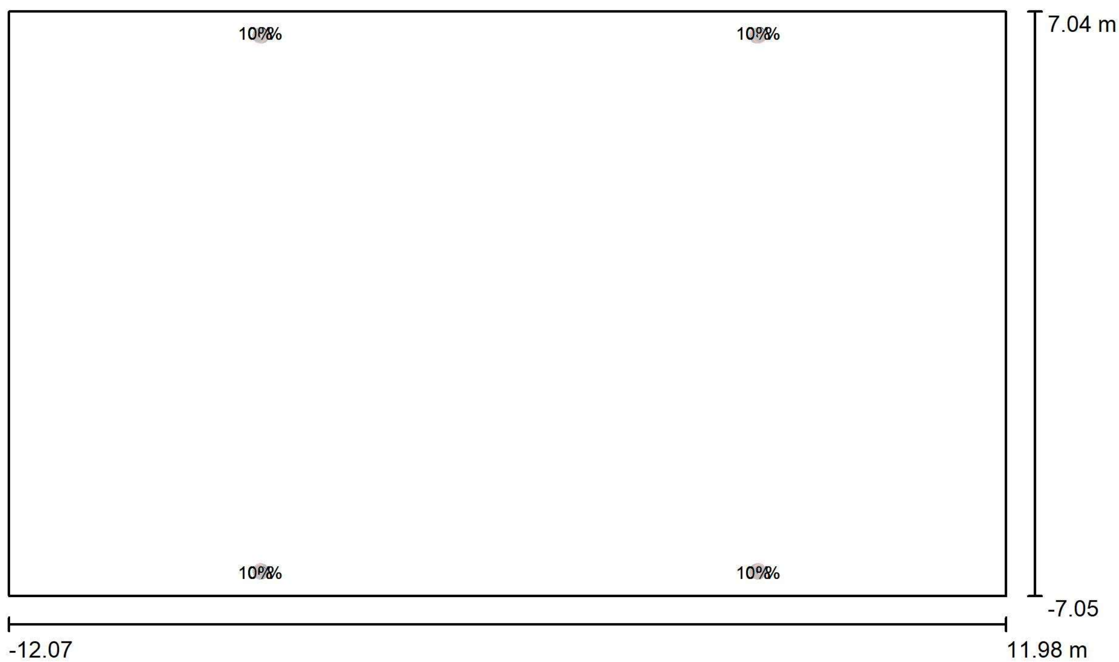


Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
555	414	780	0.75	0.53

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / Planning data

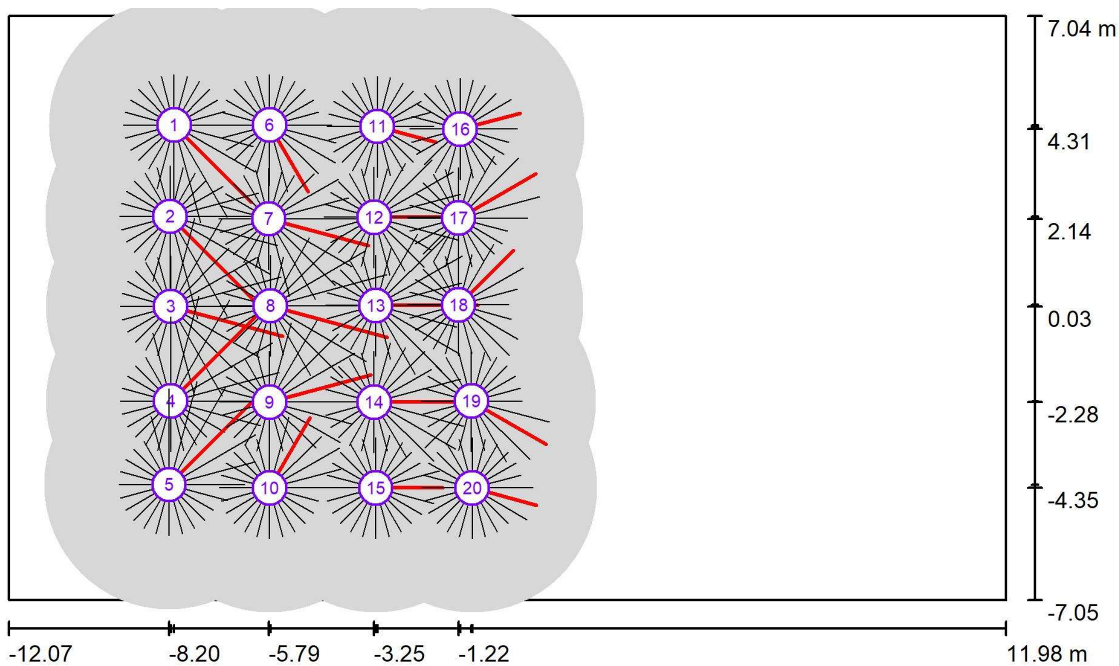


Scale 1 : 172

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	Control group 1 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
2	Control group 2 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
3	Control group 3 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
4	Control group 4 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
5	Control group 5 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	100
6	Control group 6 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
7	Control group 7 (PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED)	0
	All other luminaires	0

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / GR Observer (Results Overview)



Scale 1 : 172

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-8.080	4.406	1.500	0.0	360.0	15.0	-2.0	22 [2)]
2	GR Observer 2	-8.177	2.198	1.500	0.0	360.0	15.0	-2.0	24 [2)]
3	GR Observer 3	-8.158	0.029	1.500	0.0	360.0	15.0	-2.0	23 [2)]
4	GR Observer 4	-8.158	-2.257	1.500	0.0	360.0	15.0	-2.0	25 [2)]

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / GR Observer (Results Overview)

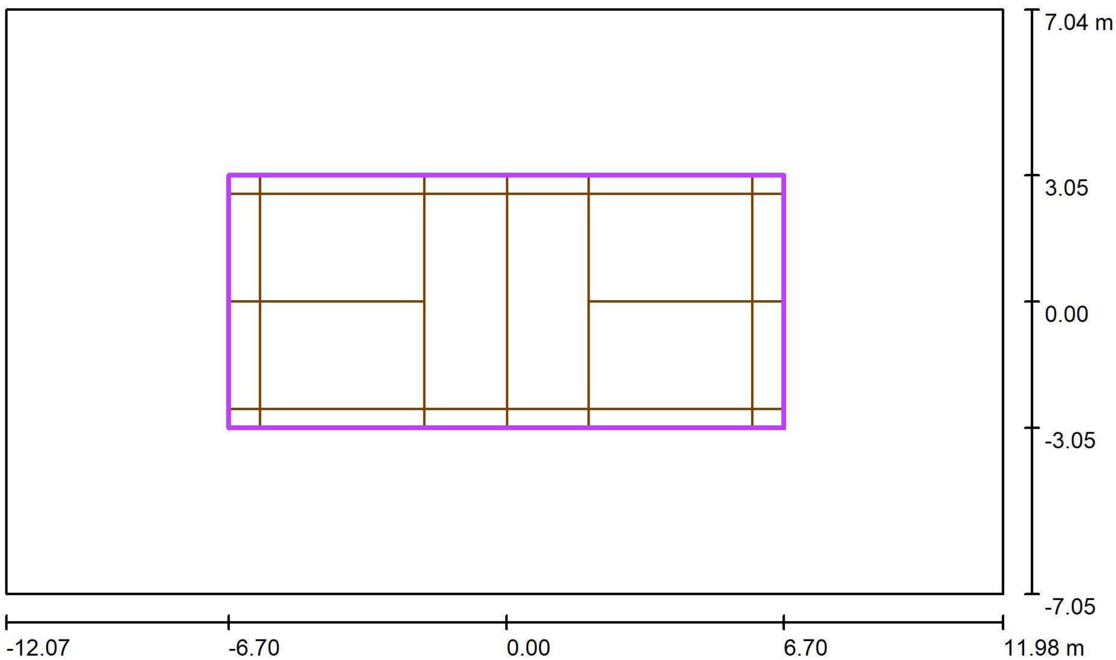
GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
5	GR Observer 5	-8.197	-4.269	1.500	0.0	360.0	15.0	-2.0	23 2)
6	GR Observer 6	-5.774	4.406	1.500	0.0	360.0	15.0	-2.0	15 2)
7	GR Observer 7	-5.794	2.140	1.500	0.0	360.0	15.0	-2.0	20 2)
8	GR Observer 8	-5.759	0.044	1.500	0.0	360.0	15.0	-2.0	24 2)
9	GR Observer 9	-5.774	-2.276	1.500	0.0	360.0	15.0	-2.0	21 2)
10	GR Observer 10	-5.774	-4.348	1.500	0.0	360.0	15.0	-2.0	16 2)
11	GR Observer 11	-3.175	4.367	1.500	0.0	360.0	15.0	-2.0	12 2)
12	GR Observer 12	-3.253	2.179	1.500	0.0	360.0	15.0	-2.0	18 2)
13	GR Observer 13	-3.214	0.049	1.500	0.0	360.0	15.0	-2.0	20 2)
14	GR Observer 14	-3.253	-2.276	1.500	0.0	360.0	15.0	-2.0	19 2)
15	GR Observer 15	-3.214	-4.348	1.500	0.0	360.0	15.0	-2.0	13 2)
16	GR Observer 16	-1.182	4.309	1.500	0.0	360.0	15.0	-2.0	12 2)
17	GR Observer 17	-1.221	2.159	1.500	0.0	360.0	15.0	-2.0	18 2)
18	GR Observer 18	-1.221	0.068	1.500	0.0	360.0	15.0	-2.0	15 2)
19	GR Observer 19	-0.909	-2.257	1.500	0.0	360.0	15.0	-2.0	17 2)
20	GR Observer 20	-0.889	-4.348	1.500	0.0	360.0	15.0	-2.0	13 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 14 x 7 Points
Belongs to the following sport arena: Badminton 1

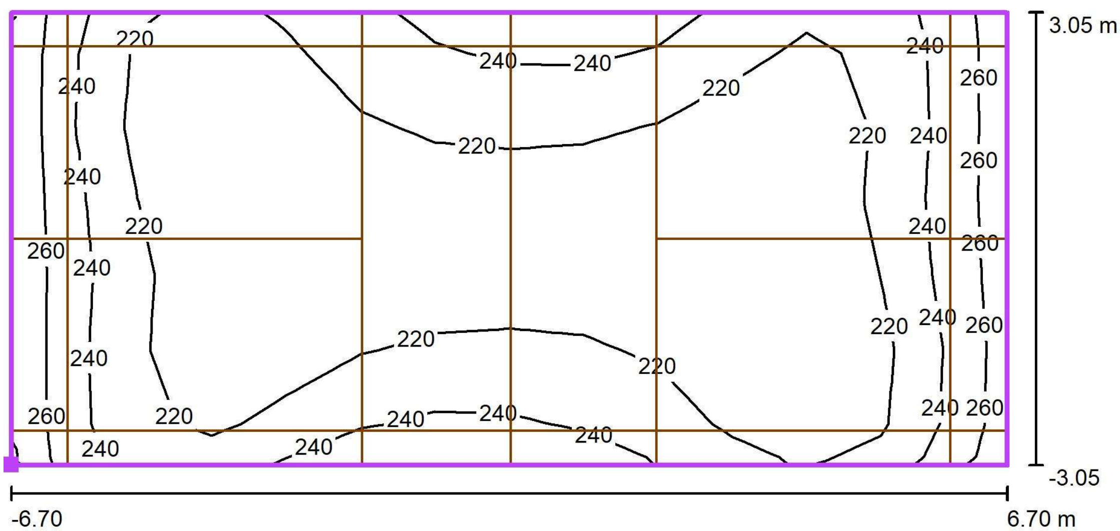
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\ m}/E_m$	H [m]	Camera
1	horizontal	227	200	267	0.88	0.75	/	0.000	/

$E_{h\ m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

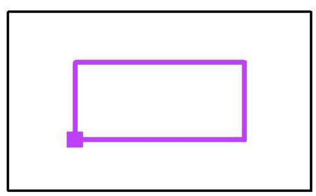
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

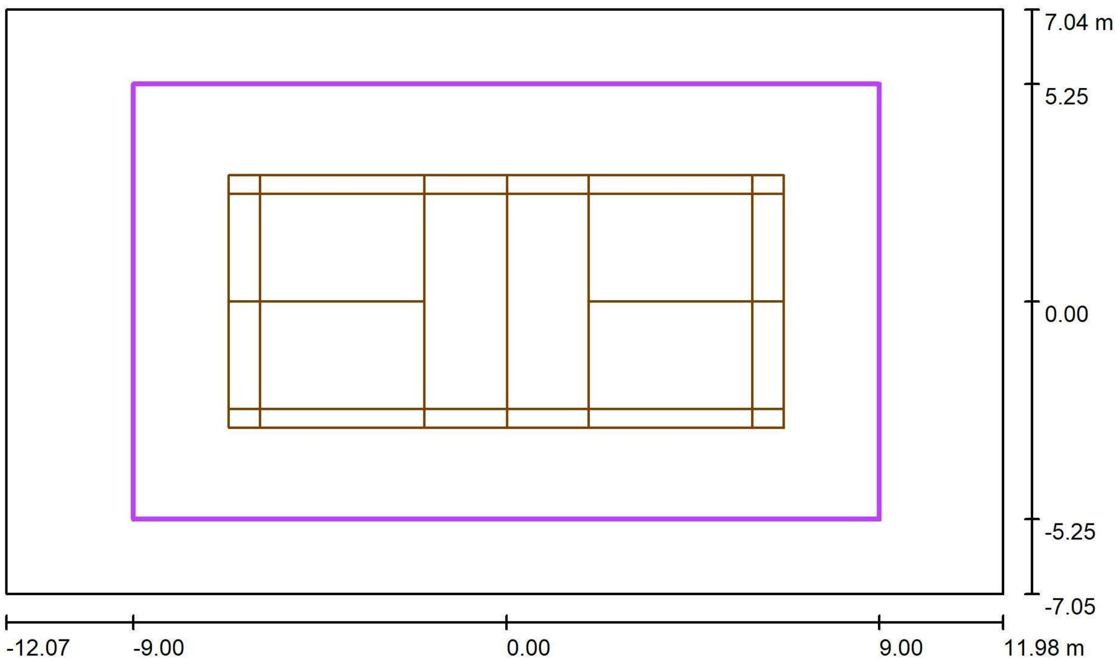


Grid: 14 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
227	200	267	0.88	0.75

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 10 x 6 Points
Belongs to the following sport arena: Badminton 1

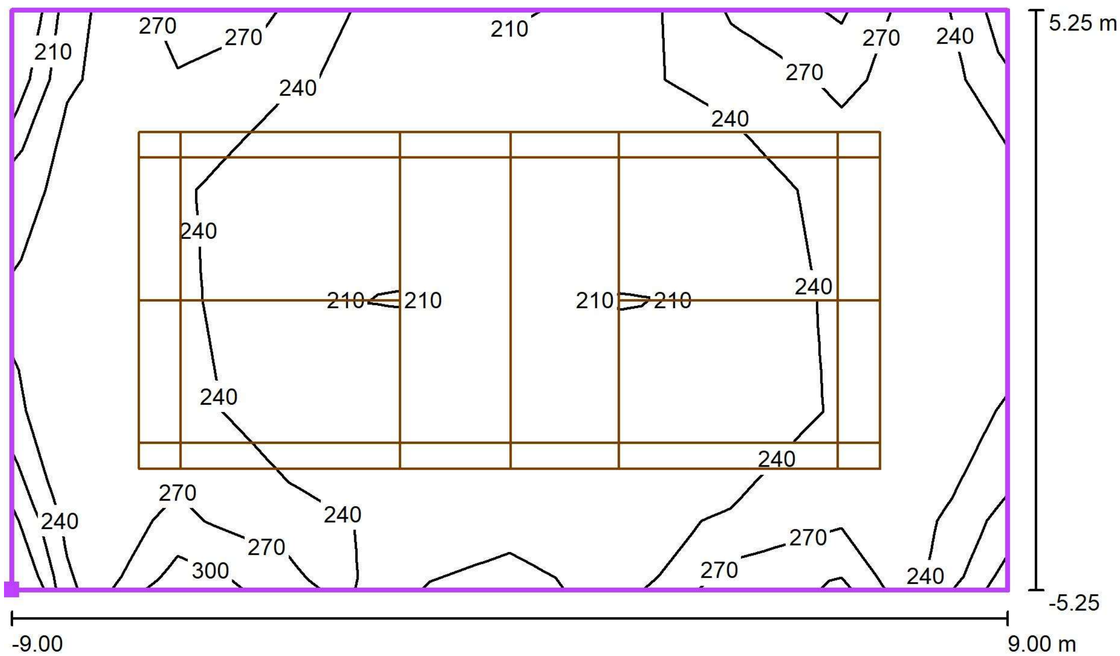
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	239	169	300	0.71	0.56	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

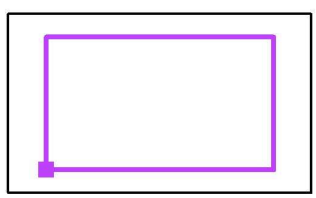
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

