Indian Standard Based Lighting Software Development & Its Validation through Application in Lighting Design

A thesis submitted towards partial fulfillment of the requirements for the degree of

Master of Technology

In Illumination Technology and Design

Submitted by:

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CLASS ROLL NO:001631101017

EXAM ROLL NO: M6ILT19018

Under the guidance of

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Industrial Guide

2019

School of Illumination Science, Engineering and Design

Jadavpur University

M. Tech. (Master of Technology in Illumination Technology and Design)
Course affiliated to
Faculty of Engineering and Technology
Jadavpur University, Kolkata, India

CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitled **"Indian Standard Based Lighting Software Development & Its Validation through Application in Lighting Design"** is a bonafide work carried out by **Tirupati Bhattacharya** under my supervision and guidance for partial fulfillment of the requirement of M. Tech. **(Master of Technology in Illumination Technology and Design)** in School of Illumination Science, Engineering and Design, during the academic session 2016-2019.

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CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented by **TIRUPATI BHATTACHARYA (Examination Roll No: M6ILT19018)** in a satisfactory manner to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

Committee of final examination ----------

For evaluation of Thesis ----------

** Only in case the thesis is approved.

DECLARATION OF ORIGINALITYAND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of the thesis for the degree of M.Tech. **(Master of Technology in Illumination Technology and Design)** studies during academic session 2016-2019.
All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by the rules and conduct, I have fully cited and referred all material and results that are not original to this work

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Last but not the least, I would like to express my indebtedness to the **developers and manufacturers of 'DIALux'**, which served as the basic idea of my thesis.

I have gained valuable experience in lighting designing software application in architectural lighting designing factors necessary for maintaining visual comfort as per the Indian standard protocol, thereby leading to completion of the project assigned to me.

TIRUPATI BHATTACHARYA

Dated:

Place:

Contents: -

CHAPTER:-I Introduction & Problem Statement

1 Introduction: -

Light is one of the fundamental requirements of all life forms on this earth, directly or indirectly. While daylight coming from the sun is key to all natural and man-made activities in the world, it is the artificial lighting that has slowly taken up a major share in all studies, researches, industries and applications. Visual optimization is not just the only factor for which lighting systems or better to say light is required but it is essential also for the purpose of indicative existence as in the case of lighting systems operating in flight controlling towers, emergency exit lighting areas, indicators provided on the roads maintaining the road safety parameters, beautification of cities and aesthetic beautification of buildings both residential and commercial ones.

Artificial or electric lighting started its journey in the early 19th century through great inventors and today it is one of the utilities that urban living cannot be imagined without.

In pedagogical domain, art and science of lighting has evolved into technology, engineering and most importantly, design. In the era of soft computing, lighting engineering and design have been further simplified by the usage of softwares and currently, lighting industry as well as lighting design practitioners have a multitude of such softwares for application. Several lighting designing softwares such as DIALux, Calculux, LiteStar 4D, Visual 3D, Relux and other similar lighting software details and their usage are discussed in 'CHAPTER V' for further reference.

Amongst these, DIALux is the most popular lighting designing software available in the public domain as well as in our University for the research and learning practice of students. DIALux can be used for designing of Indoor as well as Outdoor lightings.

DIALux features are as follows:

- CAD drawings can be imported in DIALux for lighting design
- Luminaires array of spacing can be done in DIALux
- Output printing such as ISOLUX lines and printing of layout drawing can be possible
- Uniformity and Average Lux level can be obtained in DIALux
- Daylight with artificial lighting design is possible in DIALux
- Technical specification of the Luminaire can be gathered by importing Luminaire IES files in project.

DIALux is useful for the following personnels:

- Lighting Engineers and Designers
- Luminaire Manufacturers
- Luminaire Distributors
- University researchers and students

However few limitations of DIALux have been noticed:

- DIALux is the proprietary software of the renowned Luminaire manufacturer (DIAL Bahnhofsallee 18 · 58507 Lüdenscheid, Germany),so no changes can be made without intimating the manufacturer.
- DIALux has the database of only Luminaire IES files from which technical specification of the luminaire is not easy to read without importing IES files in DIALux project.
- DIALux can be only used limitedly as per Indian Standard Specification.
- DIALux is not able to calculate the cost-effectiveness of the consumption rates as per Indian Electricity Tariff.
- New features in DIAlux cannot be modified or implemented.

In this context the need of an indigenous lighting designing software was felt and therefore, an academic attempt through this thesis has been initiated. The proposed software has been named as JU-LUX and has been presented in this thesis as an effort to customized a lighting software as per the Indian standard (ECBC, IS3646) that would also assist the students as well as the researchers in referring all previous academic exercises on illumination design, forming an integral database of Jadavpur University.

The above software will not only help the students but the researchers as well for immediate assistance and will also be time effective.

Since the last few years the students have been searching for the research papers on internet on purpose of reference for their Term/Research paper, but now with the help of this application they can go through the specific references of those related thesis papers of 'Jadavpur University' by just choosing the subject at the click of a button.The said software not only takes account of energy efficient design but also the parameters related to economy with respect to time and health concerns. The concerned software development is a platform for fast lighting solutions according to the existing Indian standard parameters, that incorporates within itself the advantage to edit with due importance to the demand and supply ratio.JU-LUX having luminaire database with various categories of luminaire depends on the light distribution (projections), application (Indoor/Outdoor), rating-wise (wattage, efficacy) and type (LED, MH etc).It is a complete package of all kinds of related features and is a cumulative reflection of its own set of prototype characteristics.

1.1 Problem Statement: -

"Most of the existing lighting research focuses on illuminance and colour temperature while there have been few studies of the relationship of the distribution of light and spatial perception. Distribution of light is difficult to measure and better suited for visual evaluation, and is therefore possibly not as well researched. The focus on the level of light, visual task and performance may have caused lighting research and the lighting industry to prioritize uniform lighting that works better for the central vision .The standards and recommendations from the International Commission of Illumination (CIE) are based mainly on the central vision's (fovea vision) need for uniformity to facilitate reading details: "In general, the more uniform the distribution of light in the visual field, the better one sees the visual task" . Traditional light planning and luminaire development have long departed from the distribution of light that is as uniform as possible to support road safety and indoor visual performance". (Lindh, 2012)

As stated above a major bulk of lighting research that has been carried out across the globe emphasizes on the example of "illuminance and colour temperature" and not much in-depth study has been done with regards to the "relationship of the distribution of the light and spatial perception" owing to the difficulty in measuring. *"Distribution of light, as it is better suited for VISUAL COMFORT also enhances Visual Task . Not much research has been done in this field. Uniform lighting has been prioritized with an eye on the arena of better performance for the central vision and for this due explanation has been given on the level of light, visual task and performance"* (Lindh, 2012).

As a student of Illumination Technology & Design, I have always found that the solutions of fundamental calculation are only partly available on the lighting designing software DIALux. Mainly in our university we use DIALux as the most popular lighting designer software application with the in-built proprietary functionality which cannot be stated or modified as per our Indian standard norms and the execution pattern of IES on lighting distribution. So having knowledge of a software developer, I have always been in search of a technique to develop such kind of software application which can solve the basic needs of designing parameters for lighting designers as well as for consumers, who can be benefitted by providing visual comfort (with proper lux level as per task and mood) on the basis of efficient lighting design by retrofitting / new design of lighting layout and have also tried to understand and validate the justification of lighting rules in an application and its further enhancement as per the Indian standards and economy.

In the process of developing the software I have gone through various factors and fundamental calculations of the lighting design, primarily to create an easier way for lighting design using a software which comes with simple features with the available resources (database luminaire) and guidance of in-built standard protocol.

The Idea of JU-LUX comes as a package software which has some simple features, database of luminaire and ready reference of relevant Indian standards in-built within the system.

The outcome of JU- LUX is easily comprehensible to both the lighting designer as well as the consumers based on the Indian Electricity Tariff in terms of energy consumption cost.

The validation part of JU-LUX has also been confirmed by working on a demonstrative project 'Residential Plan' with the help of AutoCAD drawings provided by my thesis supervisor and the outcome of the same has been compared both by the softwares DIALux and JU-LUX and the results are given in Chapter IV.

I have used two different versions of DIALux as:

i.DIALux EVO V8

ii.DIALux 4.3

The parameters of the room have been taken from DIALux EVO and lighting designing, field arrangements, Isolux diagram have been taken from DIALux 4.3

JU-LUX is based on the Visual Basic (Microsoft) programming language. All the available lighting designing features are developed by implementation (Logic) of lighting design fundamental calculations from the text of research papers (as given in the reference section) as well as relevant Indian standards (ECBC /IS3646).

CHAPTER: - II Aim, Objectives, First and Second Module of JU-LUX

2.0 Aims and Objectives: -

Modern life and Lighting system go hand in hand, lighting has become an important as well as an essential part of our everyday life existence. Hence research work has been going on to enhance the efficient way of using the lighting design which is to cater. to visual comfort and uniformity without glare, with an eye on reducing consumption of energy in a cost effective way.

The lighting software is the essential key to assist the lighting designer / Engineers for new building design / planning and also for the retrofit of the existing lighting system with a more efficient one.

There are two main categories of designs:

- Replacement / Retrofit of existing lighting with efficient lighting.
- Design of lighting layout and fixtures with graphical representation and energy efficient outcome through calculations by lighting designing software program.

The aim of this thesis is to:

i. Develop a lighting design software with maximum features which can cater to both the categories as per the Indian standard named as JU-LUX.
ii. Validate JU-LUX through a 'Residential lighting design' exercise in respect of DIALux.
iii. Allow the software to ensure Cost effectiveness in terms of luminaire choice (wattage, luminance-wise and hours of burning) as per room's geometry on the basis of Indian Electricity Tariff.

The concept of JU-LUX comes in a way to find an easier or quicker way for lighting design for the lighting professional and as well as cost effective benefits for the consumers with standard lux level / to achieve visual comfort as per standard task parameters.

Expected deliverables of JU-LUX are as follows:

From a lighting designer's point of view:

- Number of luminaires required for the specific room
- Luminaire Data Base of all kinds of available items with parameters
- Luminaire Database can be modified or added as per the availability of lamps and features
- Maintaining lux level in a room through the choice of Luminaire
- Showing reference paper guidance
- Showing reference of Indian Standards (ECBC and IS3646)

- Daylight Factor verification for outdoor building construction by ECBC
- Room Index Calculation
- User defined Parameter for lux level and Luminaires
- Internet Of Things (IOT) as part of future work for auto response on drop of lux level (Switching ON / OFF Light remotely)

From Consumer's point of view:

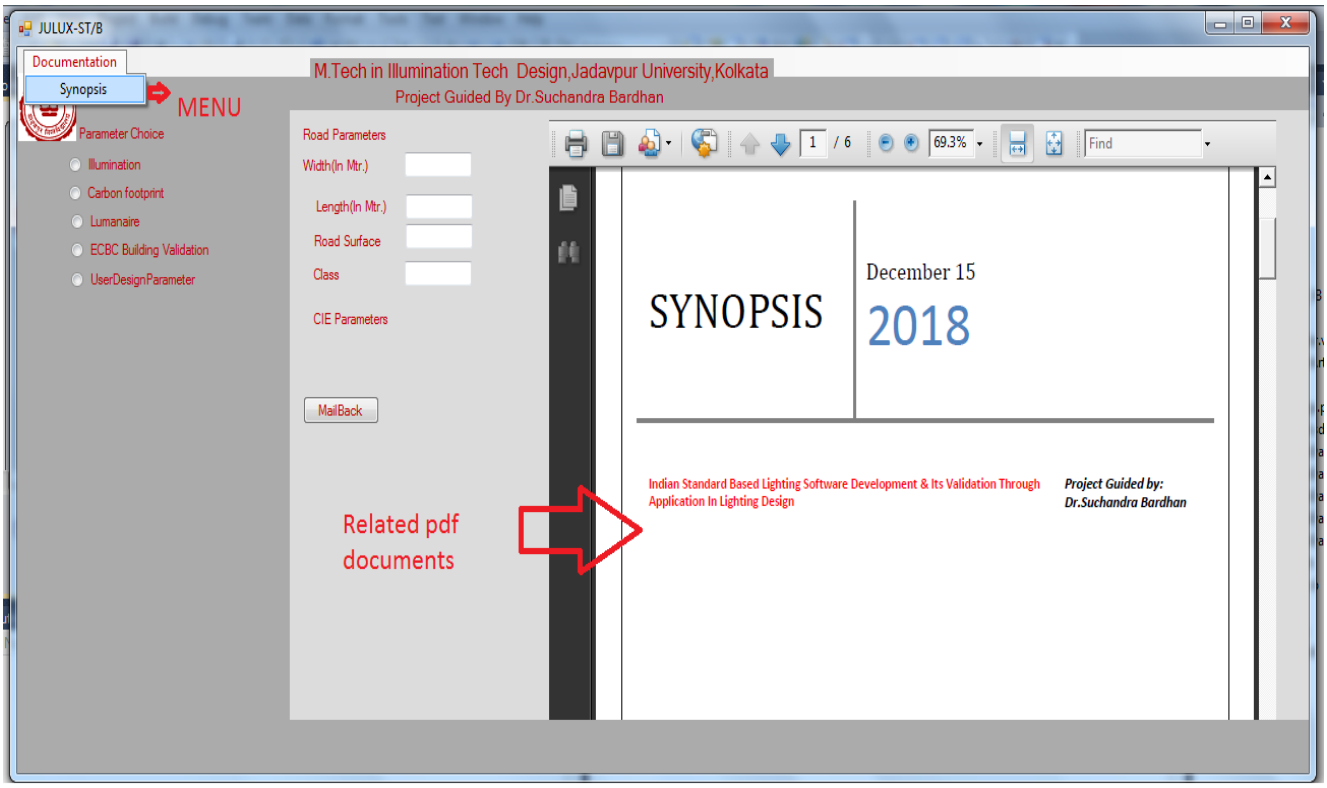
- Consumption and Cost verification (Monthly / Yearly Basis)
- Retrofitting Factors