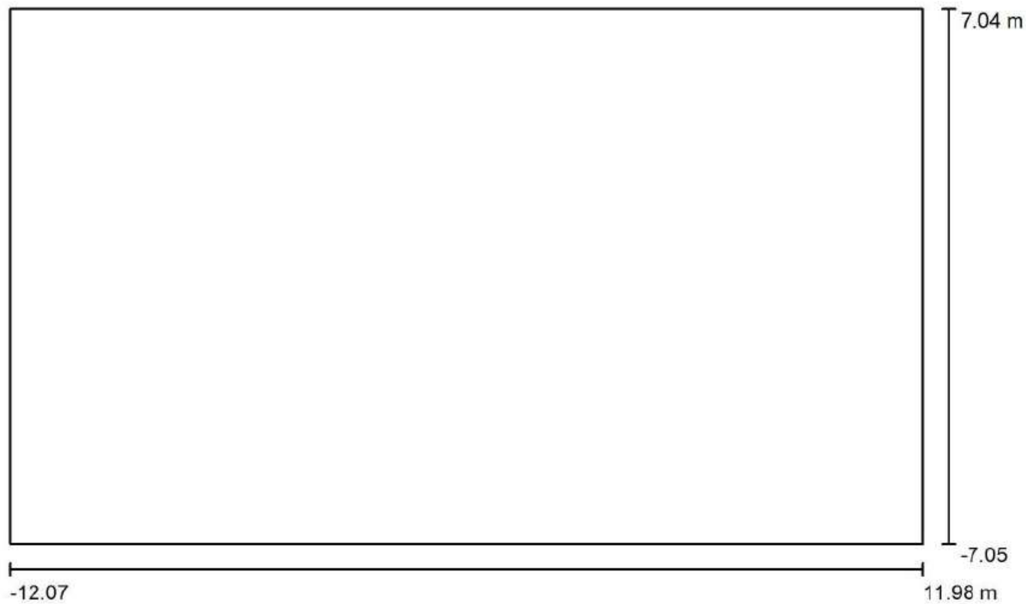


Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
239	169	300	0.71	0.56

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Planning data



Light loss factor: 0.70 ULR (Upward Light Ratio): 1.0%

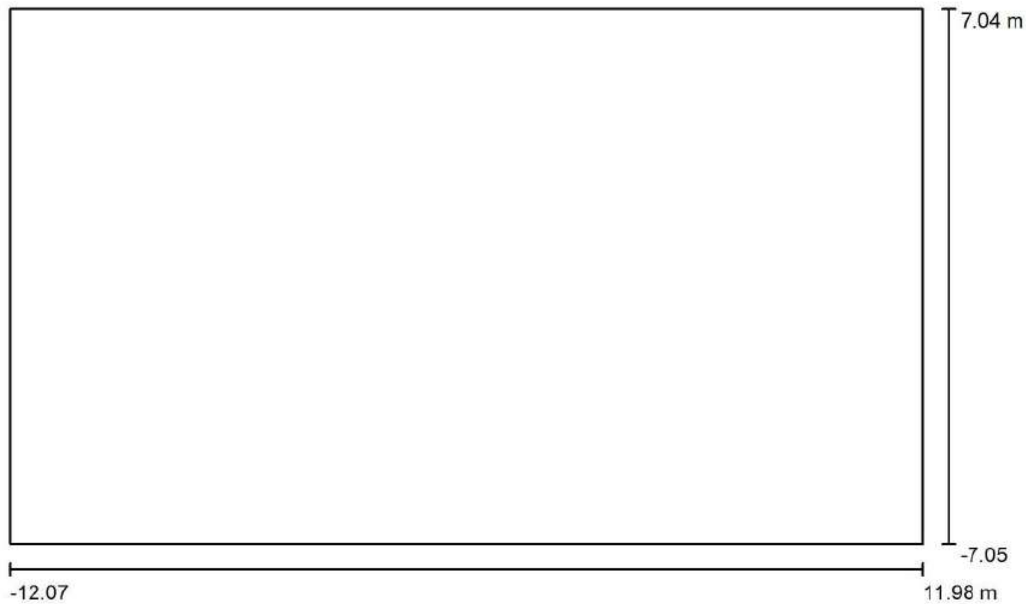
Scale 1:172

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	28	PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED (1.000)	22807	30500	433.0
			Total: 638597	Total: 854000	12124.0

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class II / Planning data



Light loss factor: 0.70 , ULR (Upward Light Ratio): 1.5%

Scale 1:172

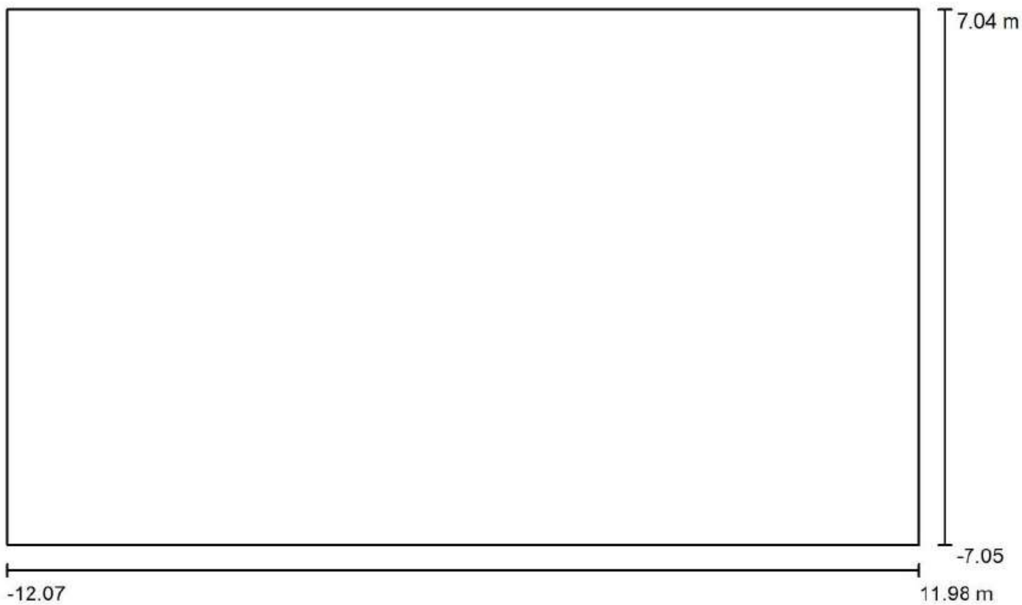
Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	20	PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED (1.000)	22807	30500	433.0
			Total: 456140	Total: 610000	8660.0

11.08.2022

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class III / Planning data



Light loss factor: 0.70 , ULR (Upward Light Ratio): 1.5%

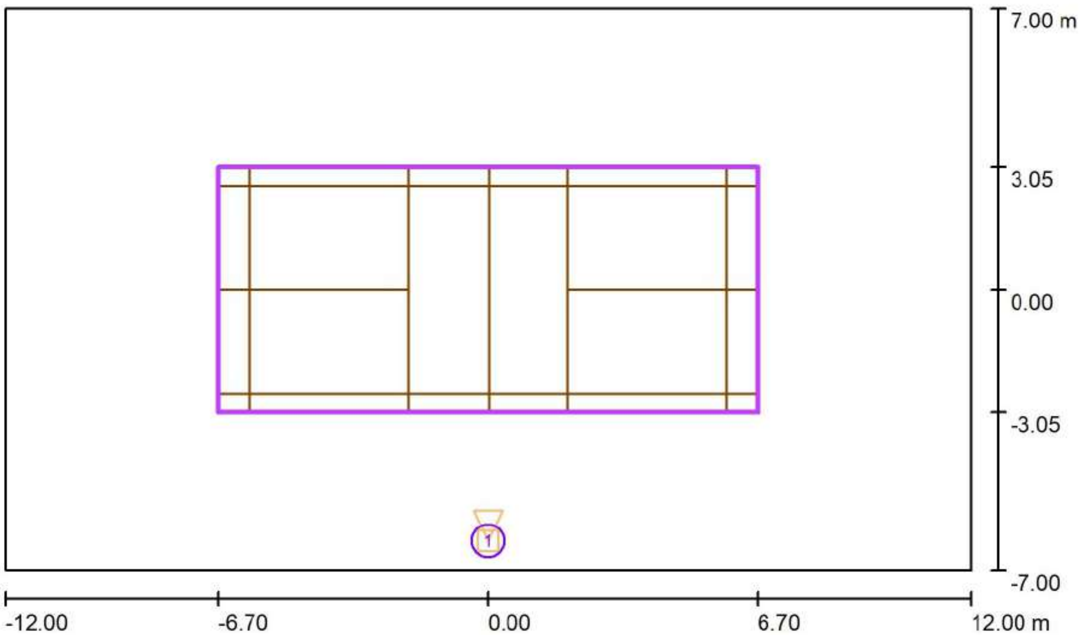
Scale 1:172

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	8	PHILIPS MWF 330/ 400W, [SYMMETRIC], CLOSED (1.000)	22807	30500	433.0
			Total: 182456	Total: 244000	3464.0

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 14 x 7 Points
Belongs to the following sport arena: Badminton 1

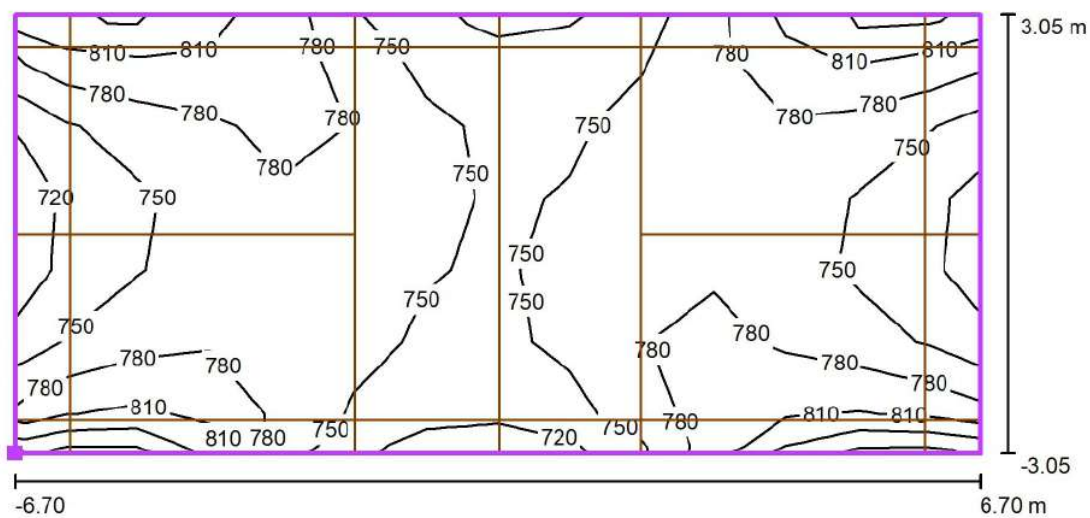
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	769	708	856	0.92	0.83	/	0.000	/
2	Camera	575	491	713	0.85	0.69	1.34	1.000	1

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

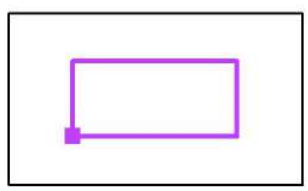
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

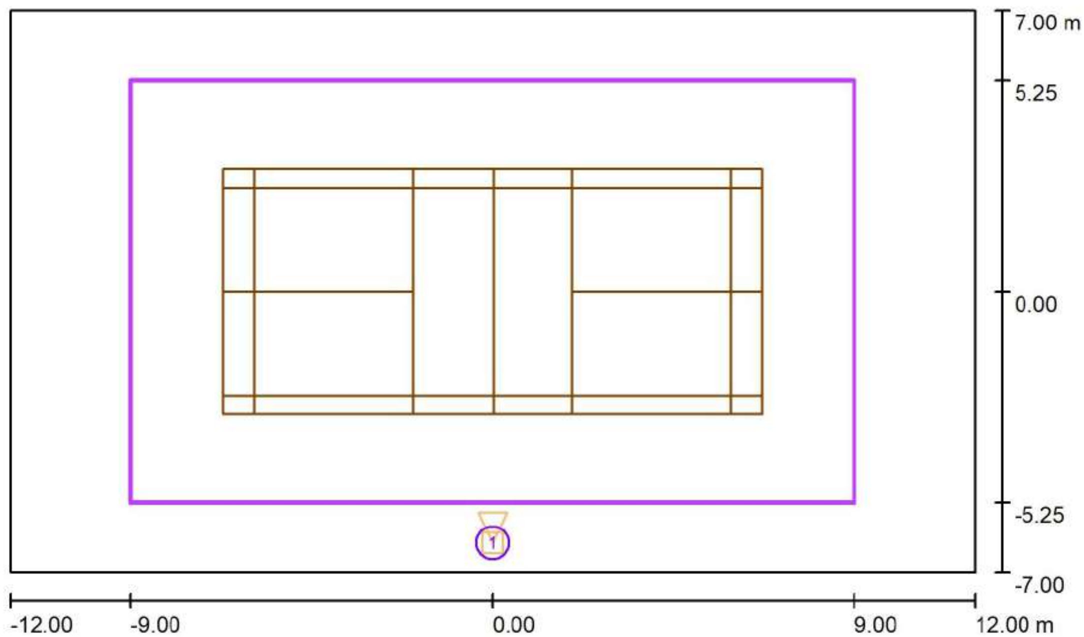


Grid: 14 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
769	708	856	0.92	0.83

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 10 x 6 Points
Belongs to the following sport arena: Badminton 1

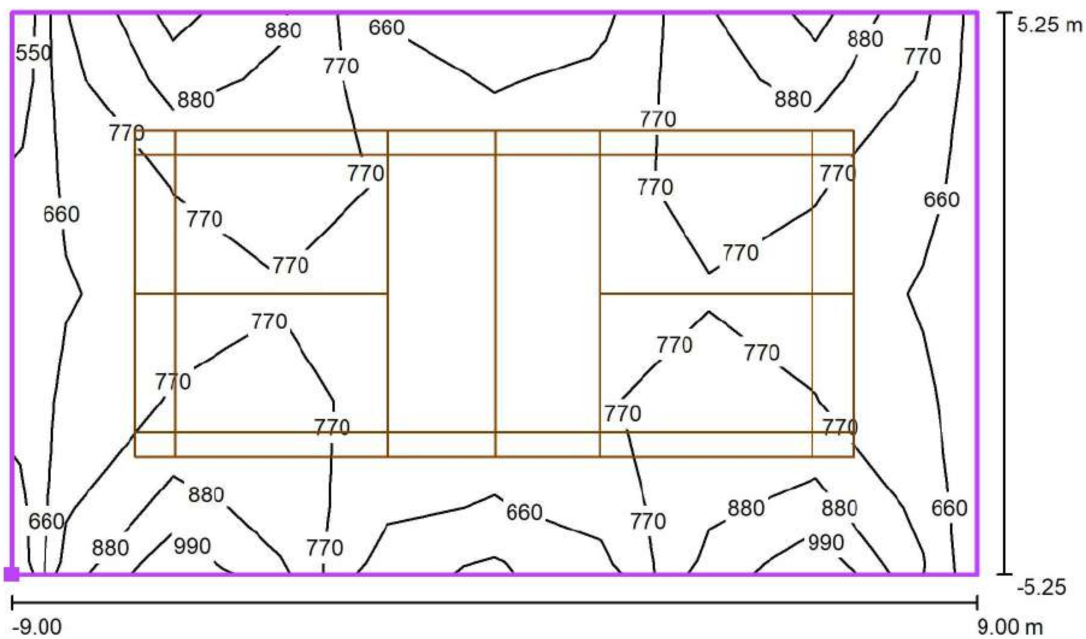
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	751	549	1060	0.73	0.52	/	0.000	/
2	Camera	587	469	903	0.80	0.52	1.28	1.000	1

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

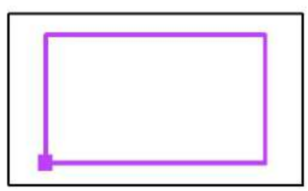
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

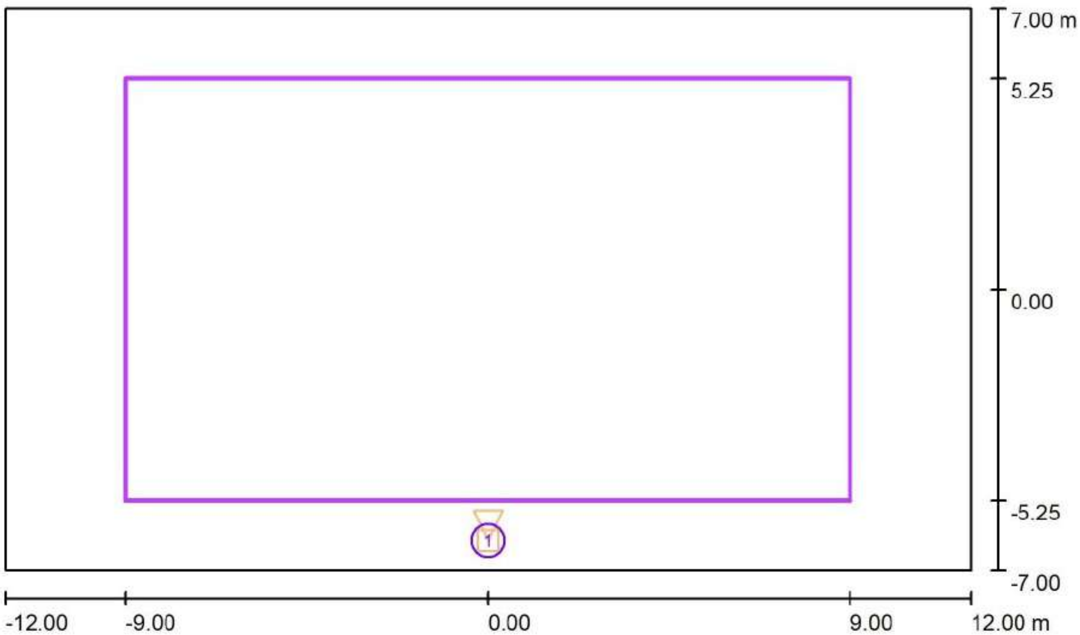


Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
751	549	1060	0.73	0.52

Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Calculation Grid Ecam / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (10.500 m, 18.000 m)
Rotation: (0.0°, 0.0°, 90.0°)
Type: Normal, Grid: 11 x 19 Points

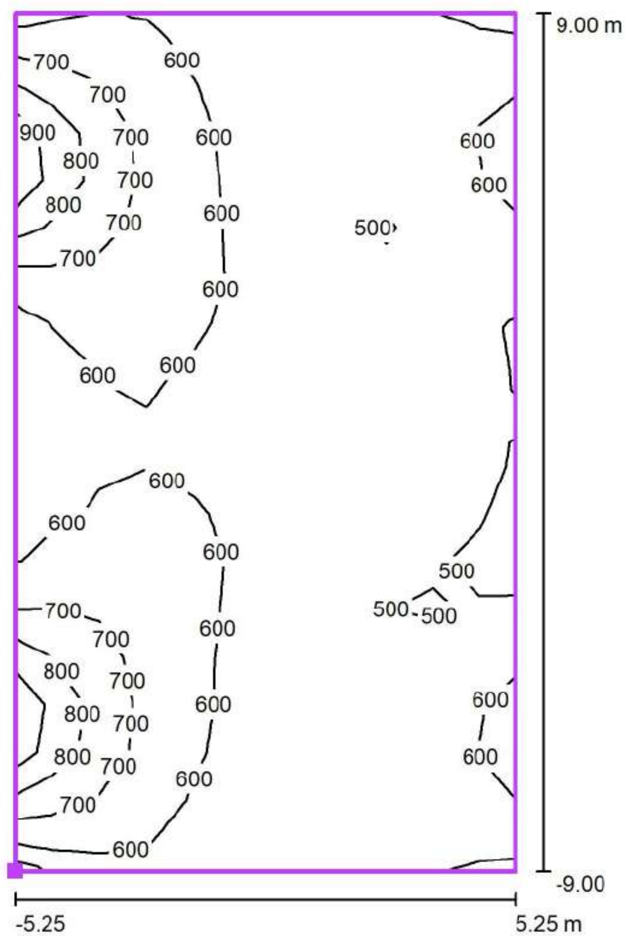
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	Camera	588	469	966	0.80	0.50	/	1.000	1

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

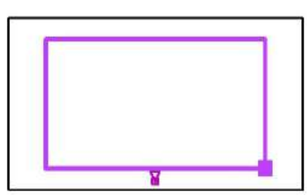
Operator 9433631025
Telephone
Fax
e-Mail ah1832@ee.jgec.ac.in

Badminton Court Floodlighting / Light scene Class I / Calculation Grid Ecam / Isolines (E, Camera)



Values in Lux, Scale 1 : 145

Position of surface in external scene:
Marked point: (9.000 m, -5.250 m, 0.000 m)
Camera Position: (0.000 m, -6.250 m, 6.000 m)



Grid: 11 x 19 Points

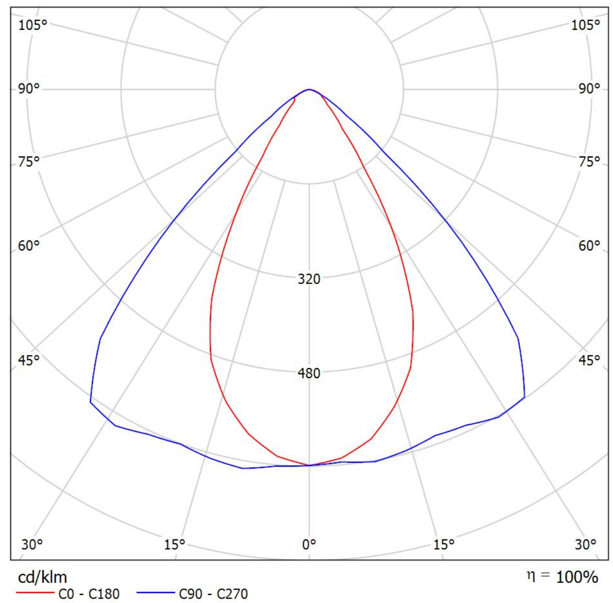
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
588	469	966	0.80	0.49

Operator
Telephone
Fax
e-Mail

INTEGRATED POWER FL FLA400BL5KN05 / Luminaire Data Sheet

See our luminaire catalog for an image of the luminaire.

Luminous emittance 1:



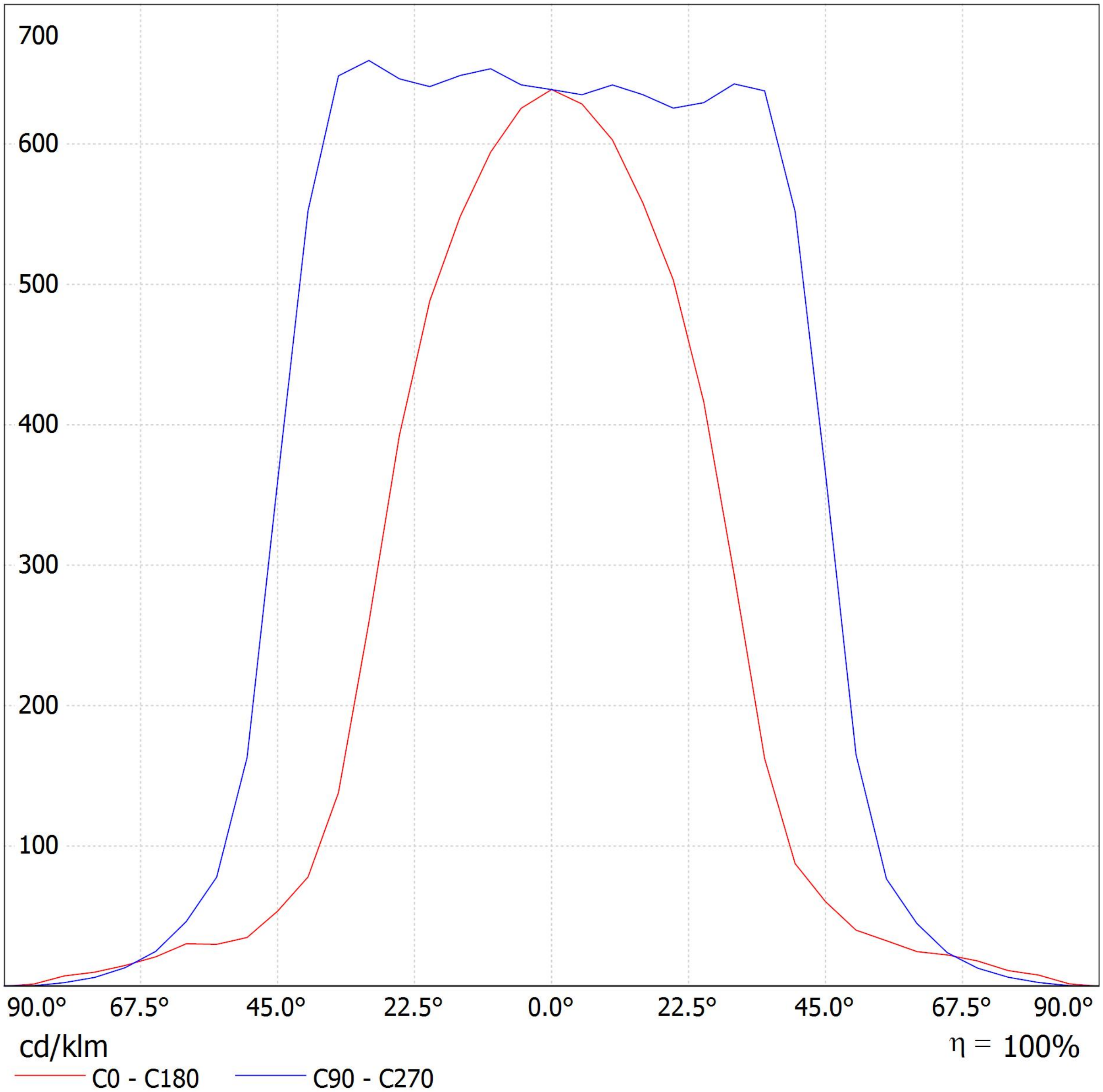
Luminaire classification according to CIE: 100
CIE flux code: 76 97 100 100 100

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

Operator
Telephone
Fax
e-Mail

INTEGRATED POWER FL FLA400BL5KN05 / LDC (Linear)

Luminaire: INTEGRATED POWER FL FLA400BL5KN05
Lamps: 1 x



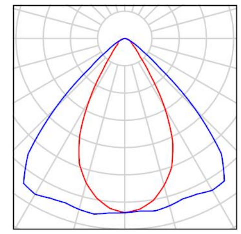
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Luminaire parts list

12 Pieces

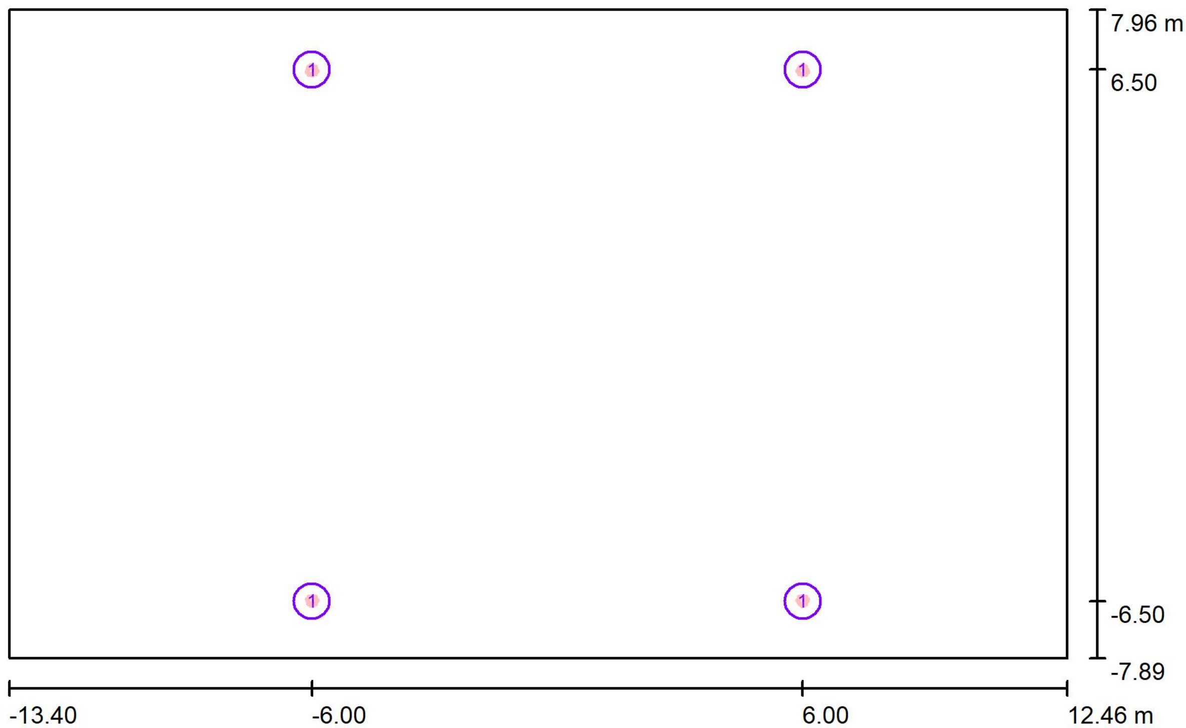
INTEGRATED POWER FL FLA400BL5KN05
Article No.: FL
Luminous flux (Luminaire): 55007 lm
Luminous flux (Lamps): 54969 lm
Luminaire Wattage: 440.0 W
Luminaire classification according to CIE: 100
CIE flux code: 76 97 100 100 100
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Luminaires (layout plan)



Scale 1 : 185

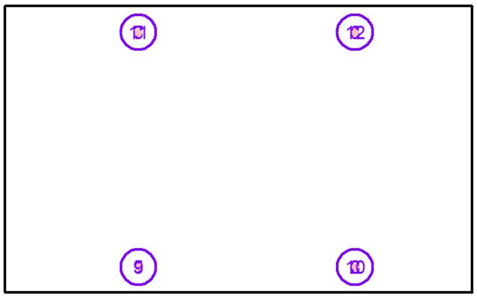
Luminaire Parts List

No.	Pieces	Designation
1	12	INTEGRATED POWER FL FLA400BL5KN05

Exterior Scene 1 / Luminaires (coordinates list)

INTEGRATED POWER FL FLA400BL5KN05

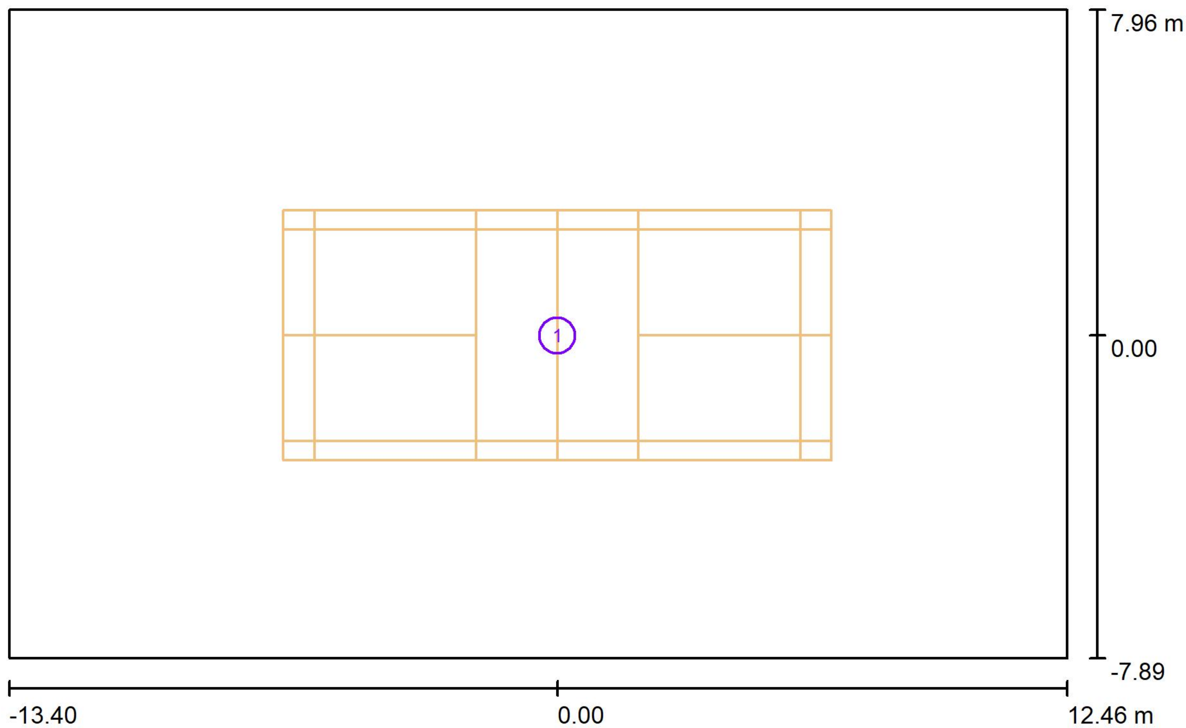
55007 lm, 440.0 W, 1 x 1 x User defined (Correction Factor 1.000).