2.1 Design Consideration based on Lumen Method (Module 1): - (Menu Bar)

The Menu bar is used in the home page of the application so that the students can go through the details of the scholars' paper or the reference paper of the related subject on which they are working with

JU-LUX 'Menu bar' Features	JU-LUX outcome
1.Menu bar : Documentation / References / Subject related Thesis paper	1.PDF of the related documents

The screen-shot of the screen appearance is given below:

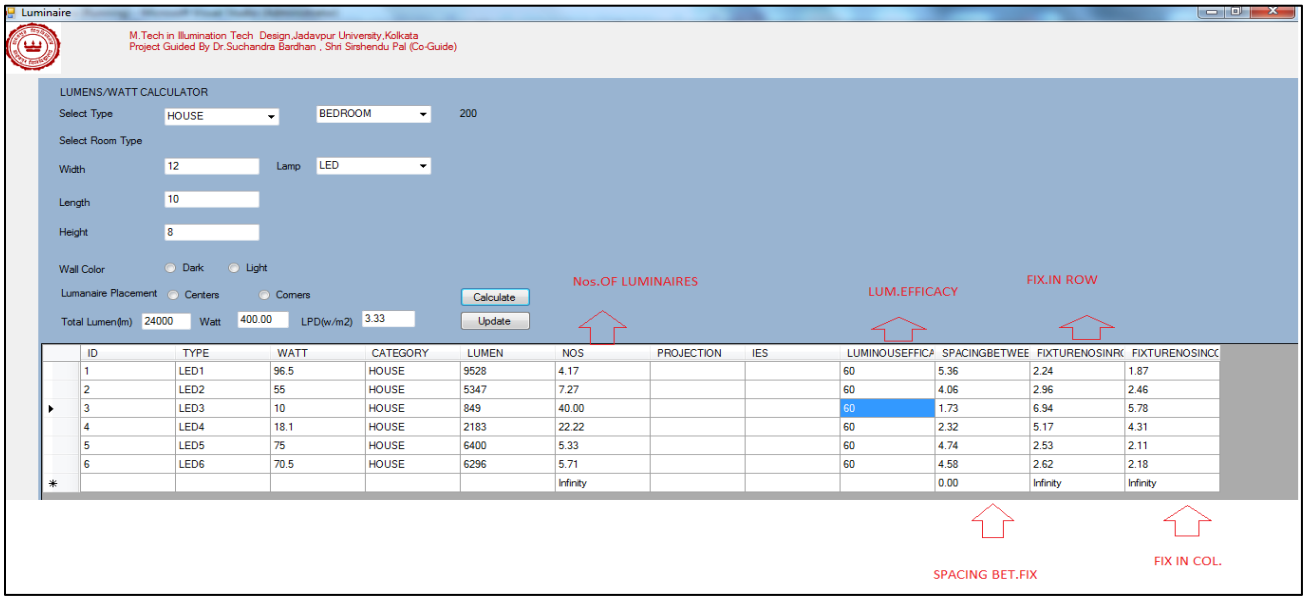


2.2 Module 2: - Luminaires

The module 2 is developed to keep in mind that in short notice of time, a lighting designer or a student dealing with the concerned field can verify the quantity of luminaries required ,spacing between the luminaries, numbers of luminaries in row & column to maintain the standard 'lux' value of the selected room from the drop down list.

Input Data	Output Data	Formula Used
1.Select Type : House Hold/Commercial etc. (For Ex) 2.If it is House Hold then room type :Bedroom/Kitchen etc(For Ex) 3.Select Room Dimension: Length/Width/Height 4.Wall Color: Dark /Light 5.Lumanaire Placement: Centre / Corners	1.Total Lumen 2.Watt 3.LPD(W/m2) 4. Number of Luminaries required as per the various type of luminaries stored in database with spacing of fixture arrangements.	1.Watt=[(Lux X Area)/Efficacy] 2.LPD=(Watt/Area) 3.Nos=(Total watt /Watt per Luminaire) 4.Spacing between the fixtures= sqrt (Total area / Nos) 5.Fixture nos in row= (Width / Spacing) 6. Fixture nos in column= (Length / Spacing)

The screen-shot of the screen appearance is given below:



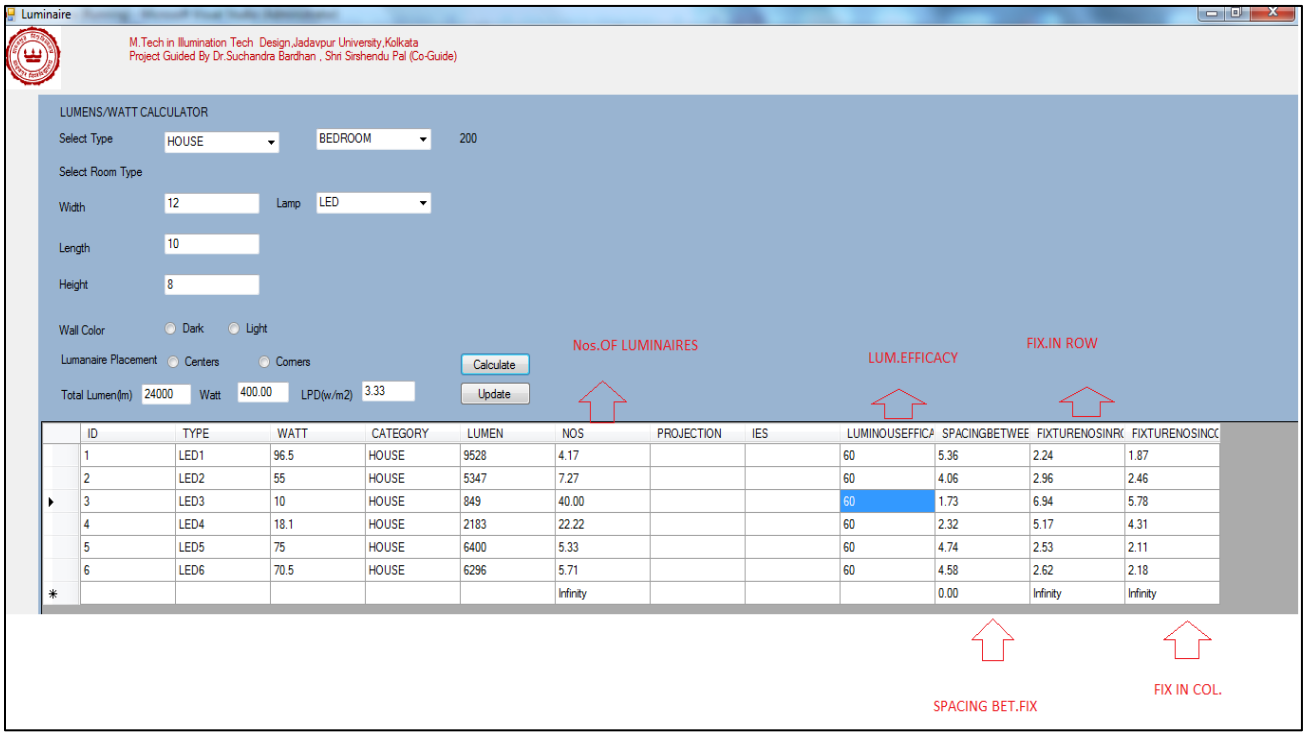
2.3 Advance Features (Module 2): - Selection of Room

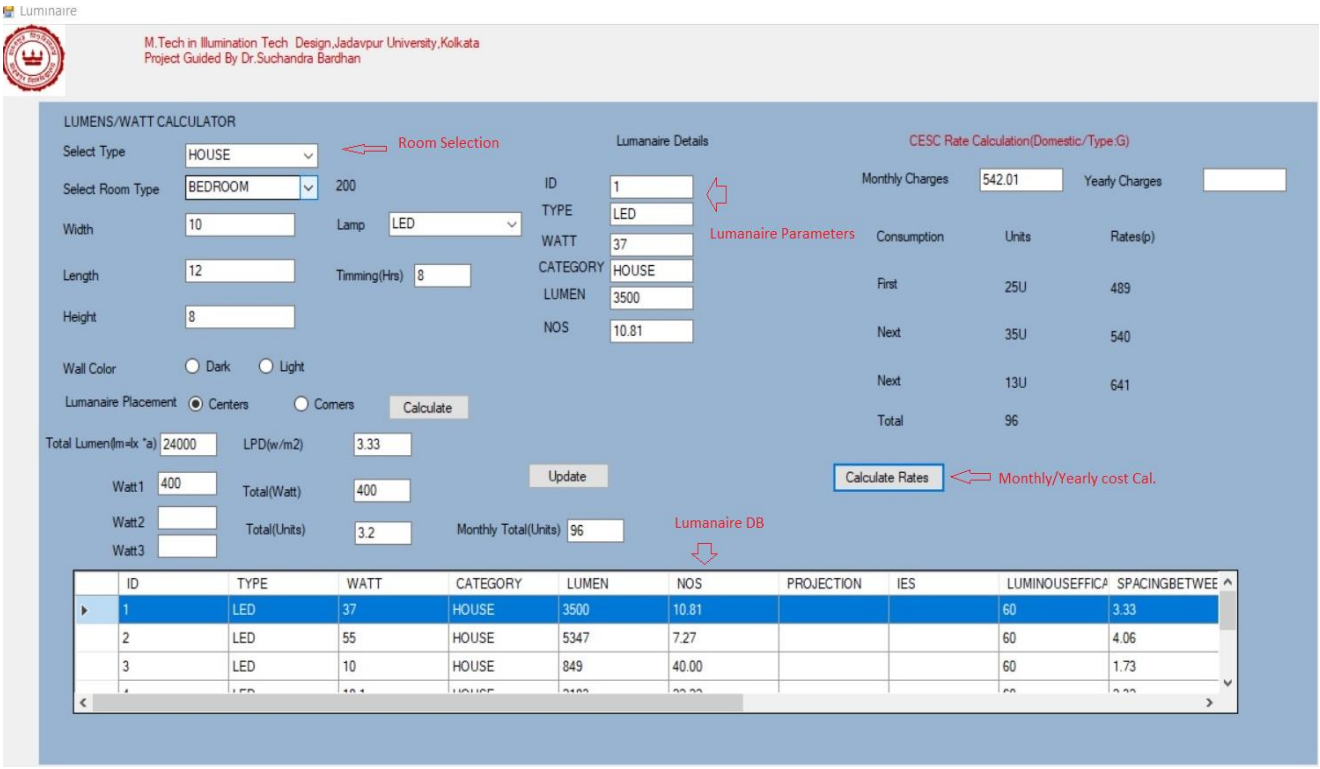
The feature simply provides a choice of selection of room with dimension, luminaire type , Burning hours etc . By selecting the choices of room with the specification and the lumanaire the wattage and consumption units will get added and the calculation will be made.

First example :

JU-LUX selction criteria			
JU-LUX input selection parameters		JU-LUX output parameters	
Select Type	House	Watt 1	400
Select Room Type	Bedroom	Units /Monthly Units	3.2 / 96
Lumanaire Type	LED	Monthly Charges	542.01
Burning Hours	8 Hrs(For Example)		
Lux level	200 lx		

The screen-shot of the screen appearance is given below:





2.3.1 Input Procedures: -

Step I: First select the room

Step II: Dimensions of the room

Step III: Type of Luminaire i.e LED/FL/MH

Step IV: Press the button to calculate the Total Lumen required for the room and the wattage required.

Step V: The module will give the details of the total wattage of consumption on daily and monthly basis. It will also give the details of the monthly Unit consumption.

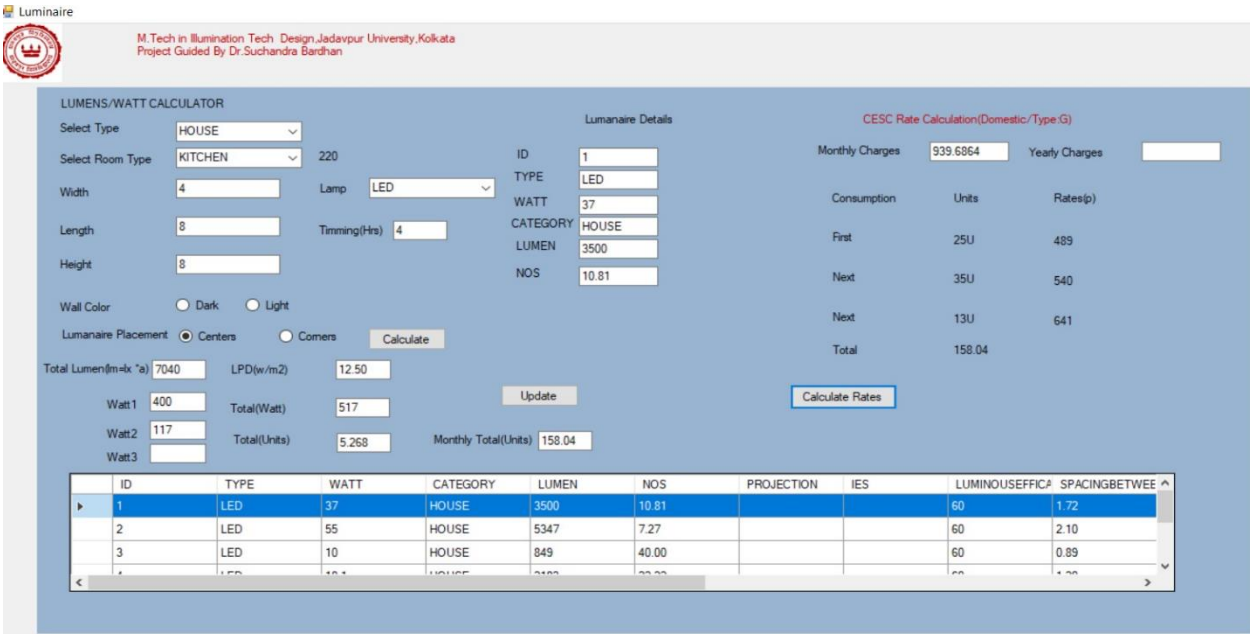
- In case of the additional area of lighting, the wattage will be added and the calculation deduced also will be adjusted as per the added wattage of consumption.

Step V: Upon Pressing the button “Calculate Rates” the total monthly / Yearly charges to be applicable for the electricity consumption will be displayed. [Ref. The charges are calculated as per the current 2019 Calcutta electricity supply corporation (CESC) ratings]

2.3.2 Selection of Other Room (Kitchen Area): -

JU-LUX selection criteria			
JU-LUX input selection parameters		JU-LUX output parameters	
Select Type	House	Watt 2	117
Select Room Type	Kitchen	Accumulated Units /Accumulated Monthly Units	5.2 / 150.04
Lumanaire Type	LED	Total Monthly Charges	939.65
Burning Hours	4 Hrs(For Example)		
Lux level	220 lx		

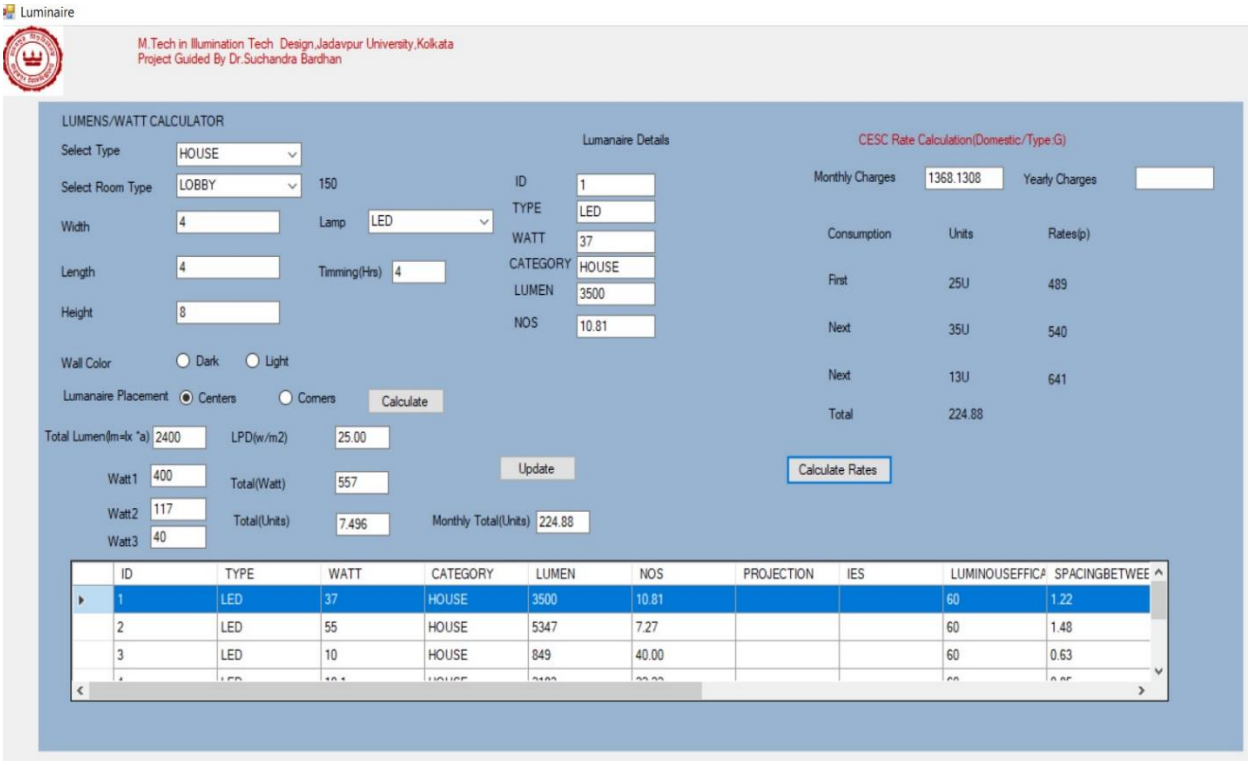
The screen-shot of the screen appearance is given below:



2.3.3 Selection of Other Area (Lobby): -

JU-LUX selection criteria			
JU-LUX input selection parameters		JU-LUX output parameters	
Select Type	House	Watt 2	40
Select Room Type	Lobby	Accumulated Units /Accumulated Monthly Units	7.4 / 150.04
Lumanaire Type	LED	Total Monthly Charges	1368.13
Burning Hours	4 Hrs(For Example)		
Lux level	150 lx		

The screen-shot of the screen appearance is given below:



CHAPTER: –III Third Module JU-LUX - ECBC Daylight

3. ECBC Daylight Standard Rules for Building: -

Floor areas above ground level should meet or exceed the Useful Daylight Illuminance (UDI) area requirements listed in Table 3-0 for 90% of the potential daylit time in a year. Mixed-use buildings shall now comply as per the criteria prescribed in para 2.5 of BEE-ECBC rules of 'Building Classification'. Demonstration may comply either through daylighting simulation method as in para 4.2.3.1 'Daylighting Simulation Method' or the manual method as per para 4.2.3.2 'Manual Daylighting Compliance Method' of ECBC 2017. *"Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 3-0". (ECBC)*

Table 3-0 Daylight Requirement (As per BEE-ECBC 2017)

Building Category	Percentage of above grade floor area meeting the UDI requirement		
	ECBC	ECBC+	Super ECBC
Business, Educational	40%	50%	60%
No Star Hotel Star Hotel Healthcare	30%	40%	50%
Resort	45%	55%	65%
Shopping Complex	10%	15%	20%
Assembly*	Exempted		
*and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area 4			

3.1 Daylighting Simulation Method: -

Only BEE approved software shall be used to demonstrate compliance through the daylighting simulation method. Buildings shall achieve illuminance level between 100 lux and 2,000 lux for the minimum percentage of floor area prescribed in Table 3.1.0 for at least 90% of the potential daylit time. Illuminance levels for all spaces enclosed by permanent internal partitions (opaque, translucent, or transparent) with height greater or equal to 2 m from the finished floor, shall be measured as follows.

Table 3.1.0 Daylight Requirement as per BEE-ECBC 2017:

Building Category	Percentage of above grade floor area meeting the UDI requirement		
	ECBC	ECBC+	Super ECBC
Business, Educational	40	50	60
No Star Hotel Star Hotel Healthcare	30	40	50
Resort	45	55	65
Shopping Complex	10	15	20
Assembly	Exempted		
*and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area			

(a) Standard measurements should be taken at a work plane height of 0.8 m above the finished floor.

(b) The period of analysis shall be fixed for 8 hours per day, in between 8:00 AM to 5:00 PM as per Indian Standard Time, for all building types excepting Schools. Schools shall be analyzed for 7 hours per day, anytime between 7:00 AM to 3:00 PM as per Indian Standard Time.

(c) Spaces with available useful daylight should be measured based on point-by point grid values. *"UDI shall be calculated for at least one point for each square meter of floor area.*

(d) All surrounding natural or man-made daylight obstructions shall be modeled if the distance between the façade of the building (for which compliance is shown) and surrounding natural or man-made daylight obstructions is less than or equal to twice the height of the man-made or natural sunlight obstructers. If the reflectance of the surfaces is not known, default reflectance of 30% and 0% shall be used for all vertical surfaces of man-made and natural obstructers respectively.

(e) Actual material specification will determine interior surface reflectance. In case of unavailability of material specification, the following default values may be used.

(f)Working upon the details provided in the material specification sheet, fenestration should be modeled with actual Visible Light Transmission (VLT)". (ECBC)

Table 3.1.1 Default Values for Surface Reflectance as per BEE-ECBC 2017

Default Values for Surface Reflectance as per BEE-ECBC 2017	
Surface Type	Reflectance
Wall or Vertical Internal Surfaces	50%
Ceiling	70%
Floor	20%
Furniture (permanent)	50%

3.2 Manual Daylighting Compliance Method: -

In the absence of any kind of simulation, the above-mentioned method can be applied for compliance of demonstration with daylighting requirements. For manual calculation of percentage of the space above the ground floor area, meeting the requirements of useful daylight illuminance (UDI), counting up to 90% of the potential daylit time yearly, Daylight Extent Factors (DEF) mentioned in Table 3.1.2 shall be used.

3.3 Daylight Extent Factors (DEF) for Manually Calculating Daylight Area as per BEE-ECBC 2017: -

Table 3.1.2

Shading	Latitude	Window Type	VLT < 0.3				VLT ≥0.3			
			North	South	East	West	North	South	East	West
No shading or PF < 0.4 ≥	>15°N	All window types	2.5	2.0	0.7	0.5	2.8	2.2	1.1	0.7
	< 15°N		2.4	2.0	1.3	0.6	1.7	2.2	1.5	0.8
Shading with PF ≥ 0.	All latitudes	All window types without light shelf	2.8	2.3	1.5	1.1	3.0	2.5	1.8	1.5
		Window with light shelf	3.0	2.5	1.8	1.6	3.5	3.0	2.1	1.8

3.4 Daylight Area Calculation as per ECBC 2017: -

In comparison to the amount of available unobstructed outside daylight under overcast sky conditions, the available amount of daylight inside a room comes down to a percentage, which is the expression for the Daylight factor.

The size, distribution, location and transmission properties of the façade, roof windows and space configuration, together with the reflective properties of the internal and external surfaces determine the magnitude as well as the distribution of the daylight factor in a space. The degree to which external structures obscure the view of the sky is an influencing factor.

(a)In accordance with the standard rules of ECBC 2017 the daylit area may be calculated in the following methods:

"i. In a direction perpendicular to the fenestration, multiply Daylight Extent Factor (DEF) by the head height of the fenestration or till an opaque partition higher than head height of the fenestration is prominent. whichever is less needs to be taken into account.

ii. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition, or one-half the distance to an adjacent fenestration, whichever is least.

iii. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least" (ECBC).

(b) Detailed daylit areas marked on the floor plans can help in the fruition of a distinct architectural plan. A summary provided in table 3.1.0 may be referred for studying the level of compliance.

(c) Glazed façades, having an orientation within within ± 45 degrees of the cardinal direction, are generally non-cardinal in feature, which can be further categorized under a particular cardinal direction.

(d) The ECBC method does not take into consideration any natural or man-made daylight obstruction. (ECBC)

3.5 Module 3: - JU-LUX ECBC Daylight Factor

The above module has been developed with the reference of manual method calculation of UDI measurement and calculation for daylight area meeting UDI from ECBC 2017, where building location and design can be validated by the standards of ECBC daylight factor. The application also contains the detailed table factors of the 'Daylight Extended Factor'. By this application a lighting designer can easily verify the ECBC building daylight factor validation within a short period of time.