No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
1	-6.000	-6.500	12.000	0.0	-25.0	120.0
2	6.000	-6.500	12.000	0.0	-25.0	60.0
3	-6.000	6.500	12.000	0.0	-25.0	-120.0
4	6.000	6.500	12.000	0.0	-25.0	-60.0
5	-6.000	-6.500	12.000	0.0	-30.0	85.0
6	6.000	-6.500	12.000	0.0	-30.0	95.0
7	-6.000	6.500	12.000	0.0	-30.0	-85.0
8	6.000	6.500	12.000	0.0	-30.0	-95.0
9	-6.000	-6.500	12.000	0.0	-25.0	50.0
10	6.000	-6.500	12.000	0.0	-25.0	130.0
11	-6.000	6.500	12.000	0.0	-25.0	-50.0
12	6.000	6.500	12.000	0.0	-25.0	-130.0

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Sport Sites (layout plan)



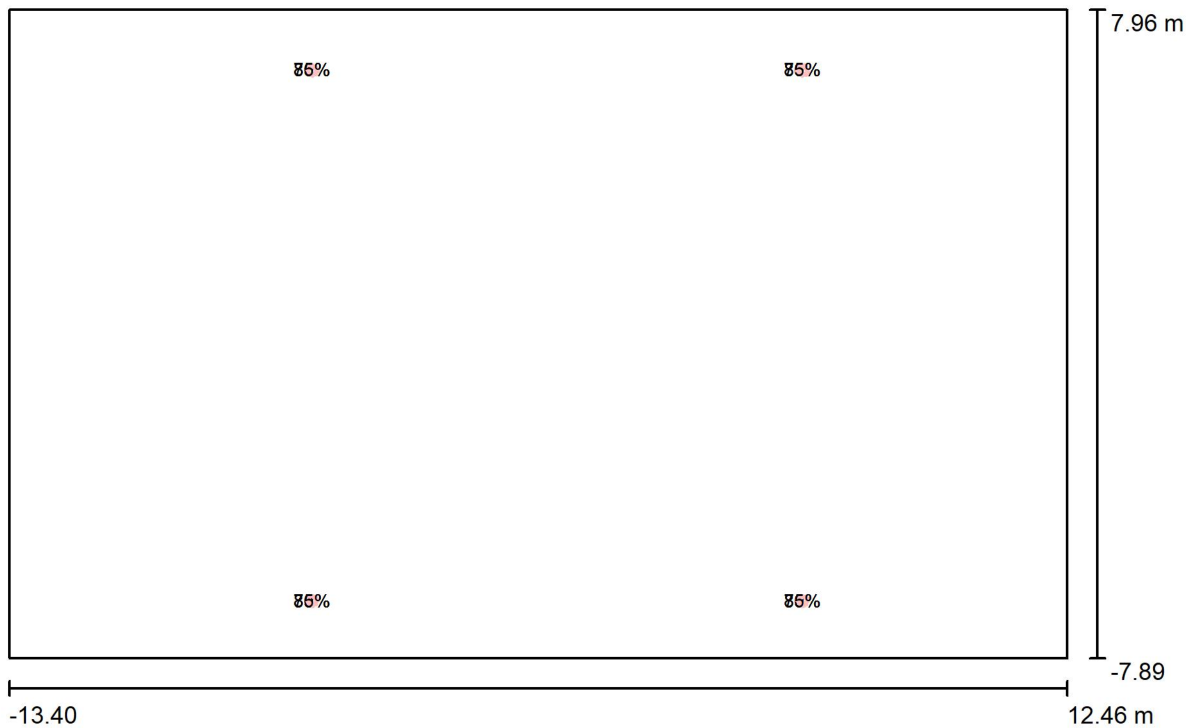
Scale 1 : 185

Sport Site Parts List

No.	Pieces	Designation
1	1	Badminton

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Planning data

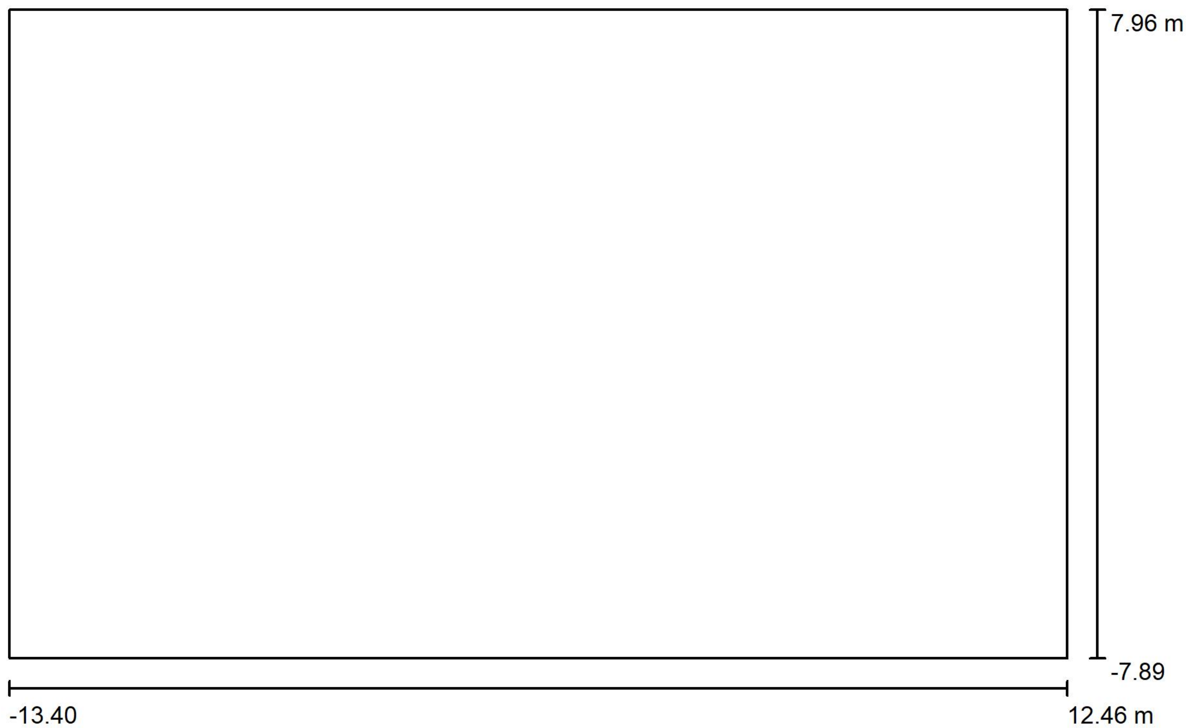


Scale 1 : 185

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	Control group 1 (INTEGRATED POWER FL FLA400BL5KN05)	80
2	Control group 2 (INTEGRATED POWER FL FLA400BL5KN05)	80
3	Control group 3 (INTEGRATED POWER FL FLA400BL5KN05)	75
	All other luminaires	0

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Planning data



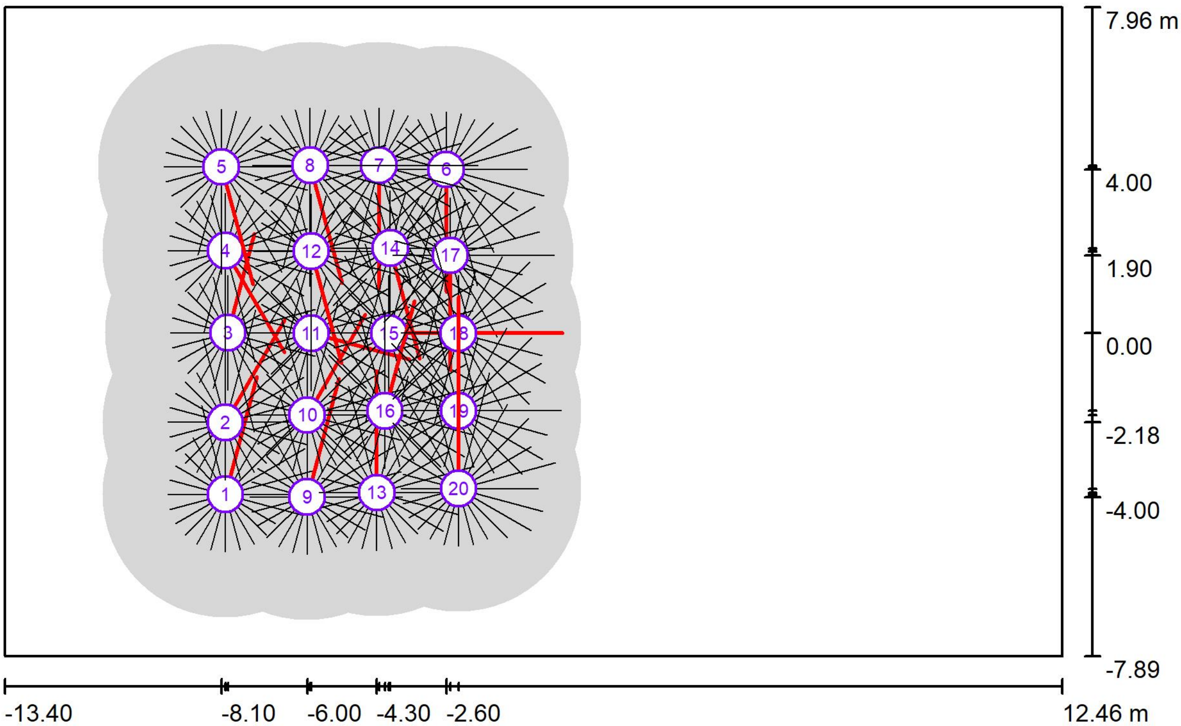
Light loss factor: 0.80, ULR (Upward Light Ratio): 0.5% Scale 1:185

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	12	INTEGRATED POWER FL FLA400BL5KN05 (1.000)	55007	54969	440.0
			Total: 660079	Total: 659629	5280.0

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / GR Observer (Results Overview)



Scale 1 : 185

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-8.000	-3.940	1.500	0.0	360.0	15.0	-2.0	21 2)
2	GR Observer 2	-8.000	-2.180	1.500	0.0	360.0	15.0	-2.0	21 2)
3	GR Observer 3	-7.938	0.010	1.500	0.0	360.0	15.0	-2.0	18 2)
4	GR Observer 4	-8.000	2.016	1.500	0.0	360.0	15.0	-2.0	20 2)

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / GR Observer (Results Overview)

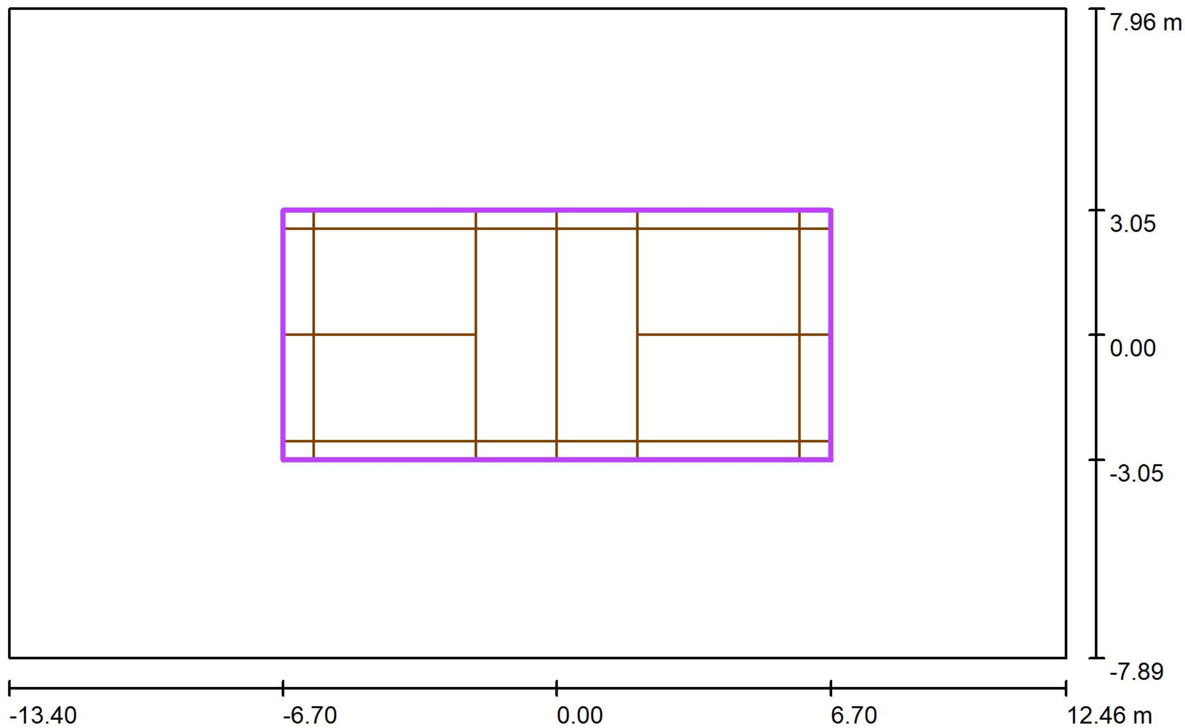
GR Observerlist

No.	Designation	Position [m] X	Y	Z	Viewing sector [°] Start	End	Increment	Slope angle	Max
5	GR Observer 5	-8.100	4.063	1.500	0.0	360.0	15.0	-2.0	21 [2)]
6	GR Observer 20	-2.600	4.000	1.500	0.0	360.0	15.0	-2.0	21 [2)]
7	GR Observer 15	-4.244	4.100	1.500	0.0	360.0	15.0	-2.0	21 [2)]
8	GR Observer 10	-5.927	4.100	1.500	0.0	360.0	15.0	-2.0	21 [2)]
9	GR Observer 6	-6.000	-4.000	1.500	0.0	360.0	15.0	-2.0	21 [2)]
10	GR Observer 7	-6.000	-2.000	1.500	0.0	360.0	15.0	-2.0	20 [2)]
11	GR Observer 8	-5.900	0.000	1.500	0.0	360.0	15.0	-2.0	18 [2)]
12	GR Observer 9	-5.900	2.000	1.500	0.0	360.0	15.0	-2.0	20 [2)]
13	GR Observer 11	-4.300	-3.900	1.500	0.0	360.0	15.0	-2.0	21 [2)]
14	GR Observer 14	-3.971	2.077	1.500	0.0	360.0	15.0	-2.0	20 [2)]
15	GR Observer 13	-4.000	0.000	1.500	0.0	360.0	15.0	-2.0	18 [2)]
16	GR Observer 12	-4.100	-1.900	1.500	0.0	360.0	15.0	-2.0	20 [2)]
17	GR Observer 19	-2.500	1.900	1.500	0.0	360.0	15.0	-2.0	20 [2)]
18	GR Observer 18	-2.303	0.000	1.500	0.0	360.0	15.0	-2.0	18 [2)]
19	GR Observer 17	-2.300	-1.900	1.500	0.0	360.0	15.0	-2.0	20 [2)]
20	GR Observer 16	-2.300	-3.800	1.500	0.0	360.0	15.0	-2.0	21 [2)]

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 185

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 5 Points
Belongs to the following sport arena: Badminton 1

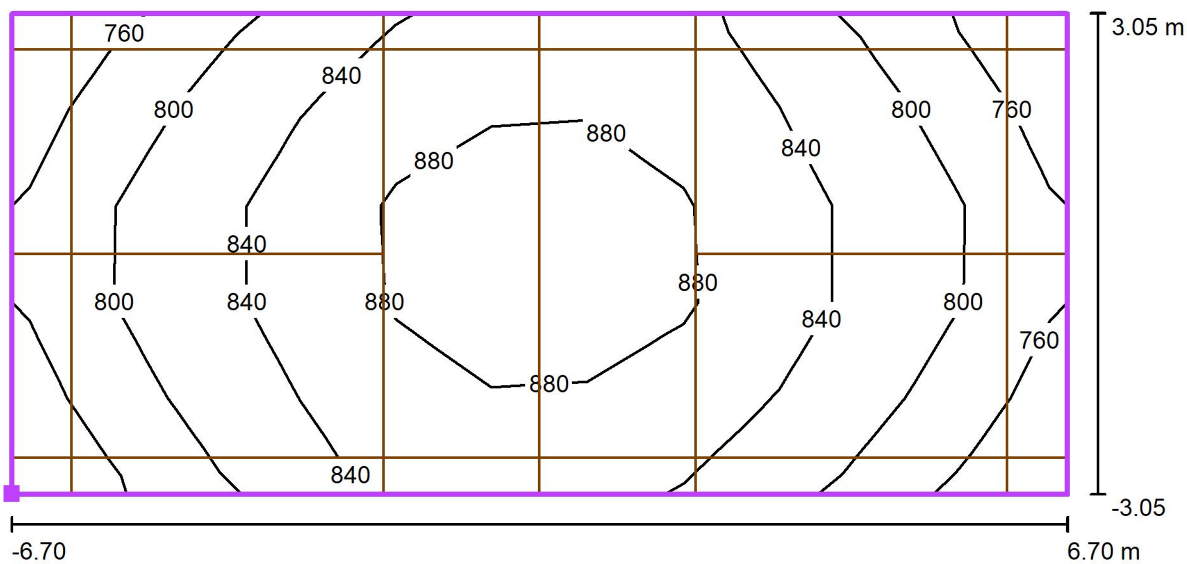
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	832	744	908	0.89	0.82	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

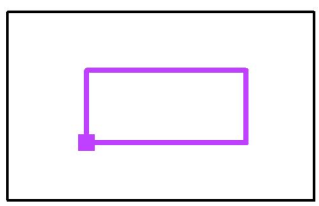
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

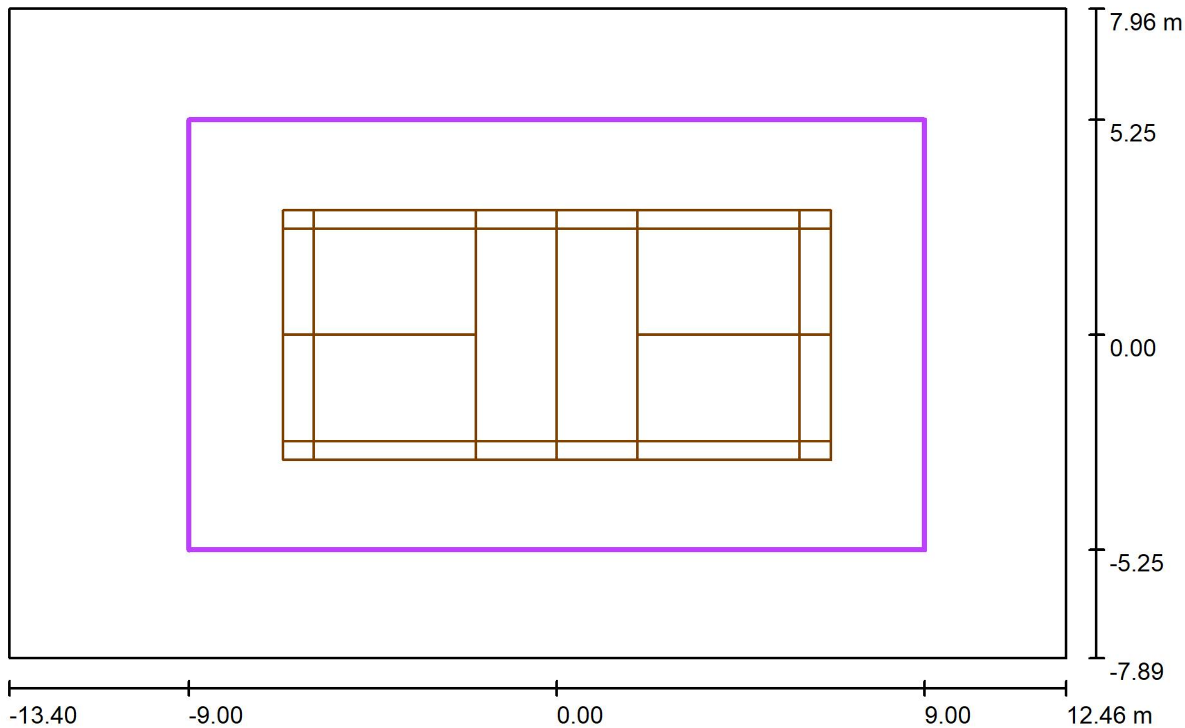


Grid: 11 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
832	744	908	0.89	0.82

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 185

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 7 Points
Belongs to the following sport arena: Badminton 1

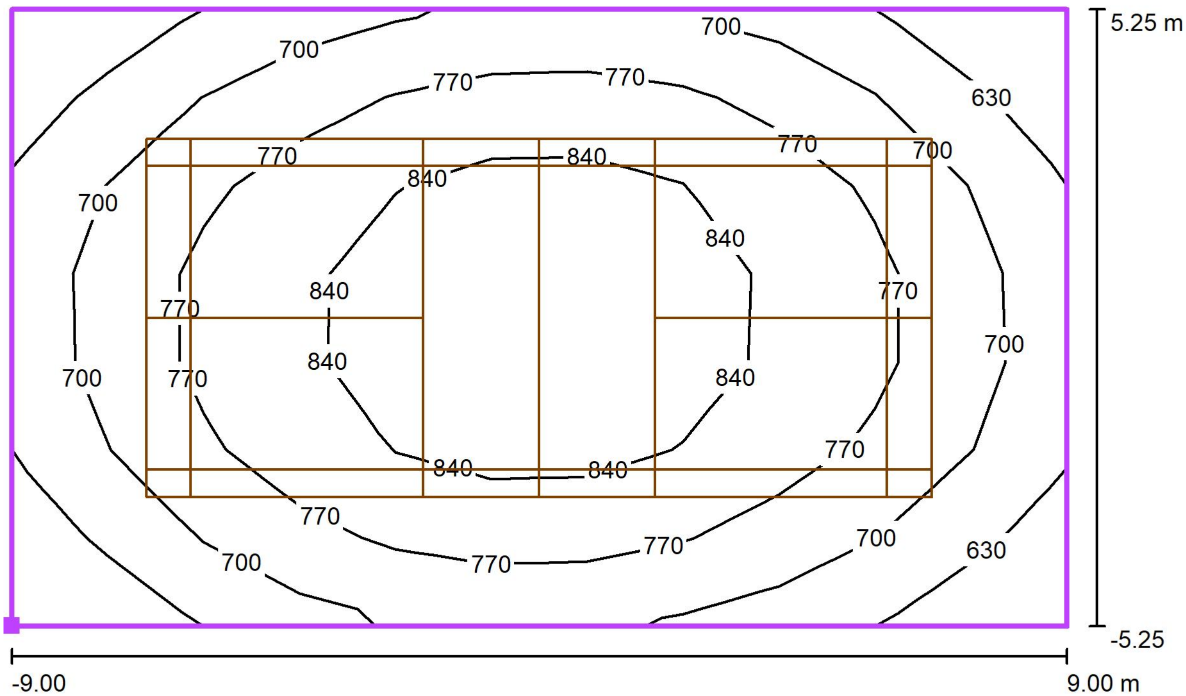
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	758	575	908	0.76	0.63	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

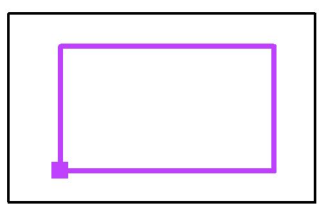
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

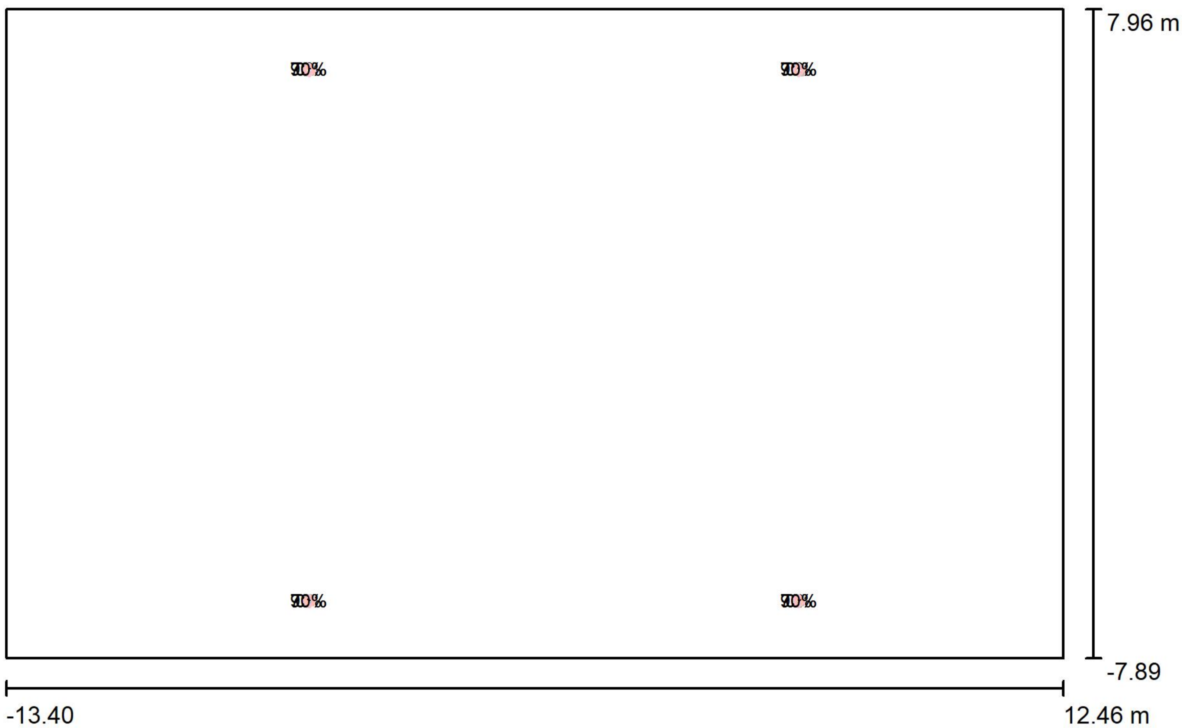


Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
758	575	908	0.76	0.63

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / Planning data

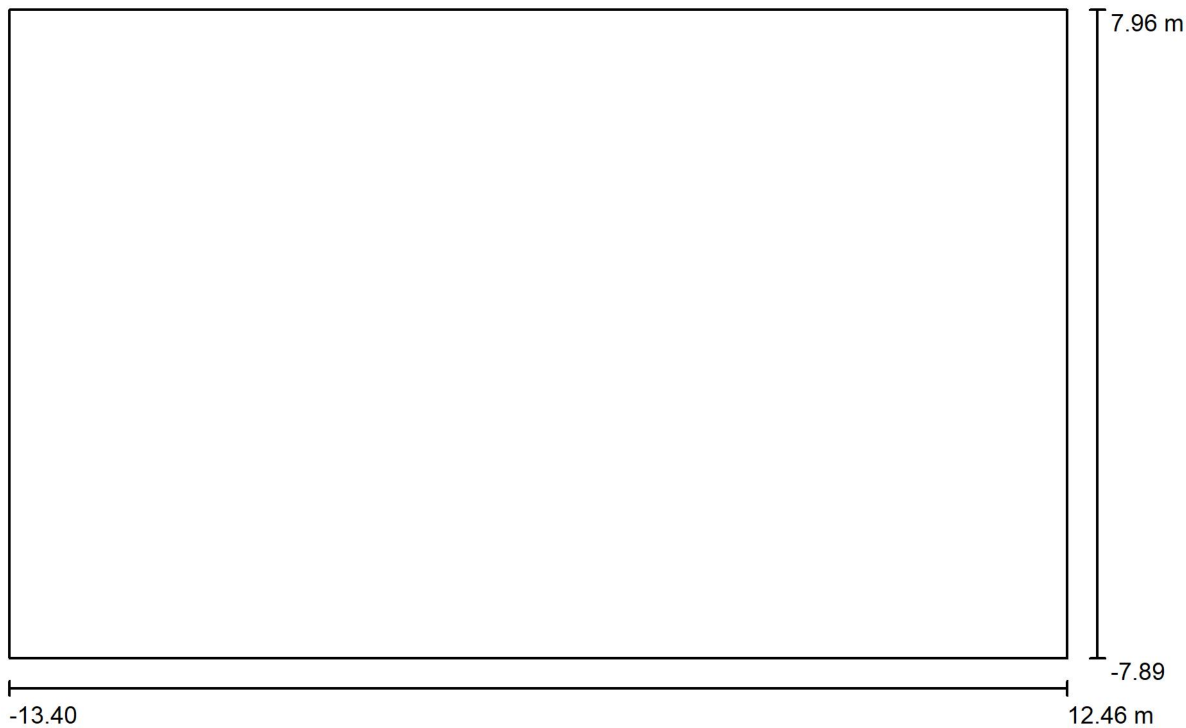


Scale 1 : 185

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	Control group 1 (INTEGRATED POWER FL FLA400BL5KN05)	70
2	Control group 2 (INTEGRATED POWER FL FLA400BL5KN05)	0
3	Control group 3 (INTEGRATED POWER FL FLA400BL5KN05)	90
	All other luminaires	0

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / Planning data

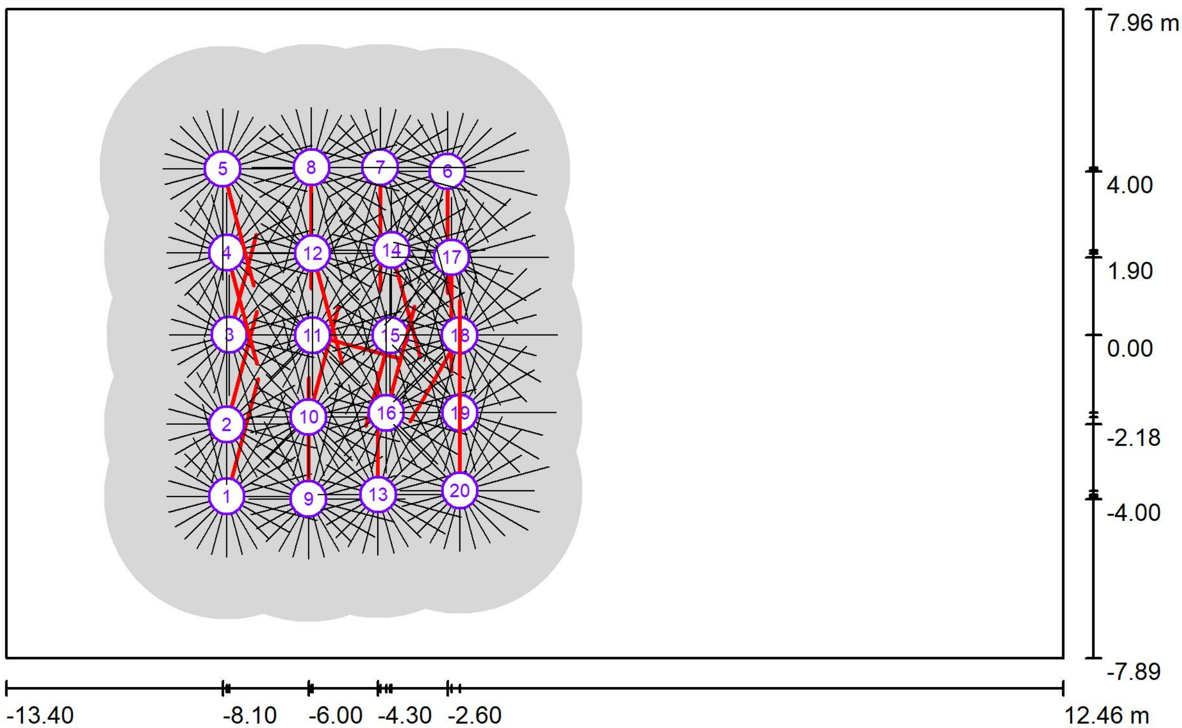


Light loss factor: 0.80, ULR (Upward Light Ratio): 0.5% Scale 1:185

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)		Φ (Luminaire) [lm]		Φ (Lamps) [lm]	P [W]
1	8	INTEGRATED POWER FL FLA400BL5KN05 (1.000)		55007		54969	440.0
			Total:	440053	Total:	439753	3520.0

Exterior Scene 1 / Light scene _Class-II / GR Observer (Results Overview)



Scale 1 : 185

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-8.000	-3.940	1.500	0.0	360.0	15.0	-2.0	20 [2)]
2	GR Observer 2	-8.000	-2.180	1.500	0.0	360.0	15.0	-2.0	19 [2)]
3	GR Observer 3	-7.938	0.010	1.500	0.0	360.0	15.0	-2.0	17 [2)]
4	GR Observer 4	-8.000	2.016	1.500	0.0	360.0	15.0	-2.0	19 [2)]

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / GR Observer (Results Overview)