JU-LUX input selection data parameters **Source:** ECBC 2017 Pg.51 Manual Method	**JU-LUX output data parameters**
1. **Building Category:** Residential/Education/Commercial etc Day Light Factors (DEF) i. 1.Shading with PF ii. 2.Latitudes iii. 3.VLT iv. 4.Windows with light shelf v. 5.Directions: North/South/East/West etc Building Parameters for calculating daylight meeting UDI i. 1.Total area ii. 2.Window Height iii. 3.Window/Fenestration width	1.Daylight Extent Factors (DEF):- i. North UDI ii. South UDI iii. East UDI iv. West UDI v. Calculation for daylight area meeting UDI 7.Total daylight area in building meeting UDI requirement during 90% of the year 8.Percentage of the area Design validation notification as

The screen-shot of the screen appearance is given in the next page below:

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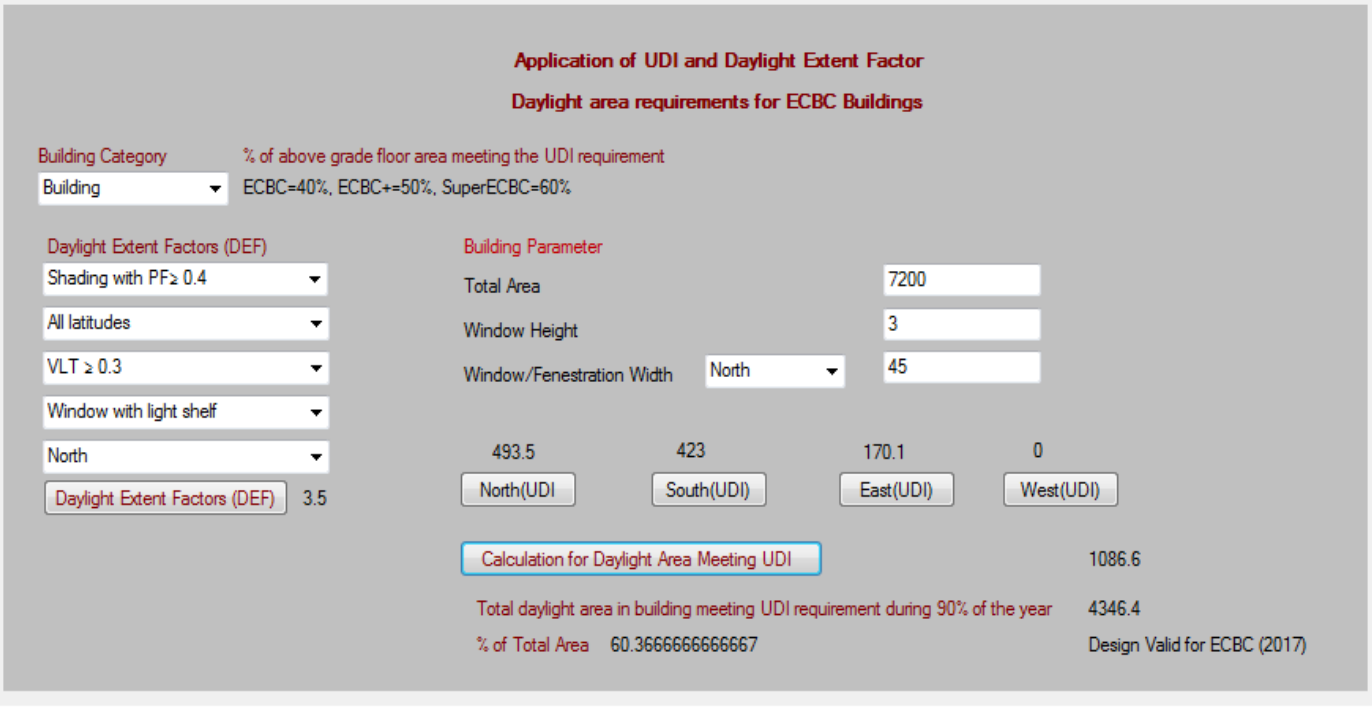
Project Guided By Dr.Suchandra Bardhan



CHAPTER: –IV Fourth Module- JU-LUX and Lighting Definitions

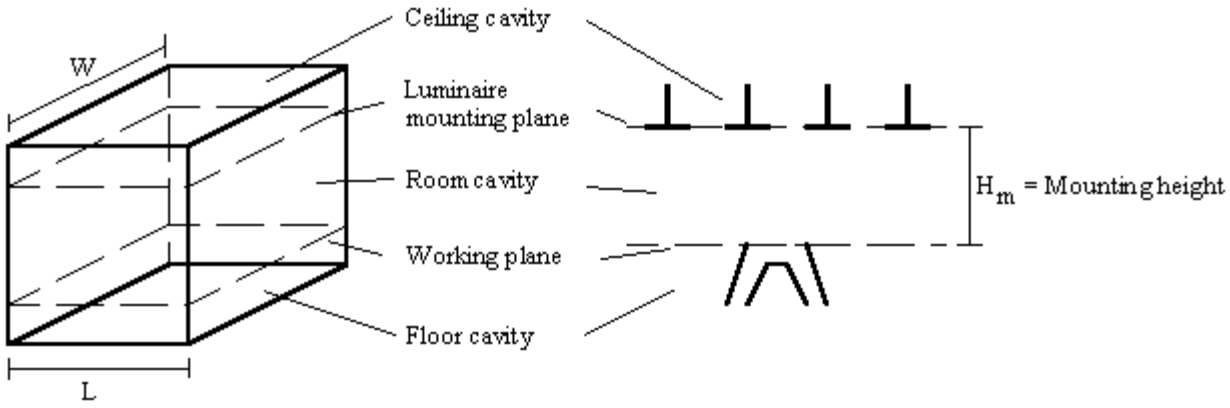
4. Few Standard Lighting Calculation and Definitions: -

The design of JU-LUX as already mentioned in chapter II section 2.1 that it is based on the Lumen Method and also other lighting fundamental calculations as are described below:-

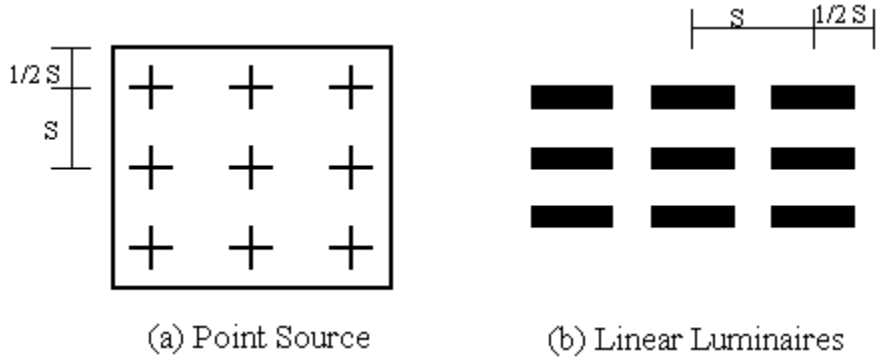
i. Lumen Method: -

Required Light Output/Fixture (Lumens) = (Maintained Illumination in Foot candles x Area in Square Feet) ÷ (Number of Fixtures x Coefficient of Utilization x Ballast Factor x Light Loss Factor)

The **lumen method** is applicable to design a uniform (general) lighting scheme in a space where flexibility of working locations or other activities is required.



The lumen method is applied only to square or rectangular rooms with a <u>regular array</u> luminaire as shown in Figure below. (lumen)



(a) Point Source (b) Linear Luminaires

ii. Foot-candles & Lumens: -

Foot-candles (fc) = Total Lumens (lm) ÷ Area in Square Feet

1 Lux (lx) = 1 Foot-candle (fc) x 10.76

Lux = Total Lumens ÷ Area in Square Meters

iii. Light Loss Factors (more on Light Loss):-

Light Loss Factor (LLF) = Ballast Factor x Fixture Ambient Temperature Factor x Supply Voltage Variation Factor x Lamp Position Factor x Optical Factor x Fixture Surface Depreciation Factor x Lamp Burnouts Factor x Lamp Lumen Depreciation Factor x Fixture Dirt Depreciation Factor x Room Surface Dirt Depreciation Factor

Lamp Burnout Factor = 1 - Percentage of Lamps Allowed to Fail Without Being Replaced

iv. Calculating the number of luminaires needed to achieve a given average illuminance (E_{avg}) at the work plane: -

Mean Illuminance may be derived from the requirements to be met for the planned activity or type of interior (DIN 5035 Part 2).

A luminaire is selected

Floor space is calculated as: length of room x width of the room (m^2).

Utilisation factor may be assumed as UF .

Number of lamps per luminaire be z.

The luminous flux of a lamp be Φ (lm).

The design factor p may be determined to take account of dirt accumulation in the room and the luminaires and lamp's ageing factor. The factor usually comes down to 1.25, but this figure could vary depending on the increased account of dirty or dusty environment.

The number n of luminaires may now be calculated

The value for n is to be rounded off to obtain a whole number of luminaires and a logical luminaire configuration, for the interior, e.g. 7.7 = 9 (for 3 x 3 luminaires). (DIALUX - EVO)

v. Calculating mean illuminance E available at the work plane in the long term with the planned lighting system: -

i. The utilisation factor is assumed as ηB.
ii. The planned number of luminaires for the room be supposed as n.
iii. The Number of lamps per luminaire be taken as z.
iv. Let the rated luminous flux of a lamp be Φ.
v. Let the design factor be p and the floor space be A respectively
vi. Average illuminance may be Calculated as Eavg. (DIALUX - EVO)

$$\bar{E} = \frac{\eta_b * z * \Phi * n}{p * A}$$

vi. Luminous flux:-

The luminous flux describes the quantity of light emitted by a light source. The luminous efficiency is the ratio of the luminous flux to the electrical power consumed (lm/W). It is a measure of a light source's economic efficiency. (lichthandbuch)

Abbreviation: Φ Phi Unit: lm Lumen

vii. Luminous intensity: -

The luminous intensity describes the quantity of light that is radiated in a particular direction. This is a useful measurement for directive lighting elements such as reflectors. It is represented by the luminous intensity distribution curve (LDC). (lichthandbuch)

Abbreviation: I Unit: cd Candela

viii. Illuminance: -

Illuminance describes the quantity of luminous flux falling on a surface. Relevant standards specify the required illuminance (e.g. EN 12464 "Lighting of indoor workplaces"). (lichthandbuch)

Illuminance: E(lx) = luminous flux (lm) area (m2)

Abbreviation: E Unit: lx Lux

ix Luminance: -

Luminance is the only basic lighting parameter that is perceived by the eye. It describes on one hand a light source's impression of brightness, and on the other, a surface and therefore depends to a large extent on the degree of reflection (colour and surface). (lichthandbuch)

Abbreviation: L Unit: cd/m2

x. Lamp Lumen Maintenance Factor (lumen):-

Lamp lumen maintenance factor (LLMF) is the proportion of the initial light output of a lamp produced after a set time to those produced when new. It allows for the decline in lumen output from a lamp with age. Its value can be determined in two ways:

(a) by consulting a lamp manufacturer's catalog for a lumen depreciation chart, and

(b) by dividing the maintained lumens by the initial lamps.

xi. Room Proportion (*lumen*):-

a. Calculating the Room index: -

The ratio of room plan area will be determined as half of the wall area between the working planes and luminaire planes.

$$RI = \frac{L \times W}{H_m \times (L + W)}$$

where L = length of room

W = width of room

Hm = mounting height, that is the vertical distance between the working plane and the luminaire. (lumen)

b. Calculating room reflectance: -

The room is considered to consist of three main surfaces:

(a) Ceiling cavity

(b) Walls

(c) Floor cavity (or the horizontal working plane).

The effective reflectance of the above three surfaces affect the quantity of reflected light received by the working plane.

c. Spacing to Height Ratio (*lumen*):-

Spacing to Height ratio (SHR or S/Hm) is defined as the ratio of the distance between adjacent luminaires (centre to centre), to their height above the working plane. For a rectangular arrangement of luminaires and by approximation,

$$SHR = \frac{1}{H_m}\sqrt{\frac{A}{N}}$$

where A = total floor area

N = number of luminaires

Hm = mounting height

Under a regular array of luminaires the illuminance on the working plane is not uniform. The closer spaced the luminaires are for a given mounting height, the higher the uniformity or the greater the mounting height for a given spacing, the greater the uniformity.

Uniformity of illuminance has to have acceptable norms for general lighting. *(lichthandbuch)*

(a) Space to height ration (SHR) should not exceed maximum spacing to height ratio (SHR MAX) of the given luminaire as quoted by the manufacturer.

(b) Mean geometric spacing to height ratio of the luminaire layout should be within the range of nominal spacing to height ratio (SHR NOM) of the given luminaire as quoted by the manufacturer that is:

$$\sqrt{\text{SHR (axial)} \times \text{SHR (transverse)}} = \text{SHR NOM} \pm 0.5$$

xii. Quality characteristics of lighting as per (*lichthandbuch*):-

- Traditional quality criteria
- Sufficient illumination level
- Harmonious brightness distribution
- Glare limitation
- Avoidance of reflections
- Good modelling
- Correct light colour
- Appropriate colour rendering

xiii. Visual Performance/Visual Efficiency as per (*lichthandbuch*): -

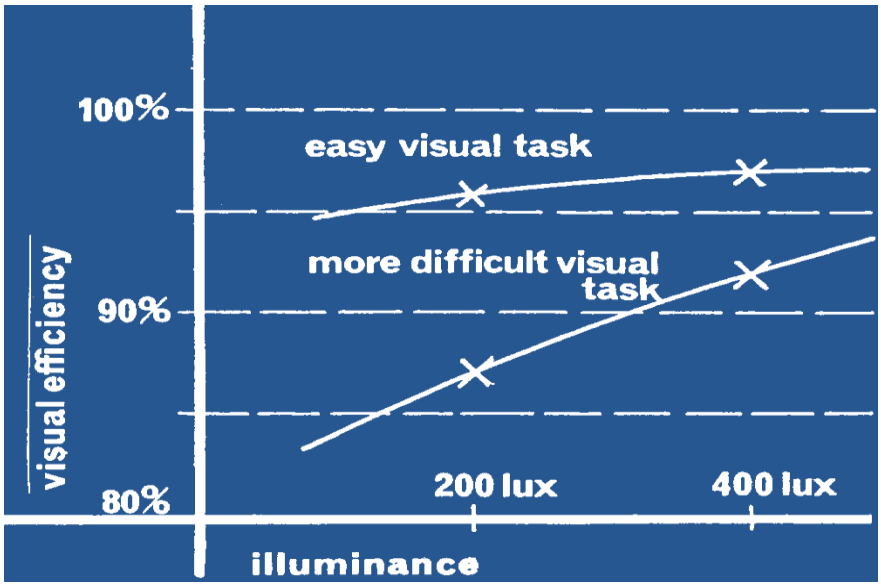
Visual performance or visual efficiency is the ratio based. It actually takes into account performance under less than ideal illumination to that under ideal illumination. Being a time taking process, Performance may be affected by such factors as the gravity of the task in hand, productivity and others.