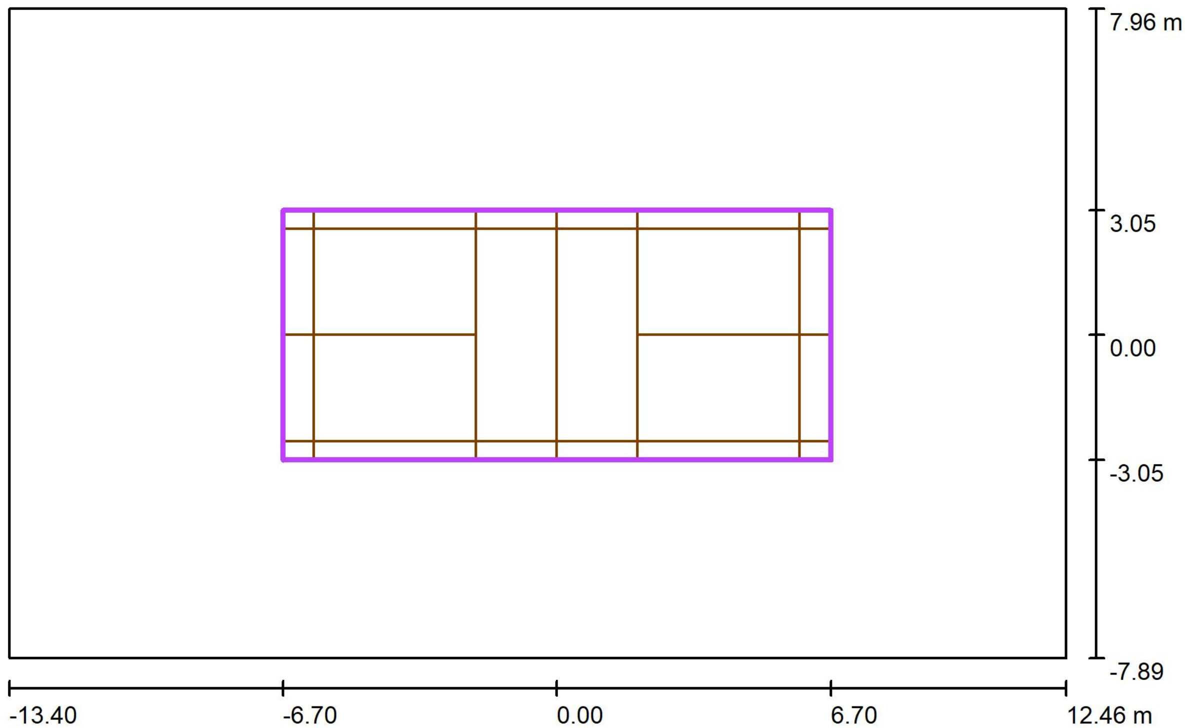
GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
5	GR Observer 5	-8.100	4.063	1.500	0.0	360.0	15.0	-2.0	20 2)
6	GR Observer 20	-2.600	4.000	1.500	0.0	360.0	15.0	-2.0	20 2)
7	GR Observer 15	-4.244	4.100	1.500	0.0	360.0	15.0	-2.0	20 2)
8	GR Observer 10	-5.927	4.100	1.500	0.0	360.0	15.0	-2.0	20 2)
9	GR Observer 6	-6.000	-4.000	1.500	0.0	360.0	15.0	-2.0	20 2)
10	GR Observer 7	-6.000	-2.000	1.500	0.0	360.0	15.0	-2.0	19 2)
11	GR Observer 8	-5.900	0.000	1.500	0.0	360.0	15.0	-2.0	15 2)
12	GR Observer 9	-5.900	2.000	1.500	0.0	360.0	15.0	-2.0	19 2)
13	GR Observer 11	-4.300	-3.900	1.500	0.0	360.0	15.0	-2.0	20 2)
14	GR Observer 14	-3.971	2.077	1.500	0.0	360.0	15.0	-2.0	18 2)
15	GR Observer 13	-4.000	0.000	1.500	0.0	360.0	15.0	-2.0	16 2)
16	GR Observer 12	-4.100	-1.900	1.500	0.0	360.0	15.0	-2.0	18 2)
17	GR Observer 19	-2.500	1.900	1.500	0.0	360.0	15.0	-2.0	19 2)
18	GR Observer 18	-2.303	0.000	1.500	0.0	360.0	15.0	-2.0	17 2)
19	GR Observer 17	-2.300	-1.900	1.500	0.0	360.0	15.0	-2.0	19 2)
20	GR Observer 16	-2.300	-3.800	1.500	0.0	360.0	15.0	-2.0	20 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 185

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 5 Points
Belongs to the following sport arena: Badminton 1

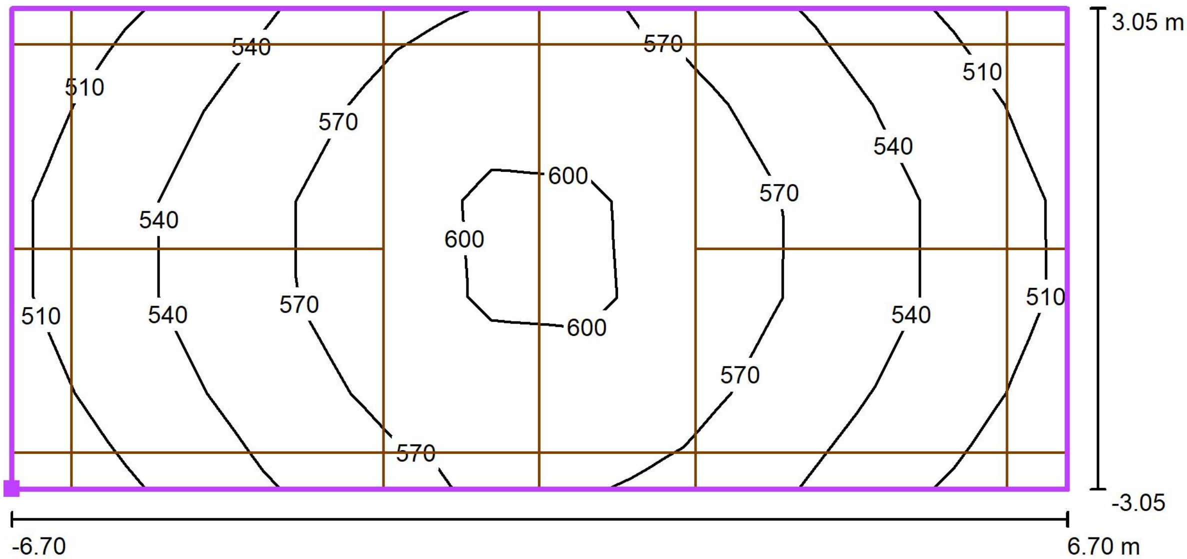
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	556	499	611	0.90	0.82	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

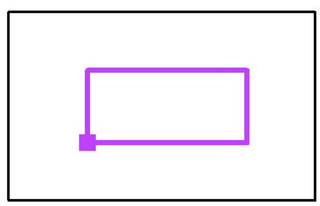
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

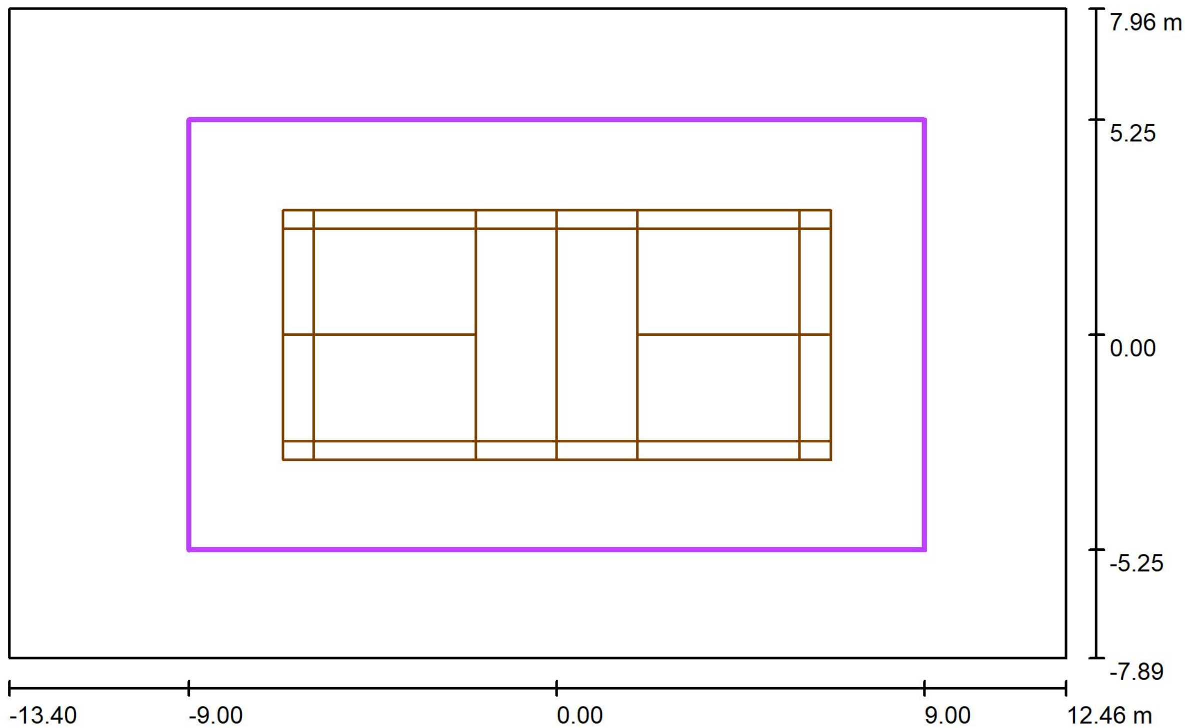


Grid: 11 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
556	499	611	0.90	0.82

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 185

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 7 Points
Belongs to the following sport arena: Badminton 1

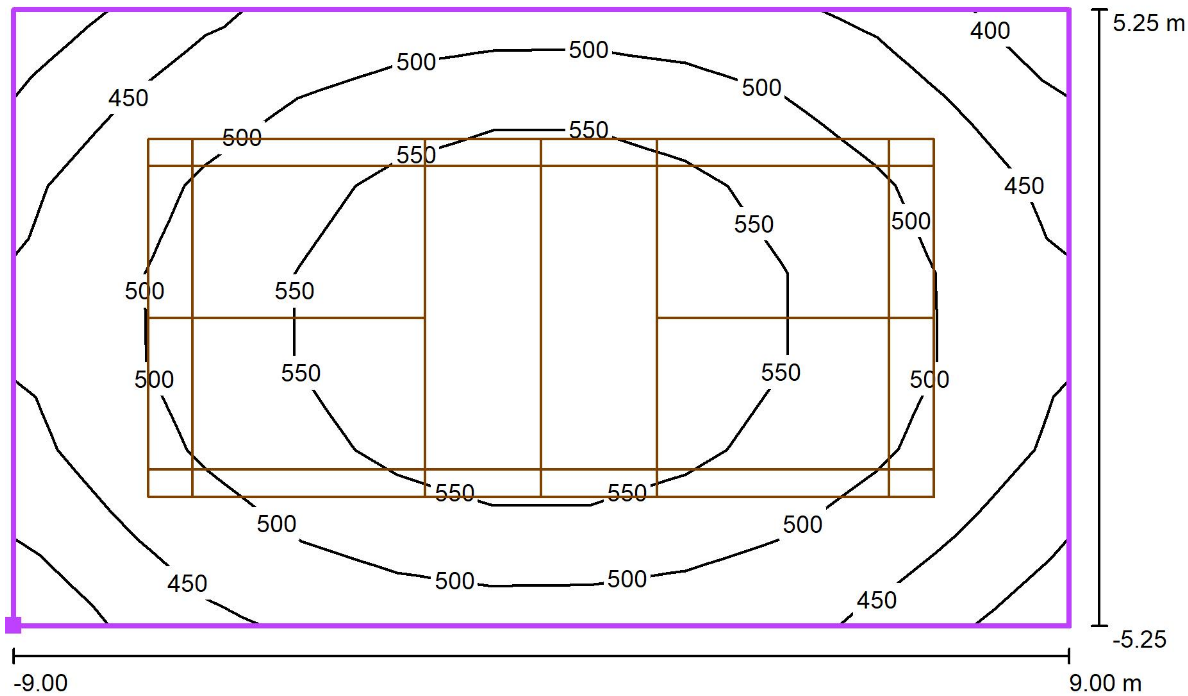
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	510	396	611	0.78	0.65	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

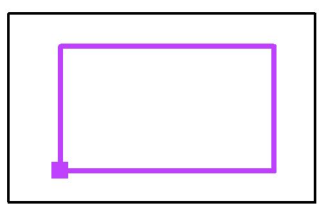
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-II / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

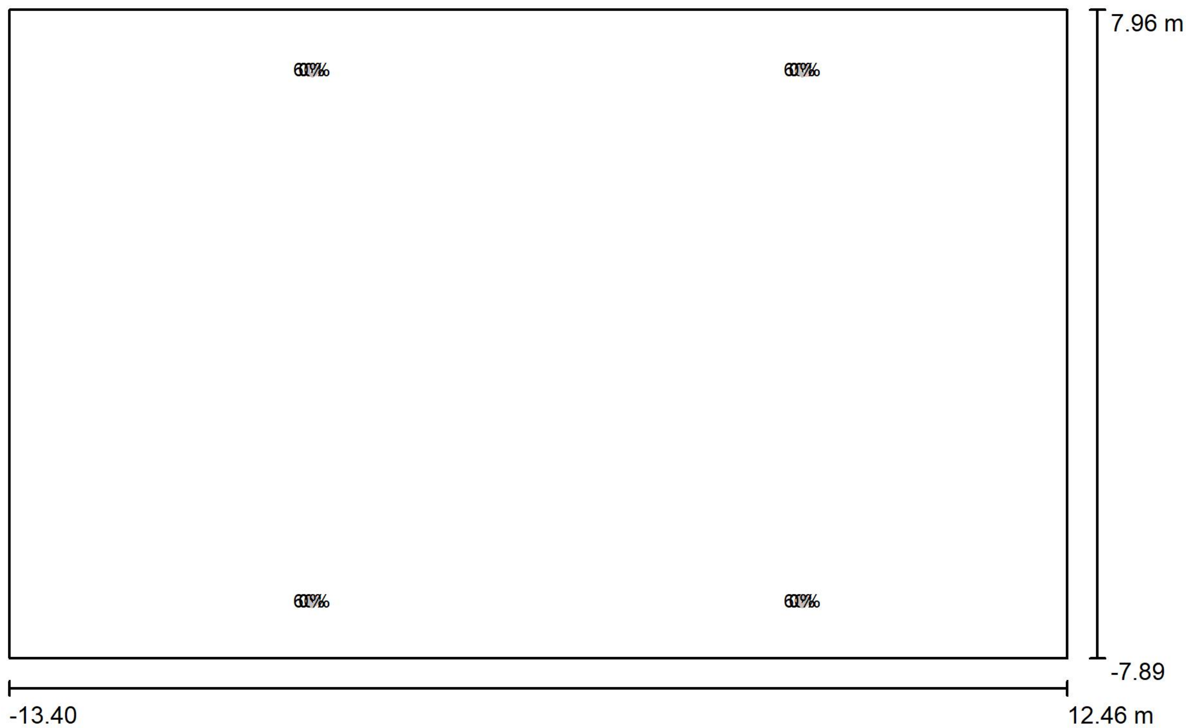


Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
510	396	611	0.78	0.65

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / Planning data

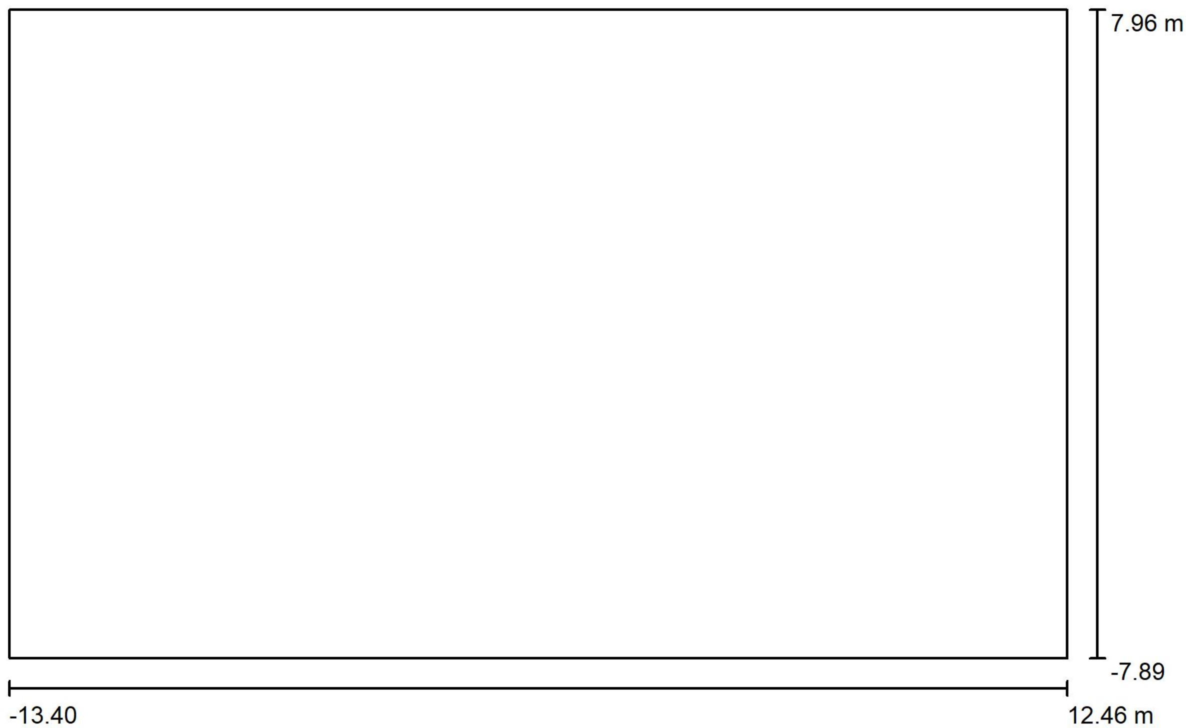


Scale 1 : 185

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	Control group 1 (INTEGRATED POWER FL FLA400BL5KN05)	0
2	Control group 2 (INTEGRATED POWER FL FLA400BL5KN05)	60
3	Control group 3 (INTEGRATED POWER FL FLA400BL5KN05)	0
	All other luminaires	0

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / Planning data



Light loss factor: 0.80, ULR (Upward Light Ratio): 0.5%

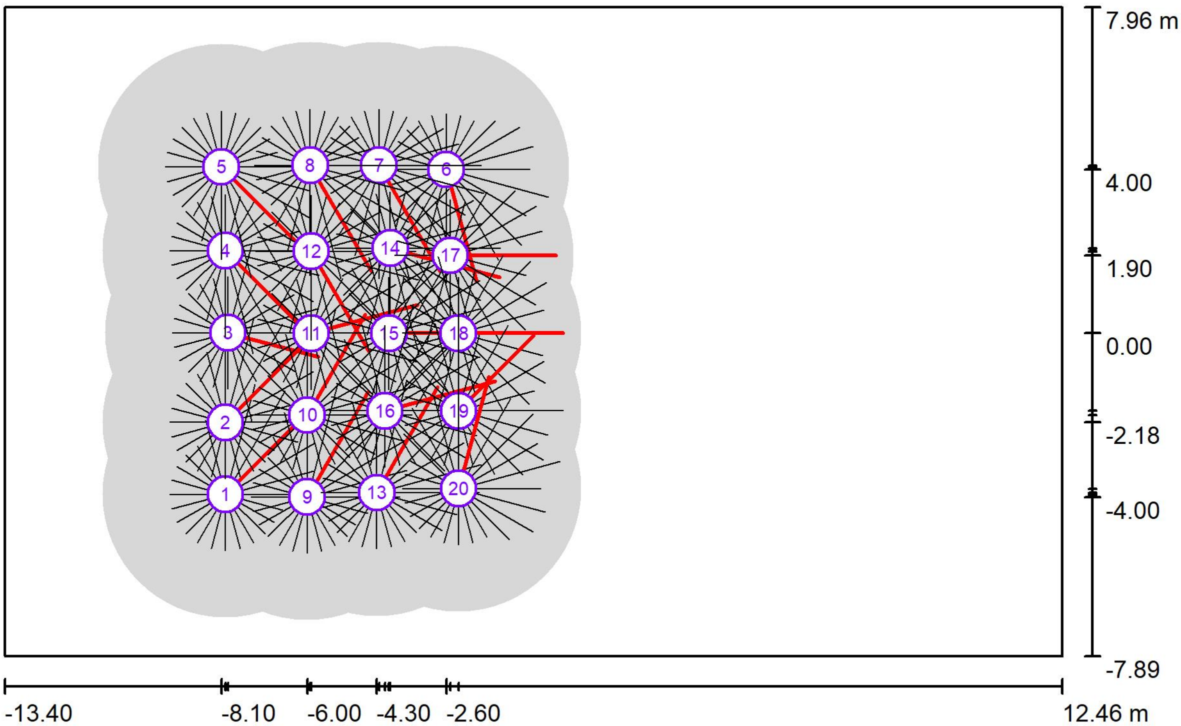
Scale 1:185

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)		Φ (Luminaire) [lm]		Φ (Lamps) [lm]	P [W]
1	4	INTEGRATED POWER FL FLA400BL5KN05 (1.000)		55007		54969	440.0
			Total:	220026	Total:	219876	1760.0

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / GR Observer (Results Overview)



Scale 1 : 185

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-8.000	-3.940	1.500	0.0	360.0	15.0	-2.0	22 [2)]
2	GR Observer 2	-8.000	-2.180	1.500	0.0	360.0	15.0	-2.0	21 [2)]
3	GR Observer 3	-7.938	0.010	1.500	0.0	360.0	15.0	-2.0	17 [2)]
4	GR Observer 4	-8.000	2.016	1.500	0.0	360.0	15.0	-2.0	21 [2)]

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / GR Observer (Results Overview)

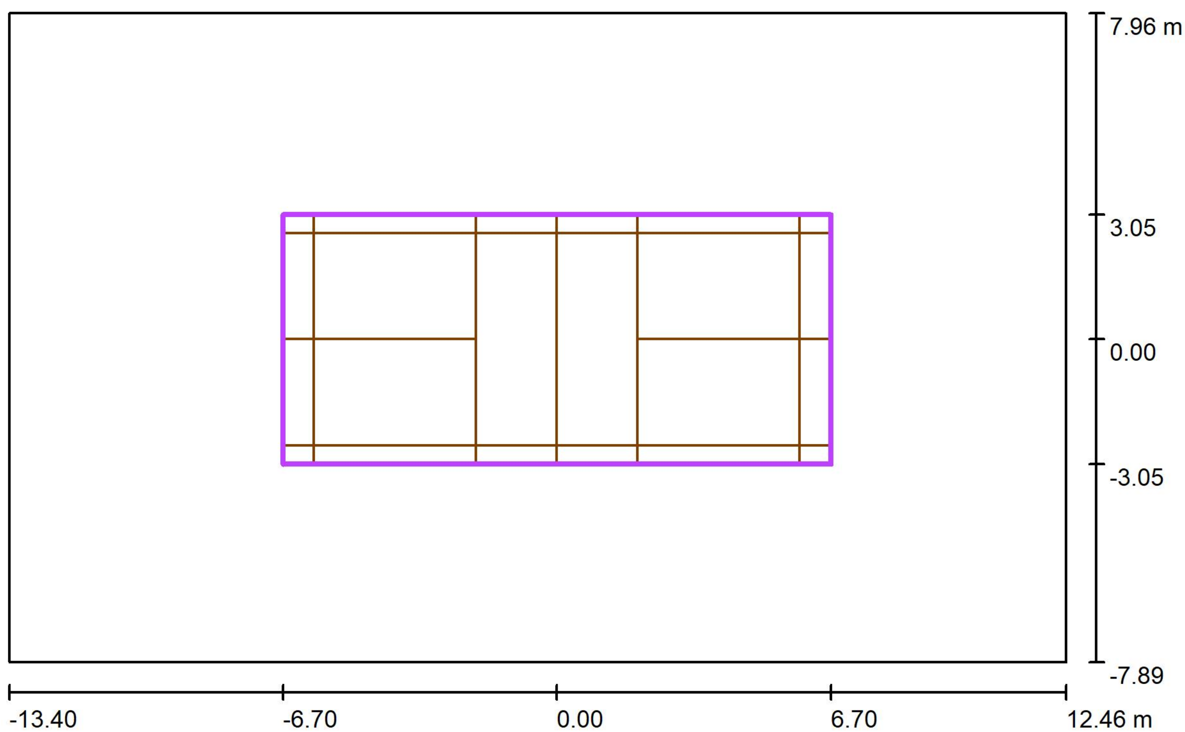
GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
5	GR Observer 5	-8.100	4.063	1.500	0.0	360.0	15.0	-2.0	22 2)
6	GR Observer 20	-2.600	4.000	1.500	0.0	360.0	15.0	-2.0	21 2)
7	GR Observer 15	-4.244	4.100	1.500	0.0	360.0	15.0	-2.0	22 2)
8	GR Observer 10	-5.927	4.100	1.500	0.0	360.0	15.0	-2.0	22 2)
9	GR Observer 6	-6.000	-4.000	1.500	0.0	360.0	15.0	-2.0	22 2)
10	GR Observer 7	-6.000	-2.000	1.500	0.0	360.0	15.0	-2.0	21 2)
11	GR Observer 8	-5.900	0.000	1.500	0.0	360.0	15.0	-2.0	20 2)
12	GR Observer 9	-5.900	2.000	1.500	0.0	360.0	15.0	-2.0	21 2)
13	GR Observer 11	-4.300	-3.900	1.500	0.0	360.0	15.0	-2.0	22 2)
14	GR Observer 14	-3.971	2.077	1.500	0.0	360.0	15.0	-2.0	20 2)
15	GR Observer 13	-4.000	0.000	1.500	0.0	360.0	15.0	-2.0	20 2)
16	GR Observer 12	-4.100	-1.900	1.500	0.0	360.0	15.0	-2.0	20 2)
17	GR Observer 19	-2.500	1.900	1.500	0.0	360.0	15.0	-2.0	19 2)
18	GR Observer 18	-2.303	0.000	1.500	0.0	360.0	15.0	-2.0	19 2)
19	GR Observer 17	-2.300	-1.900	1.500	0.0	360.0	15.0	-2.0	19 2)
20	GR Observer 16	-2.300	-3.800	1.500	0.0	360.0	15.0	-2.0	21 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 185

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 5 Points
Belongs to the following sport arena: Badminton 1

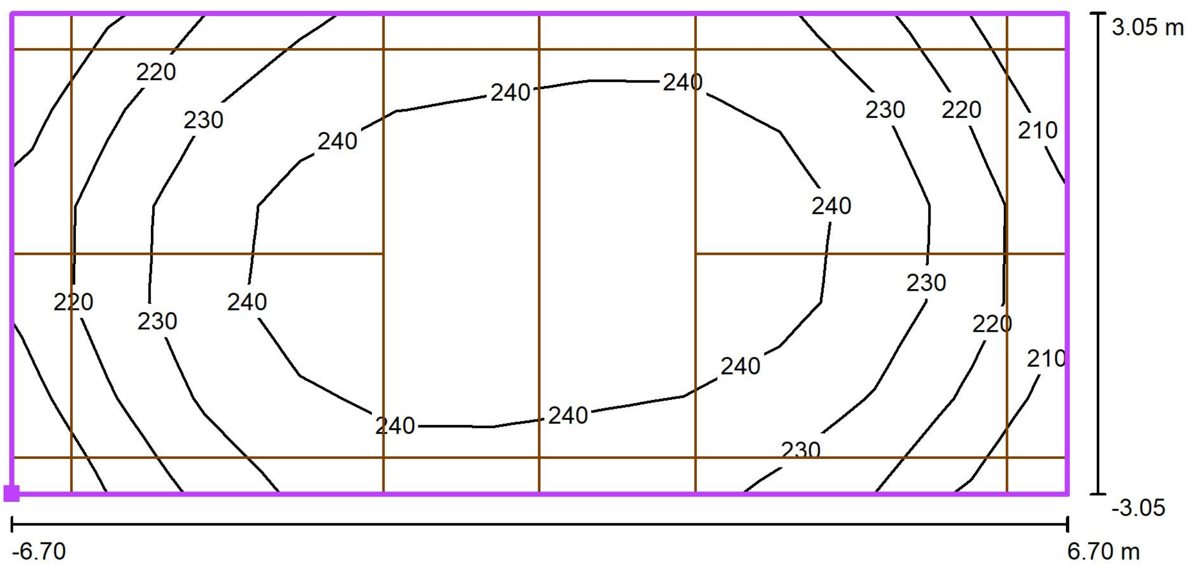
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\ m}/E_m$	H [m]	Camera
1	horizontal	233	206	247	0.89	0.83	/	0.000	/

$E_{h\ m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

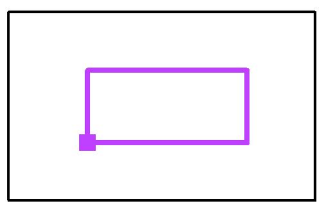
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

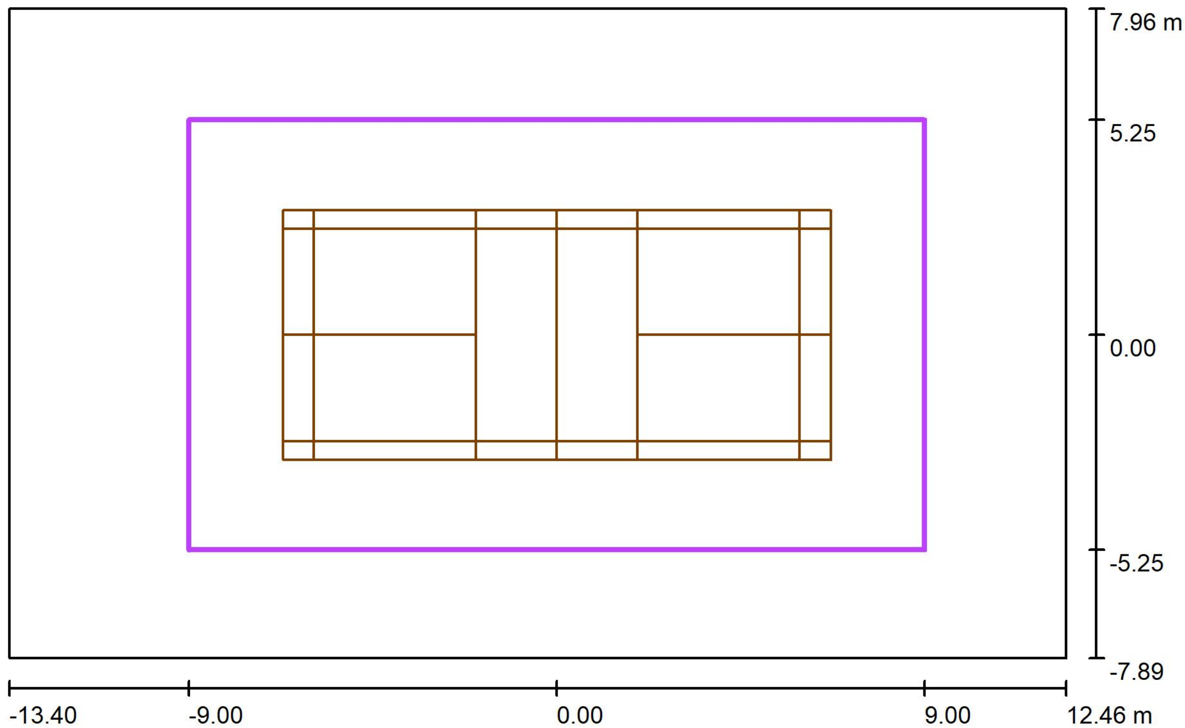


Grid: 11 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
233	206	247	0.89	0.83

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 185

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 7 Points
Belongs to the following sport arena: Badminton 1

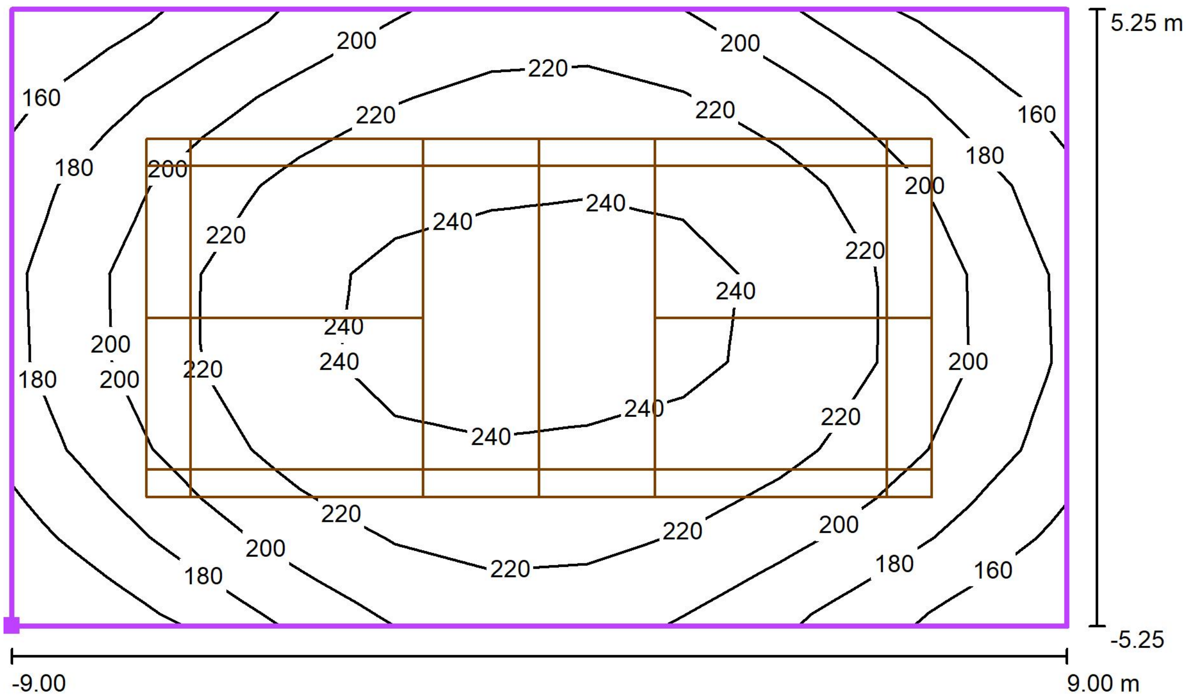
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	210	149	247	0.71	0.60	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

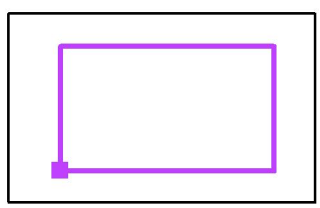
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class_III / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