The effect of illuminance on visual performance is shown in Figure below, which has the following points:

(i) Increasing the illuminance on the task produces an increase in performance following a law of diminishing returns.

(ii) The illuminance at which performance levels off, is dependent on the visual difficulty of the task. In short, the more difficult the task, the higher the illuminance at which performance culminates.

(iii) Merely by increasing illuminance, it is impossible to effect a similar level of performance on upon a difficult visual task.



xiv. Visual task area: -

Illuminance levels are specified for specific visual tasks and are designed for the area in which these may take place. If the exact location is unknown, the room as a whole or a defined area of the workstation is used for specification. The visual task area may be a horizontal, vertical or inclined plane. With regards to the area immediately surrounding the visual task area, illuminance may be one level lower than in the visual task area (e.g. 300 lx to 500 lx)

xv. New quality criteria: -

- Changing lighting situations
- Personal control
- Energy efficiency
- Daylight integration
- Light as an interior design element

xvi. Lighting Criteria: -

In lighting situations, it is necessary to consider:

(i) the way the task is lit, and

(ii) the way the interior as a whole is lit and relates to the task.

xvii. Task Illuminance: -

The illuminance needed for the task depends on:

(i) The visual difficulty and complexity of the task,

(ii) The average standard of eyesight, and

(iii) The level of visual performance required.

Table 4.0 Standard Service Illuminance for Various Activities/Interiors: -

Standard illuminance (lx)	Characteristics of the activity/interior	Representative activities/interiors
50	Interiors visited rarely with visual tasks confined to movement and casual seeing without perception of detail.	Cable tunnels, indoor storage tanks, walkways.
100	Interiors visited occasionally with visual tasks confined to movement and casual seeing calling for only limited perception of detail.	Corridors, changing rooms, bulk stores.
150	Interiors visited occasionally with visual tasks requiring some perception of detail or involving some risk to people, plant or product.	Loading bays, medical stores, switchrooms.
200	Continuously occupied interiors, visual tasks not requiring any perception or detail.	Monitoring automatic processes in manufacture, casting concrete, turbine halls.
300	Continuously occupied interiors, visual tasks moderately easy, i.e. large details > 10 min arc and/or high contrast.	Packing goods, rough core making in foundries, rough sawing.

500	Visual tasks moderately difficult, i.e. details to be seen are of moderate size (5-10 min arc) and may be of low contrast. Also colour judgment may be required.	General offices, engine assembly, painting and spraying.
750	Visual tasks difficult, i.e. details to be seen are small (3-5 min arc) and of low contrast, also good colour judgments may be required.	Drawing offices, ceramic decoration, meat inspection.
1000	Visual tasks very difficult, i.e. details to be seen are very small (2-3 min arc) and can be of very low contrast. Also accurate colour judgments may be required.	Electronic component assembly, gauge and tool rooms, retouching paintwork.
1500	Visual tasks extremely difficult, i.e. details to be seen extremely small (1-2 min arc) and of low contrast. Visual aids may be advantage.	Inspection of graphic reproduction, hand tailoring, fine die sinking.
2000	Visual tasks exceptionally difficult, i.e. details to be seen exceptionally small (< 1 min arc) with very low contrasts. Visual aids will be of advantage	Assembly of minute mechanisms, finished fabric inspection.

xviii. General Brightness (lumen)

Table 4.1 Recommended Illuminance Ratios and Surface Reflections

	Recommendations
Illuminance ratios: (a) Minimum illuminance/average illuminance (A.I.) on task area (b) In an interior with general lighting,	0.8 min.
A.I. on the ceiling / A.I. on the horizontal working plane	0.3 - 0.9
A.I. of any wall / A.I. on the horizontal working plane	0.5 - 0.8

(c) In an interior with localised or local lighting, the ratio of illuminance on the task area to illuminance around the task area	3 : 1 max.
Surface reflectance: (a) Ceiling cavity (b) Principal walls (c) Window wall surfaces (d) Floor cavity (e) Equipment and furnishings in work interiors (e.g. desk top) (f) Immediate background to a task (g) Ratio of reflectance of the immediate background to reflectance of the related task (h) Large surface areas, e.g. on the ceiling or upper walls where indirect lighting is used.	 0.6 min. 0.3 - 0.7 0.6 min. 0.2 - 0.3 0.2 min. Matt 0.3 - 0.5 Gloss finished not recommended

xix. Glare (lumen)

Glare is the discomfort or impairment of vision experienced when parts of the visual field are excessively bright in relation to the general surroundings.

i. **Disability Glare**
ii. **Discomfort Glare**
iii. **Reflected Glare**
iv. **Veiling Reflection**
v. **Control of Glare**

Table 4.2 Limiting Glare Index

Limiting glare index	Applications
16	Museums, art galleries, lecture theatres, control rooms, industrial inspection.
19	Classroom, libraries, laboratories, general offices, fine assembly work.
22	Supermarket, circulation areas, medium assembly work.
25	Boiler houses, rough assembly work.
28	Foundries, works store areas.

Glare is controlled by the following means:

(i) To limit the luminance of the lighting sources in the direction of the eye, e.g. replacing bright source with a number of weak sources

(ii) To screen the light sources from the view, e.g. introducing down stand screens or light-diffusing fittings to the luminaires

(iii) To reposition the work station

(iv) To use working surfaces, paper, office machines etc. that have matt surface

(v) To raise the background luminance against which the luminance sources are seen

(vi) To construct external obstructions or low transmittance glass to limit daylight penetration

(vii) To construct windows on adjacent or opposite walls to reduce contrast.

xx. Colour Quality

The quality of colour is characterized by its colour appearance and its colour rendering capabilities. The colour rendering parameters are shown in Table 4.3 as follows: -

i. **Colour Appearance**
ii. **Colour Rendering**

Table 4.3 Colour Rendering Groups

Colour rendering group	CIE general colour rendering index	Typical application
1A	Ra ³ 90	Wherever accurate colour matching is required, e.g. colour printing inspection.
1B	80 £ Ra < 90	Wherever accurate colour judgments are necessary and/or good colour rendering is required for reasons of appearance, e.g. shops and other commercial premises.
2	60 £ Ra < 80	Wherever moderate colour rendering is required.
3	40 £ Ra < 60	Wherever colour rendering is of little significance but marked distortion of colour is un acceptable.
4	20 £ Ra < 40	Wherever colour rendering is of no importance at all and marked distortion of colour is acceptable.

xxi. Illuminance Lux level as per IS3646 as shown in table 4.4: -

Table 4.4 Illuminance Lux level by IS3646(part 1):1992

Type of Interior	Illuminance in Lux	Quality class of direct glare limitations	Remarks
Bed rooms	30-50-100	-	Supplementary local lighting at the bed head, writing table should be provided
Bath rooms	50-100-150	-	Supplementary local lighting near the mirror is desirable
Reading rooms	200-300-500	-	
Entrance halls, lobbies, waiting rooms	150-200-300	-	
Corridors, passageways, stairs	50-100-150	-	

4.1 Module: -IV JU-LUX User Design Parameters: -

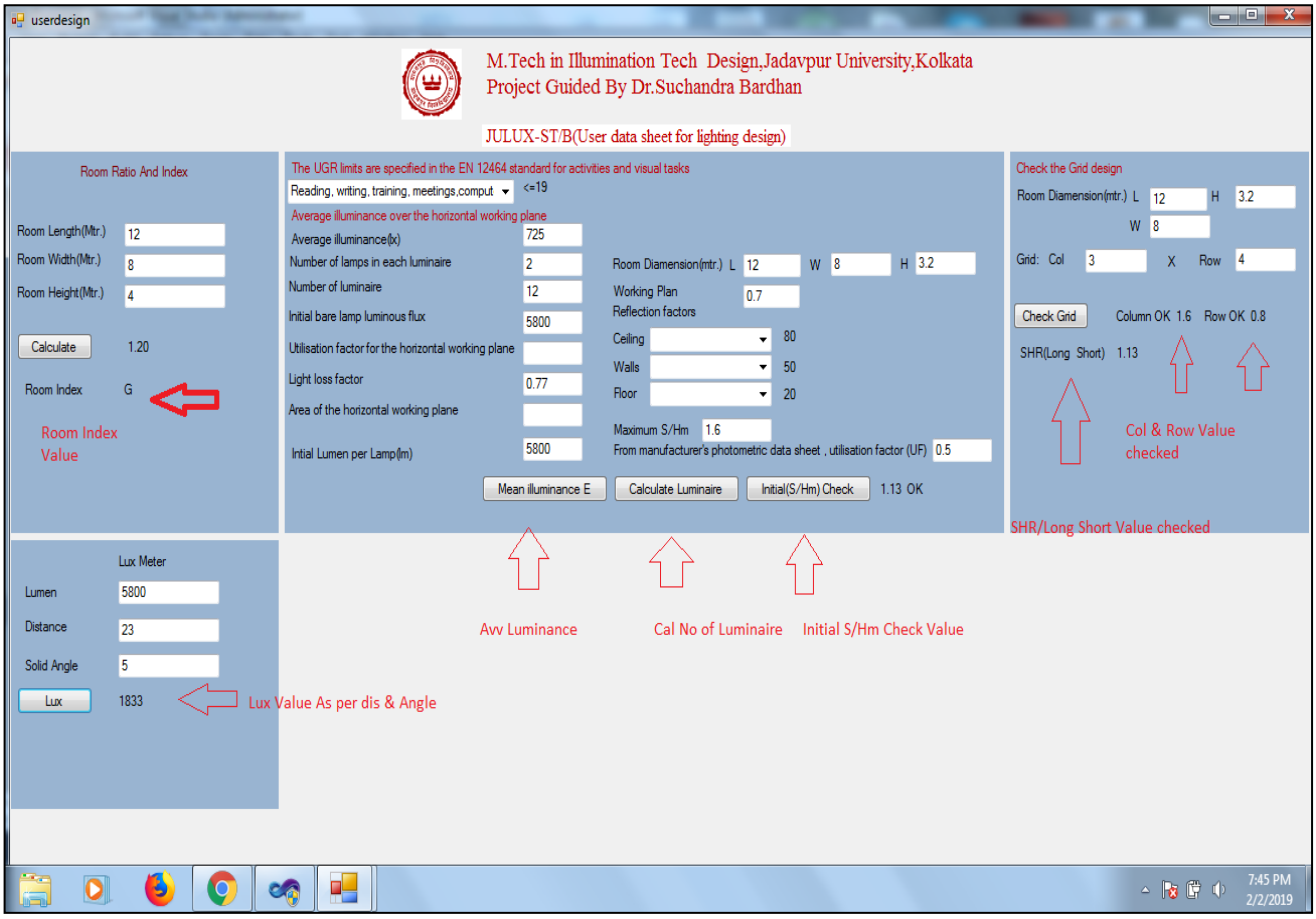
This module has been developed for the user design parameter for the lighting designer to find out the Room Index value, Number of luminaries required to achieve the required 'Lux' level by providing the details of few parameters such as:

i. Required lux value
ii. Room dimension
iii. LLF
iv. UF
v. Lumen value of each Luminaries
vi. No. of lamps per Luminaries

Table 4.5 JU-LUX Input Output Parameters: -

Input Data	Output Data	Formula Used Source: Reference Paper-I
1.Room Dimension: Length(m) Width(m) Height(m) 2.UGR value as per task 3.Avg. luminance over the horizontal working plane • AvgIlluminance (lx.) • No of lamps in each Luminaire • Initial bare lamp Luminous flux • Utilisation factor for horizontal working plane • LLF • Area of Hor.Working plane • Initial Lumen per Lamp(lm) **Check Grid Deigns of Luminaries Arrangements** 1.Room Diamensions: Length Height Width 2.Column And Row Arrangements **Lux Meter:** • Lumen • Distance • Solid Angle **Under Process of development** 1.E-mail auto response are in process of development while the lux level drops from its standard specified value.	1.Room Index value & Abbreviation number. 2.UGR Value(For.Ex<=19) 1.Min.Illuminance 2.Cal.No Of Luminaire 3.Initial(S/Hm Check) 4.Vrification of no. of col & row of Luminaries 5.Calculate Lux Value	1.The lumen Method= $E = \frac{n \times N \times F \times UF \times LLF}{A}$ 2.LLF= $LLF = LLMF \times LMF \times RSMF$ 3.Room Index= $RI = \frac{L \times W}{H_m \times (L + W)}$ 4.Spacing with Height Ratio= $SHR = \frac{1}{H_m}\sqrt{\frac{A}{N}}$ 5.**Notes**: Under a regular array of luminaires the illuminance on the working plane is not uniform. The closer spaced the luminaires for a given mounting height, the higher the uniformity; or the greater the mounting height for a given spacing, the greater the uniformity. If uniformity of illuminance is to be acceptable for general lighting, (a) SHR should not exceed **maximum spacing to height ratio** (SHR MAX) of the given luminaire as quoted by the manufacturer, and (b) geometric mean spacing to height ratio of the luminaire layout should be within the range of **nominal spacing to height ratio** (SHR NOM) of the given luminaire as quoted by the manufacturer, i.e. $\sqrt{SHR\,(axial) \times SHR\,(transverse)} = SHR\ NOM \pm 0.5$

The screen-shot of the screen appearance is given below:



CHAPTER: – V Usage of Software for Lighting Design & DIALux Functionality

5.0 Different types of Lighting Simulation Softwares and their uses: -

There are different types of lighting simulation softwares are described in table 5.0.1 as shown below: -

Table 5.0.1: *Lighting design softwares*

Sl. No.	Title	Description
1	DIALux	DIALux is a free lighting designing software for both indoor and outdoor lighting with daylight and artificial light scenarios.
2	OptiWin 3D pro	A free lighting design program for a building or renovation project by importing large 3D models for LENI (Lighting energy numeric indicator) calculations, lux level calculation and also simple calculation of emergency lighting.
3	Vectorworks Spotlight	It is the industry-leading design software for the landscape lighting, urban lighting and entertainment business that is for stage lighting with 2D and 3D capabilities, import and export capabilities available, as well as support for AutoCAD, Rhino, Photoshop, and Cinema 4D.
4	TracePro	Integrated software environment that helps to complete almost any task in contemporary illumination design. It also provides advanced tools for designing medical devices, illumination, display backlights, automotive lighting, and for other applications.
5	LiteStar 4D	A software for interior and exterior lighting design
6	MA Lighting software	Lighting design software for indoor and outdoor stage lighting
7	Visual 3D	This type of lighting design is used for many outdoor lighting scenarios e.g. parking lots and exterior facade lighting. Visual design tools can be used to quickly calculate scenarios with simple geometrics where inter-reflected light will not significantly effect the resulting illuminance.
8	AGi32	A lighting design software for providing numeric and rendered solutions for almost any lighting application, interior or exterior, including roadway and day-lighting.
9	Relux	Free lighting design software for indoor, outdoor and tunnel lighting
11	OptisWorks	This type of software is for scientific simulation of light effect- light levels, light distribution, photometric performance and light colour with respect to human visualization within a virtual reality environment. OPTIS cross-platform software products designed to work with different CAD software packages. Application areas are mostly in automotive lighting, aerospace lighting, traffic light, illuminated road signs, LED backlight and indoor

		lighting, in automotive lighting system intelligent automated adaptive lighting effect can be created by using this software to enhance driver safety, good mood and visual comfort.
12	Radiance	Radiance is a free open-source suite of programs for the analysis and visualisation of lighting in design. Its most powerful and robust software platform for computing the effects of architectural lighting and daylighting.
13	Rayfront	This type of software is used for lighting design in educational institutions and industries with daylight to compute daylight factors, work-plane illuminance and evaluate glare distribution.
14	LX Series software	Lighting design software for indoor stage lighting that helps to display beam of spotlight in particular area, lux values on stage by using DMX controlling software and glare distribution with respect to visual effect of spectators.
15	Microlux	Lighting design software for indoor stage lighting
16	Lighting Reality	Lighting software for street and outdoor area lighting
17	Capture	Capture is used for stage lighting design. Capture allows users to work with lighting, video/laser media state, motion control system and water jets. It supports a wide range of ethernet DMX protocols such as Art-Net and SACN
18	Lumicept	Lumicept is hybrid light simulation software that simulates the behaviour of light, allowing the user to know how light propagates and is distributed in space.
19	LD Assistant	Lighting design software for indoor and outdoor stage lighting as well as used entertainment industries. Users can insert lighting fixtures along camera, speaker, sound cabinets, video projectors. It supports a wide range of ethernet DMX protocols such as Art-Net and SACN
20	LightCalc	Lighting design software for indoor areas with features that include the following: overall reflectance inside room proper lighting level for general, task, and art lighting. Adjust of lighting level as per age and dark to light rooms Proper spacing needed Both Inverse Square Law and Lumen methods are used Grid layout for general lighting,Art Lighting.
21	ElumTools	Lighting design software for interior lighting design with or without daylight and exterior lighting design for light level calculation

22	CalcuLuX	CALCULUX has been developed at the Philips Lighting Design and Application Centre [LiDAC] and is a lighting design program for personal computers Application areas are : Indoor, Area and Road, and have a luminaire database.
23	Light-in-Night Road	Lighting software for street lighting
24	Ulysse	Lighting design software by Schreder company, calculate the necessary lighting levels for road applications

5.1 About DIALux :-

DIALux is known to lighting designers all over the world as a professional design software for lighting designers, architects and engineers. Yet it is much more than the prescribed definition of it. DIALux is the leading marketing platform in the lighting industry. DIALux software helps **to design, calculate and visualize light professionally with the latest luminaire data of leading luminaire manufacturers included.**

There are various versions of DIALux available such as:

- DIALux 4.12
- DIALux 4.13
- DIALux EVO (Latest Edition)

5.2 Proposed Software JU-LUX

5.3 About JU-LUX: -

JU-LUX is the indigenous lighting application software developed on the basis of Indian standard design software (IS3616 & ECBC 2017).

It helps to develop the lighting design as per the lighting mathematical calculation and also provides the references of standard parameters and scholars' papers related to the design factor.

JU-LUX is a complete package software which has some simple features, Resource available (Database of Luminaire) and Ready reference of Indian standards in-built.

JU- LUX can calculate the cost rating based on the units of electricity consumed in partly or in total lighting space and this helps in being comprehensible to the lighting designer as well as consumers regarding the cost effectiveness of the lighting design layout.

5.4 Working principle of JU -LUX: -

JU-LUX application has been developed **on the dot net platform over the windows operating system**.

The Idea of JU-LUX comes as a package software which has some simple features,like resource availability (Database of Luminaire) and ready reference of Indian standards in-built.

The financial outcome of lighting design using JU- LUX is comprehensible to both the lighting designer as well as consumers based on the Indian Electricity Board Ratings.

The validation part of the JU-LUX has been confirmed by working on a demonstrative project "Residential Lighting Design (AutoCAD drawing)" provided by my project supervisor and the outcomes of the same have been compared by the softwares DIALux and JU-LUX. Results are shown in CHAPTER IV.

Following the process of software outcomes, I have gone through the steps to import the AutoCAD drawing by a lighting software DIALux.

I have used two different version of DIALux as:

1.DIALux EVO V8

2.DIALux 4.3

The parameters of the room have been taken by DIALux EVO and lighting designing, field arrangements, outcomes (ISO LUX Lines) have been taken from the DIALux 4.3

JU-LUX is based on the Visual Basic (Microsoft) programming language. All the available lighting designing features are developed by implementation (Logic) of lighting design fundamental calculations from the text of research papers (As reference added) / Indian standards (ECBC /IS3646).

5.5 Limitations of JU-LUX: -

This software application is not totally immune to limitation. The following are the limitations:

i. The software application is a prototype.
ii. The application depends on the successful lab tests parameters as per the resources used in our University.
iii. As the JU-LUX is based on the lumen theory, there may be an error of margin regarding theoretical and practical calculations in lighting design parameters of rooms other than rectangular shape.
iv. Graphical representation is in progress.
v. Advance Internet Of Things (IOT) functionality has to be incorporated in future work.
vi. Validation of outdoor and sport lighting parameters are not tested in this current project work.

5.6 Way forward:-

With advancement of lighting technology, smart lighting is making its impression felt globally. The ongoing development process of JU-LUX must follow the foot print of smart lighting for efficient designing lighting layout. Few of the features of smart lighting may be incorporated within the domain of JU-LUX development process as discussed below:

i. Lighting can be controlled on visual, non-visual lighting factors by control devices (occupancy sensors, Daylight sensors via wired or wireless connections as per the purpose of users.
ii. Auto response text messaging features as seen in the use of PCs and mobile phones.
iii. Daylight utilization factors with artificial lighting.
iv. Outdoor lighting designing (Road lighting, Spot lighting etc).
v. Cost effective lighting with respect to colour temperature, visual comfort in spectral tuning of visual and non-visual needs in workplace.
vi. Emergency lighting in-built features in lighting layout for a quick safety indication of way out on major critical situation.

5.7 Conclusion: -

JU-LUX is an attempt to develop a prototype lighting software based on the lumen method with respect to Indian standard lighting design protocol.

a) The functionality of JU-LUX was validated on a lighting design of 'Residential Plan' AutoCAD drawing in respect of the most popular lighting software DIALux.
b) The features to calculate the cost effectiveness in JU-LUX is on the basis of luminaire parameters(Wattage, efficacy etc) as well as in Indian currency rates as per Indian Electricity Tariff.
c) JU-LUX has the feature to store and view the research papers of related subjects for the students and researchers at a button click a button at menu bar.
d) JU-LUX can be helpful to lighting engineers,designers,consumers and manufacturers.
e) Utilization of daylight factors can be calculated by JU-LUX in new building design as per ECBC'2017 parameters.

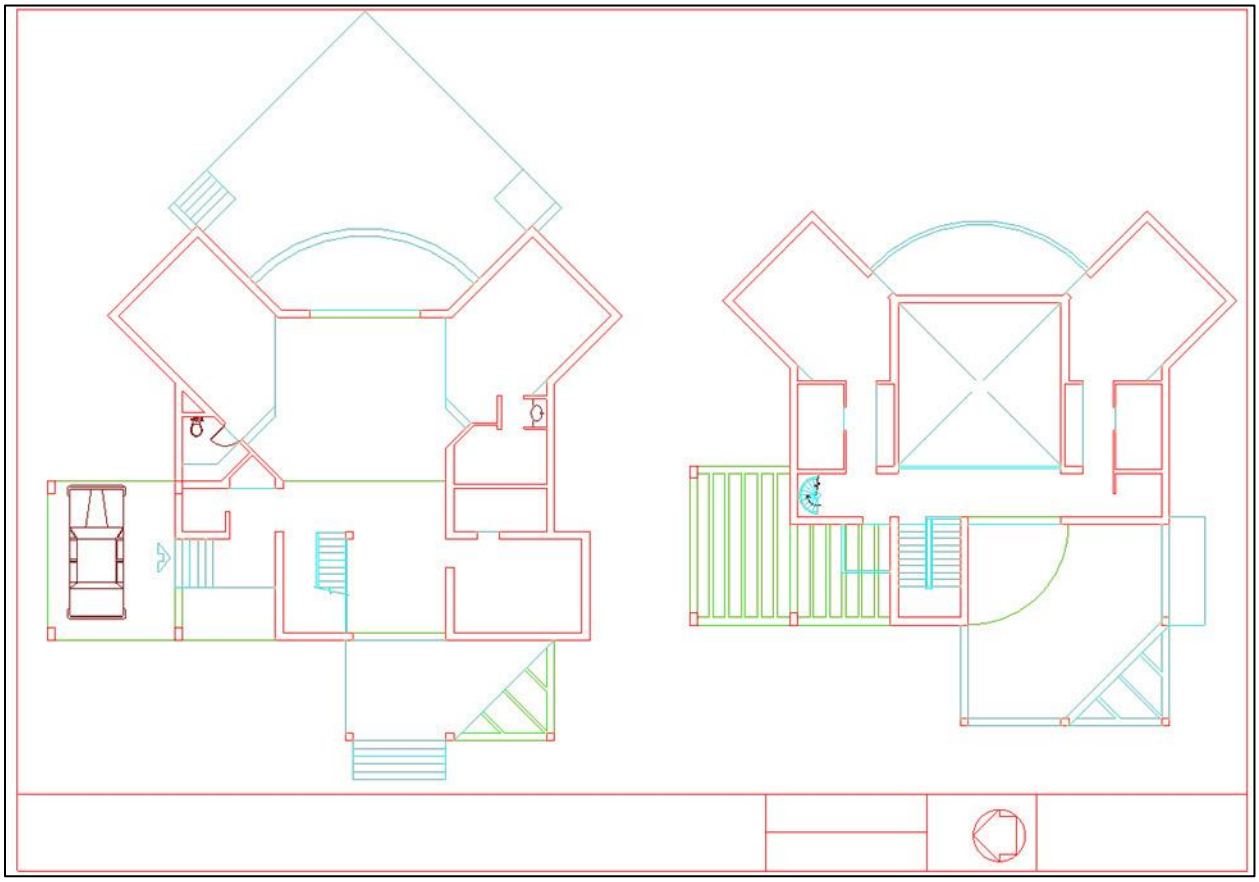
JU-LUX has some limitations which can be overcome by the development process in future work

a) JU-LUX must be incorporated with the features of smart lighting technology such as control gear, dimming facility and occupancy sensor etc.
b) Daylight with artificial lighting calculation should be incorporated
c) Auto messaging or Alarm text functionality by IOT (Internet Of Things) should be incorporated.
d) Accuracy in average lux and uniformity can be maintained in any structure of rooms by graphical representation
e) Visual comfort with spectral tuning in visual and non-visual parameters can be maintained.
f) Outdoor lighting i.e. road lighting, sport lighting should be evaluated by JU-LUX.

CHAPTER-VI Validation of JU-LUX

6.0. Validation of JU-LUX: -

Validation of JU-LUX has been cross checked with the design outcome of the DIALux project to design an auto-cad drawing provided by my project supervisor.



The following parameters have been checked with the two Lighting design softwares:

- Room Dimension
- Required Lux Level
- Number of Luminaries required
- Verification on luminaries field arrangement can be verified by the Ju-Lux

6.1 Application Areas of JU-LUX

JU-LUX can be treated as both Indoor and outdoor lighting designing application.