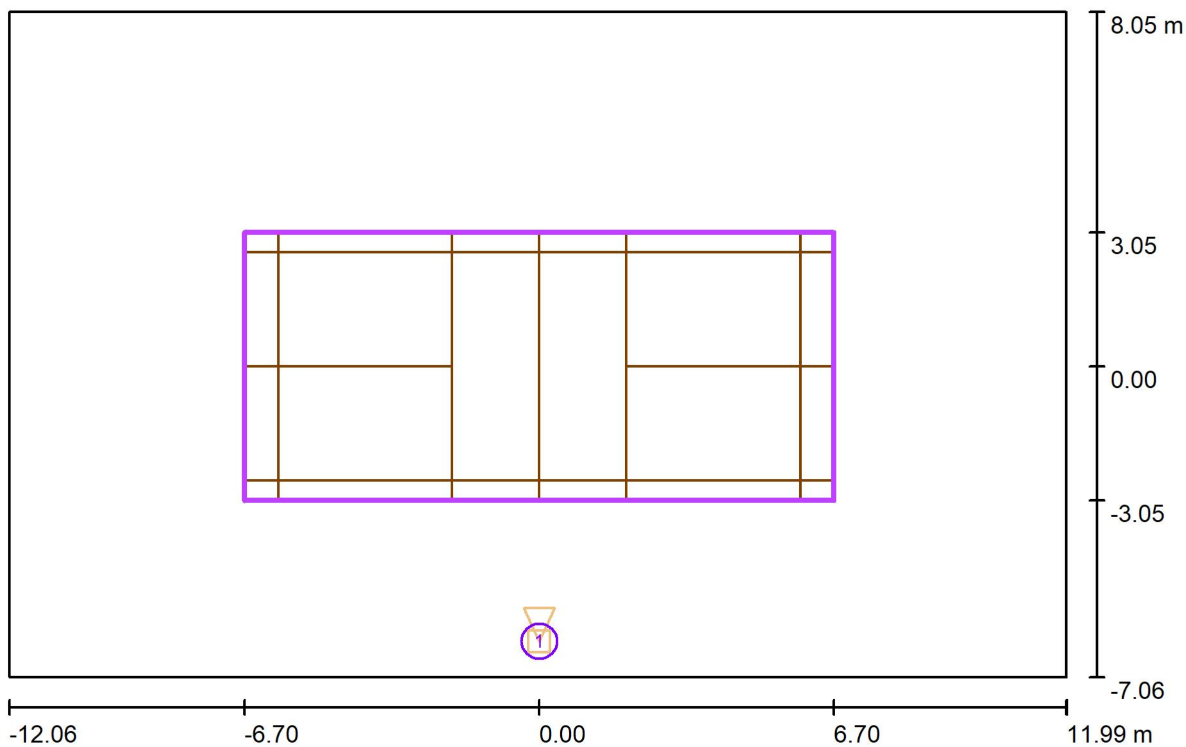


Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
210	149	247	0.71	0.60

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 5 Points
Belongs to the following sport arena: Badminton 1

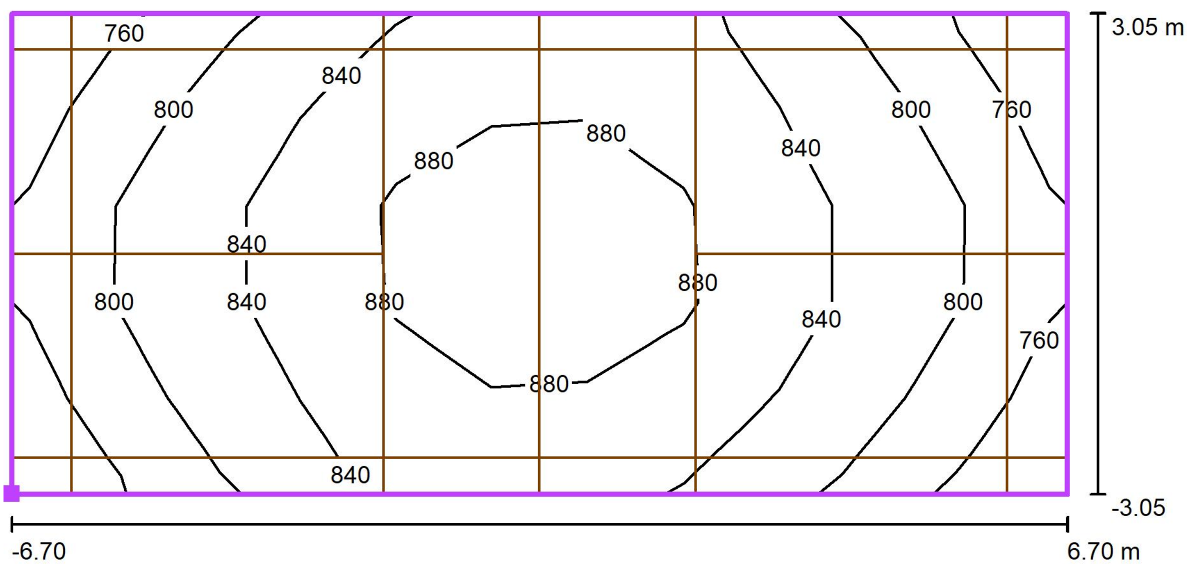
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\ m}/E_m$	H [m]	Camera
1	horizontal	832	744	908	0.89	0.82	/	0.000	/
2	Camera	641	569	748	0.89	0.76	1.30	1.000	1

$E_{h\ m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

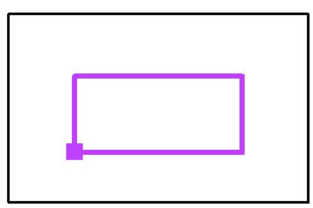
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (-6.700 m, -3.050 m, 0.000 m)

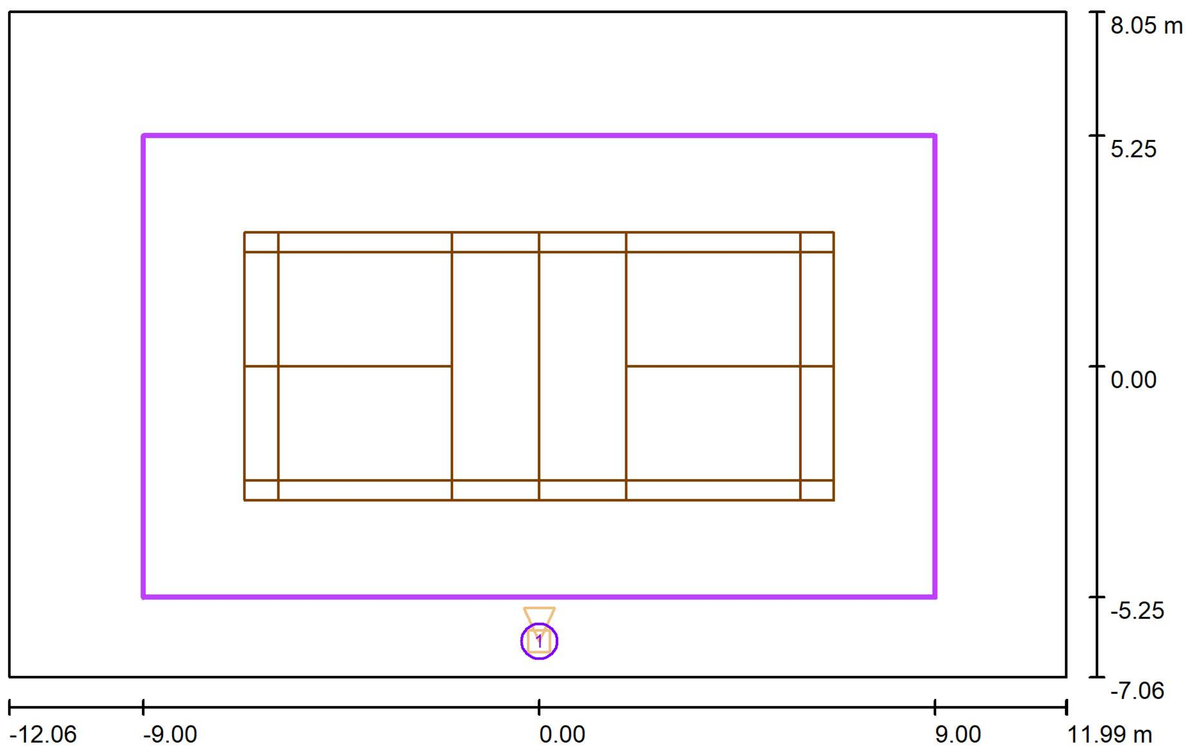


Grid: 11 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
832	744	908	0.89	0.82

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (18.000 m, 10.500 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 11 x 7 Points
Belongs to the following sport arena: Badminton 1

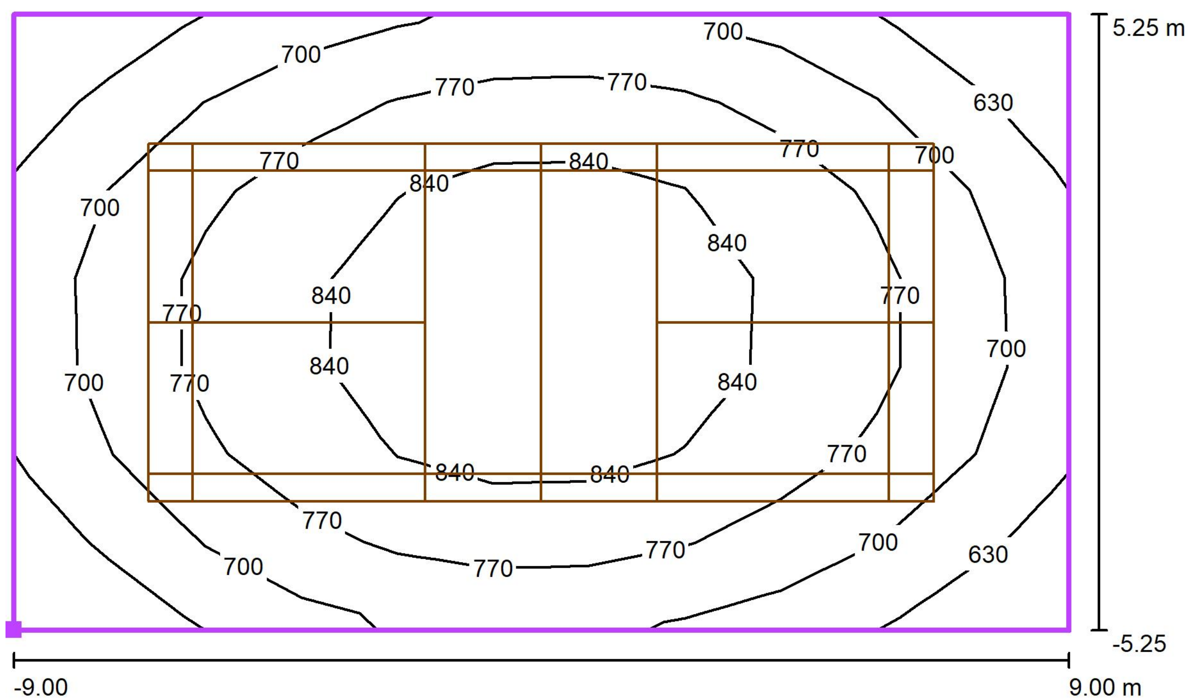
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	758	575	908	0.76	0.63	/	0.000	/
2	Camera	614	511	752	0.83	0.68	1.24	1.000	1

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

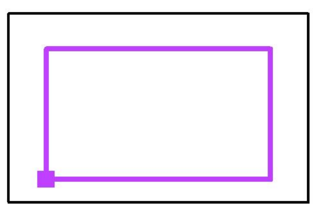
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Badminton 1 Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 129

Position of surface in external scene:
Marked point: (-9.000 m, -5.250 m, 0.000 m)

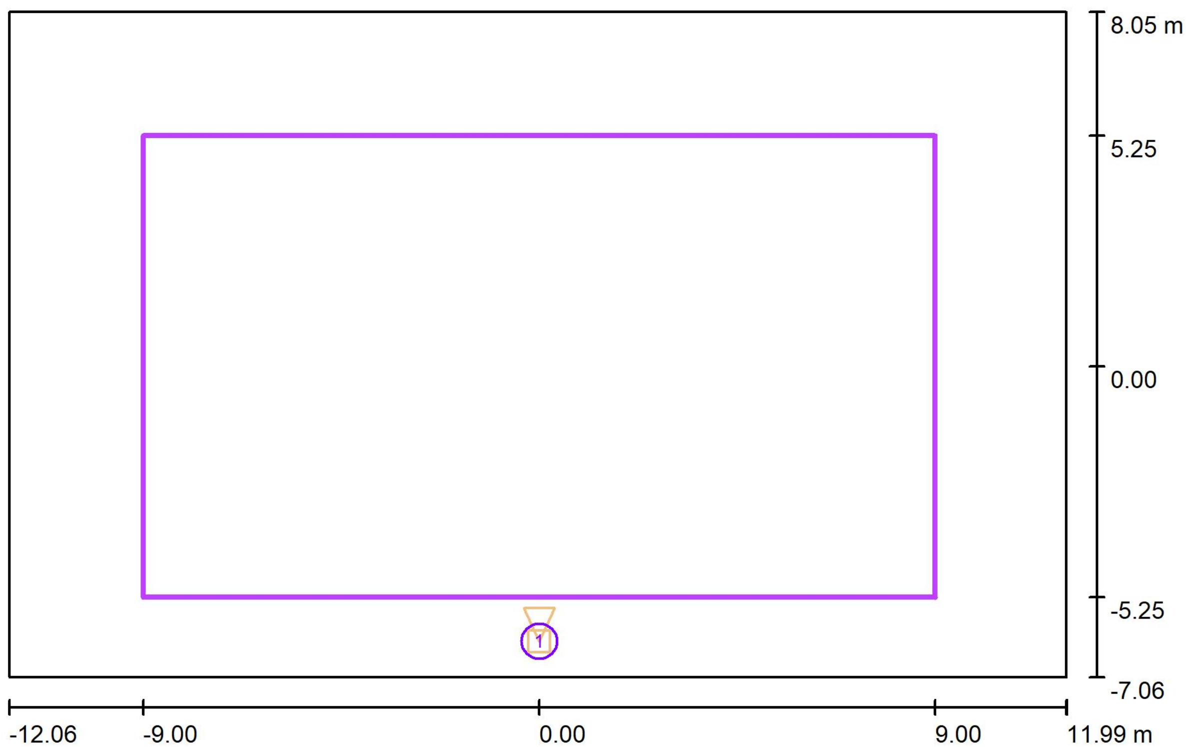


Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
758	575	908	0.76	0.63

Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Calculation Grid Ecam / Summary



Scale 1 : 172

Position: (0.000 m, 0.000 m, 0.000 m)
Size: (10.500 m, 18.000 m)
Rotation: (0.0°, 0.0°, 90.0°)
Type: Normal, Grid: 11 x 19 Points

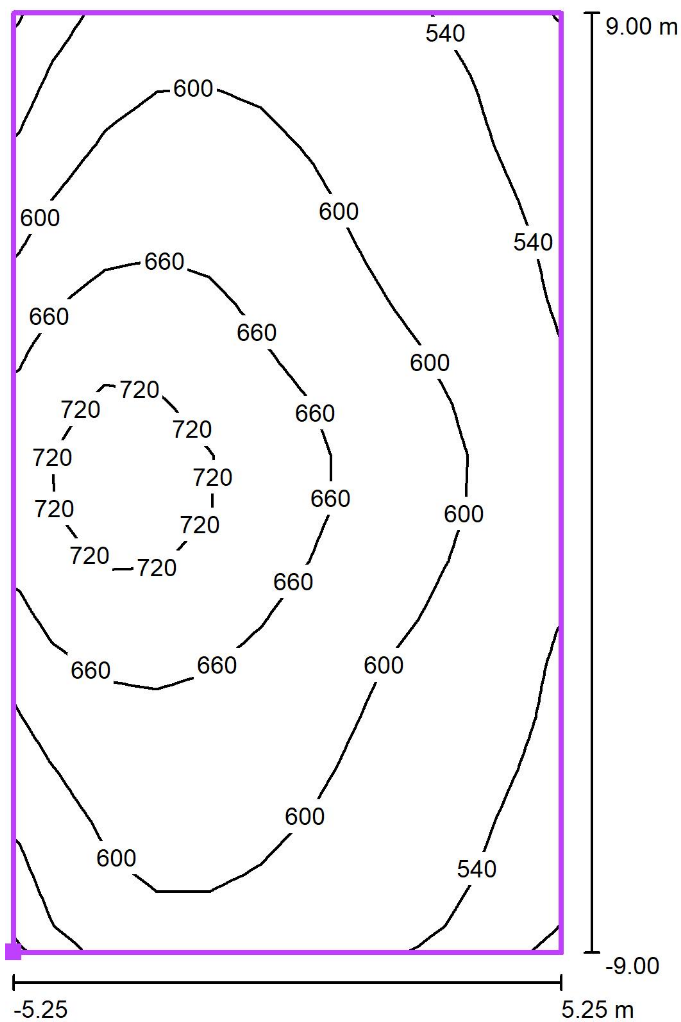
Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	Camera	606	477	752	0.79	0.63	/	1.000	1

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

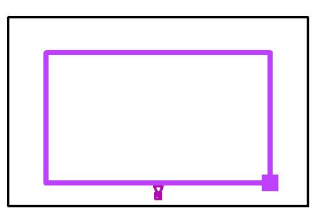
Operator
Telephone
Fax
e-Mail

Exterior Scene 1 / Light scene _Class-I / Calculation Grid Ecam / Isolines (E, Camera)



Values in Lux, Scale 1 : 145

Position of surface in external scene:
Marked point: (9.000 m, -5.250 m, 0.000 m)
Camera Position: (0.000 m, -6.250 m, 6.000 m)



Grid: 11 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
606	477	752	0.79	0.63