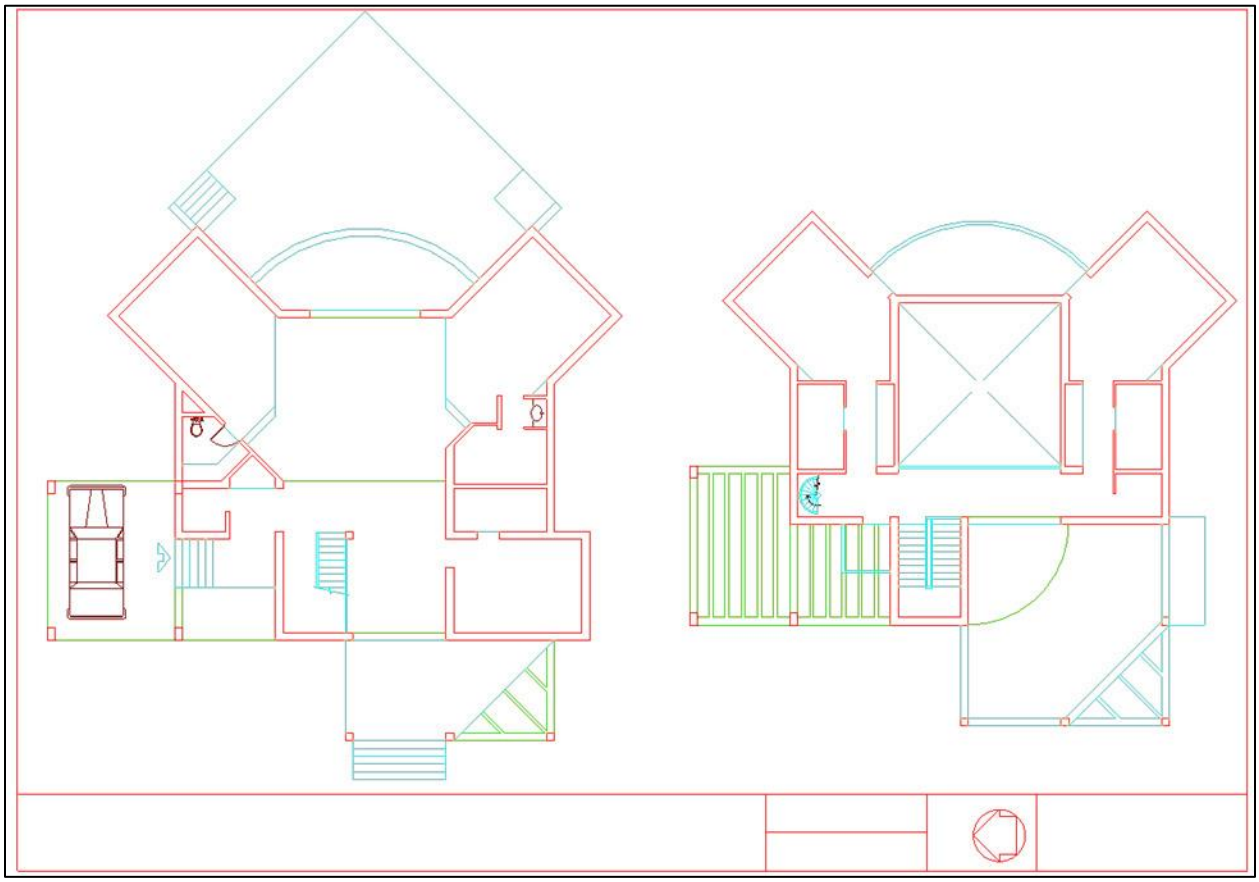
The JU-LUX technology can be utilized in the capacity of an innovative lighting design with further specific areas of development:

- Visualization of Reference paper depending on the Department/Project relation.
- Luminaire selection on selective room criteria
- Luminaire Data Base
- Luminaire spacing (spacing arrangements on Row and column)
- ECBC Daylight factor on UDI for building designing
- User design parameters

i. Room Index value
ii. Lux level requirement
iii. Numbers of Luminaire required in specific room to achieve the required Lux level
iv. Cross check of Spacing and Mounting height ratio
v. Verification of luminaire arrangements (In row and column)
vi. Lumen Lux calculator

6.2 Case Study selection (Residential Plan): -

JU-LUX has been cross checked with the design outcome of the DIALux project to design the lighting for a residence based on an AutoCAD drawing provided by my project supervisor.

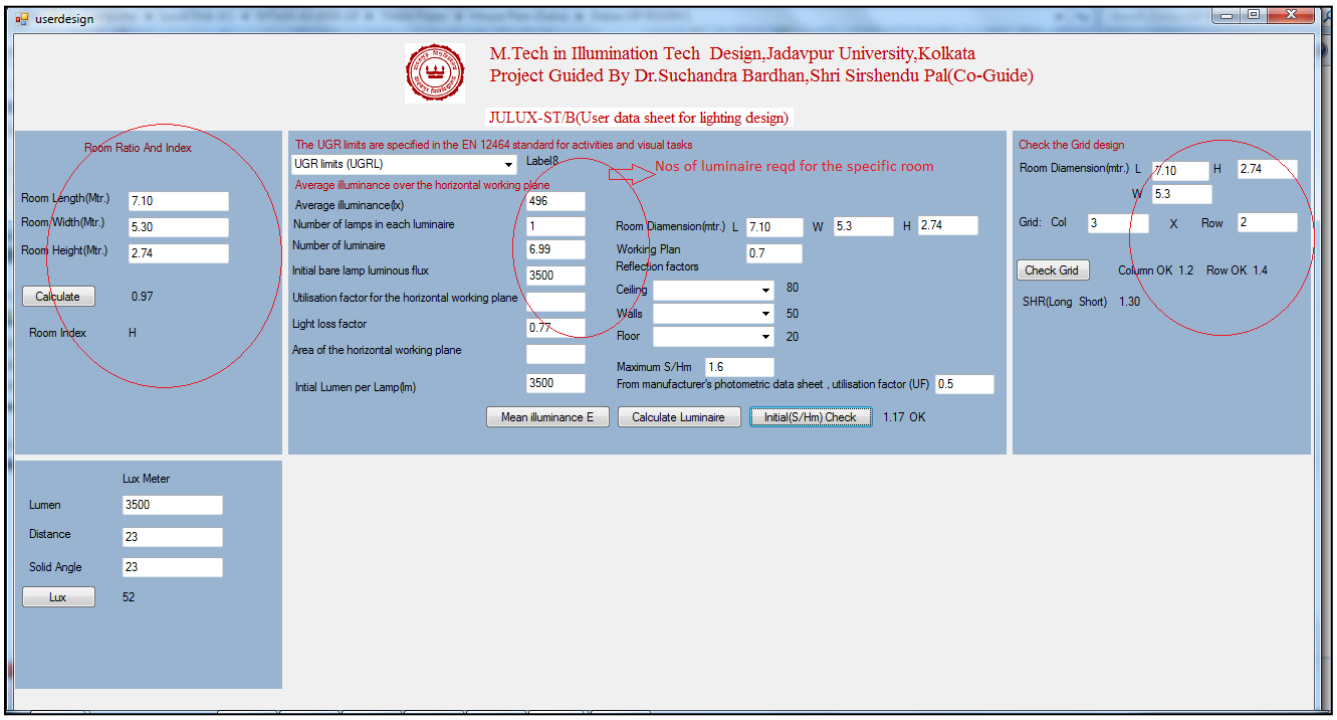


6.3 Comparison between Input / Output data Chart (Lighting plan) & design: -

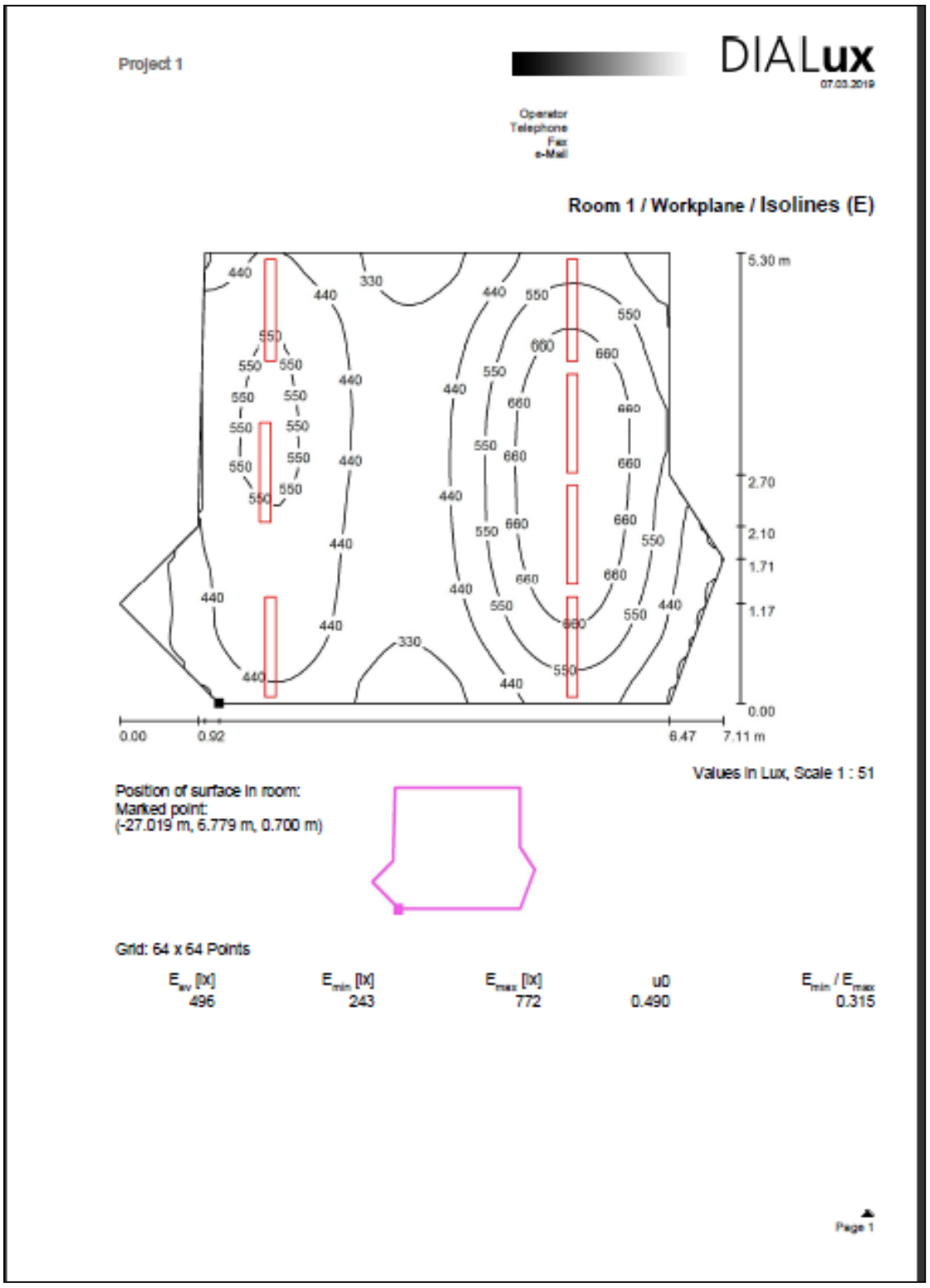
6.3.1 Case: - I JU-LUX output data from the First room parameters: -

JU-LUX		DIALux (Room 1)	
Luminaire: Philips BCS460 W22L124 MLO-PC /840 NO			
JU-LUX input selection parameters	JU-LUX Output data parameters	DIALux input selection parameters	DIALux output data parameters
Room diamenstion (m):7.01 x 5.30 x 2.74	Nos of Luminaries :6.99 (Approx 07Nos)	Room diamenstion (m): 7.01 x 5.30 x 2.74	Nos of Luminaries :07Nos
Required Lux Level: 500lx	Grid design validated by JU-LUX	Required Lux Level: 505lx	
Initial lumen of lamp: 3500	Room Ratio and Index value:0.97 , H	Initial lumen of lamp: 3500	

The screen-shot of the screen appearance in JU-LUX is given below:

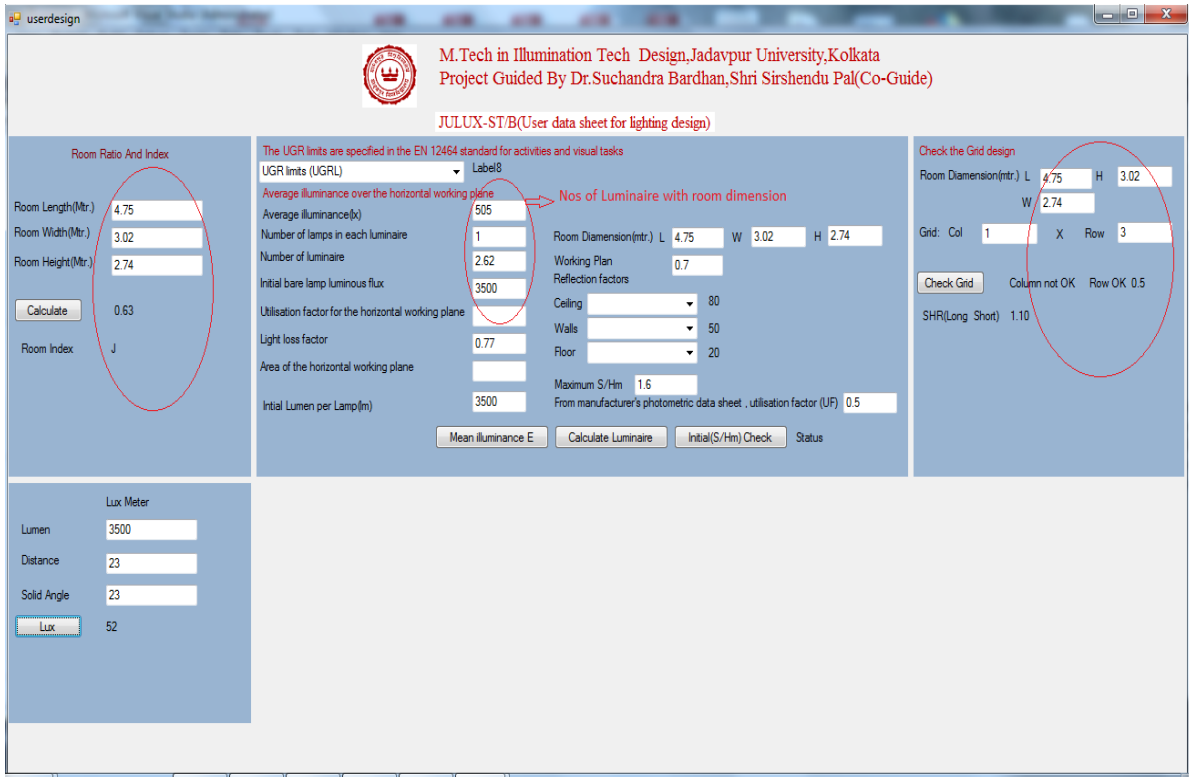


The screen-shot of the screen appearance in DIALux is given below:

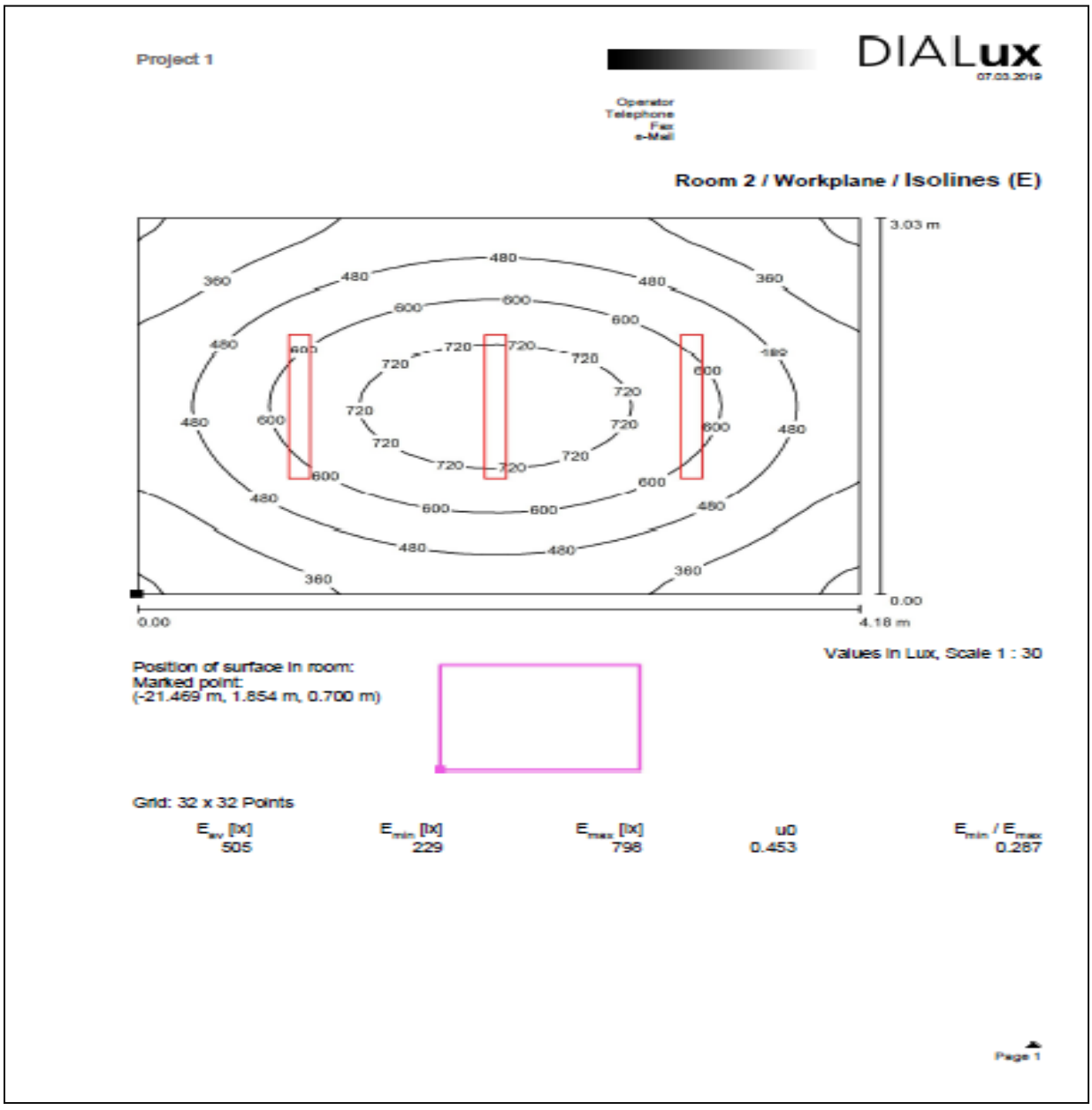


6.3.2. Case: - II JU-LUX output data from Second Room Parameters: -

JU-LUX		DIALux(Room 2)	
Luminaire: Philips BCS460 W22L124 MLO-PC /840 NO			
JU-LUX	Output data	Input data	Output data
Room dimension (m):4.75 x 3.02 x 2.74	Nos of Luminaries :2.62 (Approx 03 Nos)	Room diamenstion (m):4.75 x 3.02 x 2.74	Nos of Luminaries :03 Nos
Required Lux Level: 500lx	Grid design validated by Ju-lux	Required Lux Level: 505lx	
Initial lumen of lamp: 3500	Room Ratio and Index value:0.63 , J	Initial lumen of lamp: 3500	

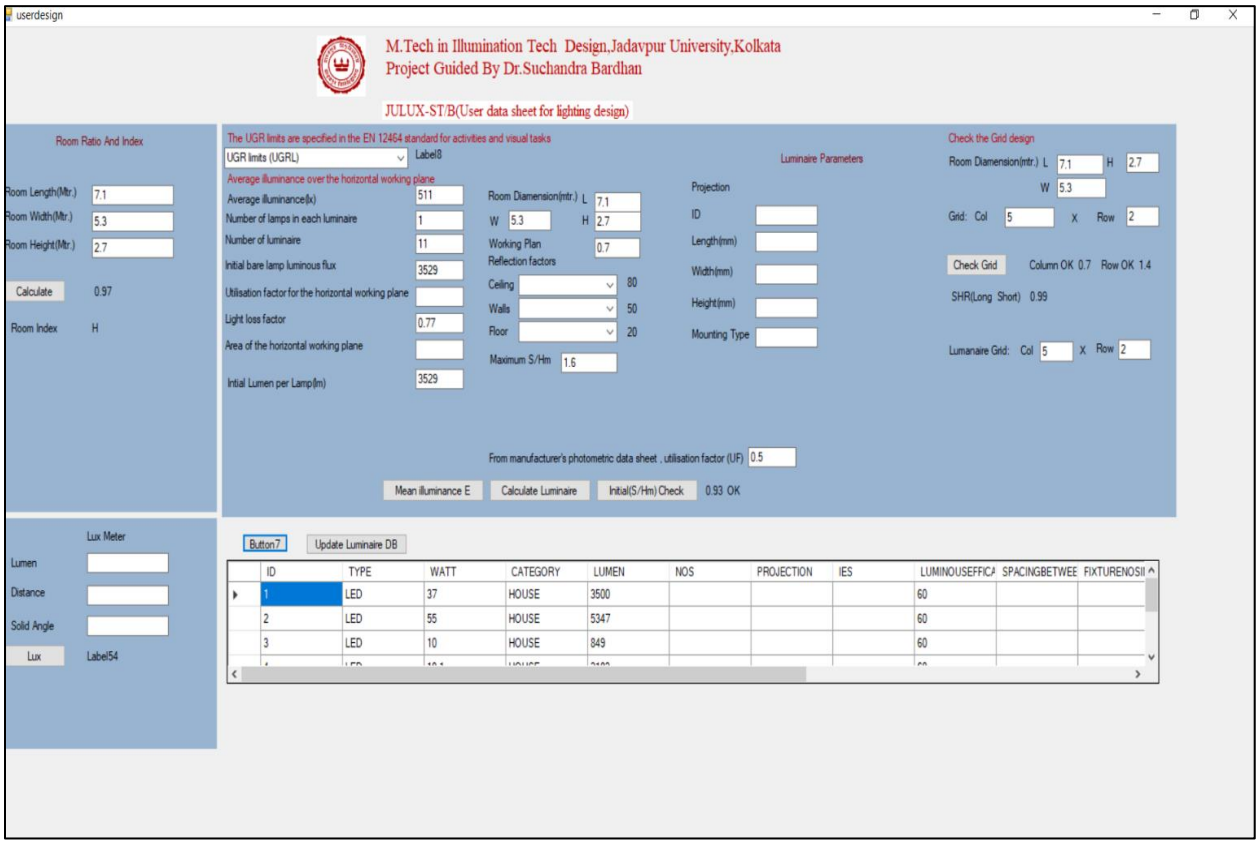


The screen-shot of the screen appearance in DIALux is given below:



6.3.3. Case: - III JU-LUX output data of Room 1 with “sparkle ultra 28w cw” led luminaire: -

JU-LUX OUTPUT:



JULUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM NO :01 (Luminaire Name: LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW)	
Room Dimension(m): 7.1 x 5.3x2.7 Lux level: 511 lux No of Luminaire required: 11 Nos.	Room Dimension (m): 7.1 x 5.3x2.7 Lux level: 546 lux No of Luminaire required: 9 Nos. (with 3 x 3 field arrangements)

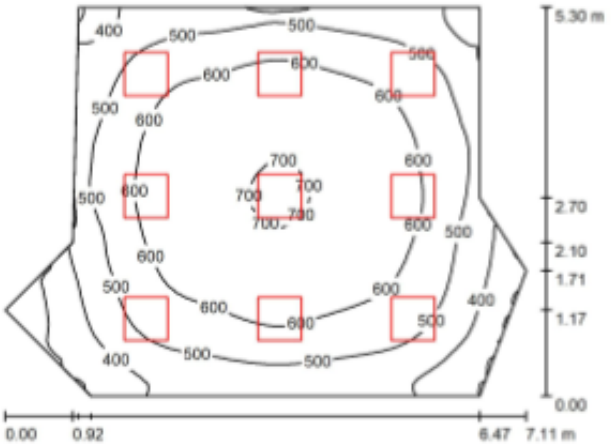
DIALux Output:

Project 1

DIALux
20.05.2019

Operator
Telephone
Fax
e-Mail

Room 1 / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.70

Values in Lux, Scale 1:69

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	546	262	713	0.481
Floor	20	468	260	601	0.557
Ceiling	80	106	49	158	0.464
Walls (8)	50	300	107	505	/

Workplane:
Height: 0.700 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.577, Ceiling / Working Plane: 0.195.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	9	LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW (1.000)	3529	3529	27.3
			Total: 31762	Total: 31762	245.7

Specific connected load: 7.94 W/m² = 1.45 W/m²/100 lx (Ground area: 30.96 m²)

Page 1

Project 1

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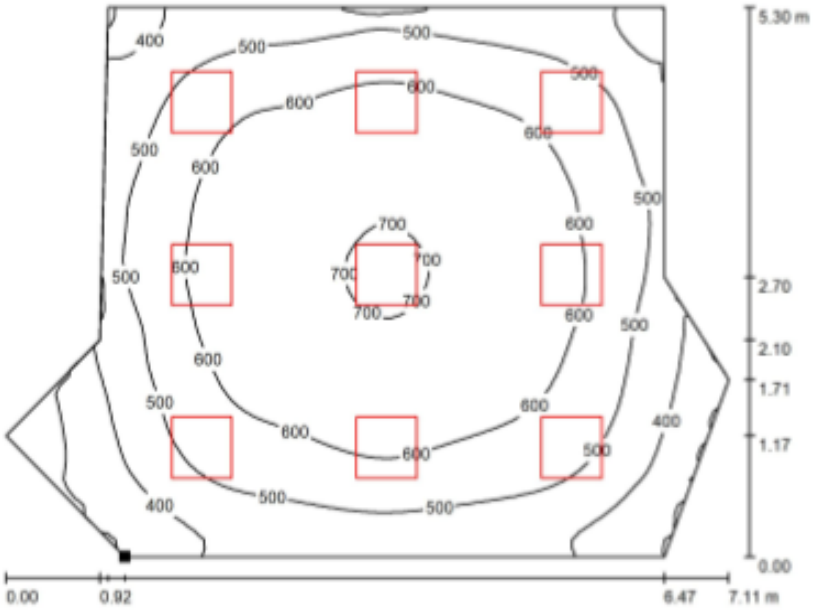
Room 1 / Workplane / Isolines (E)



Values in Lux, Scale 1 : 51

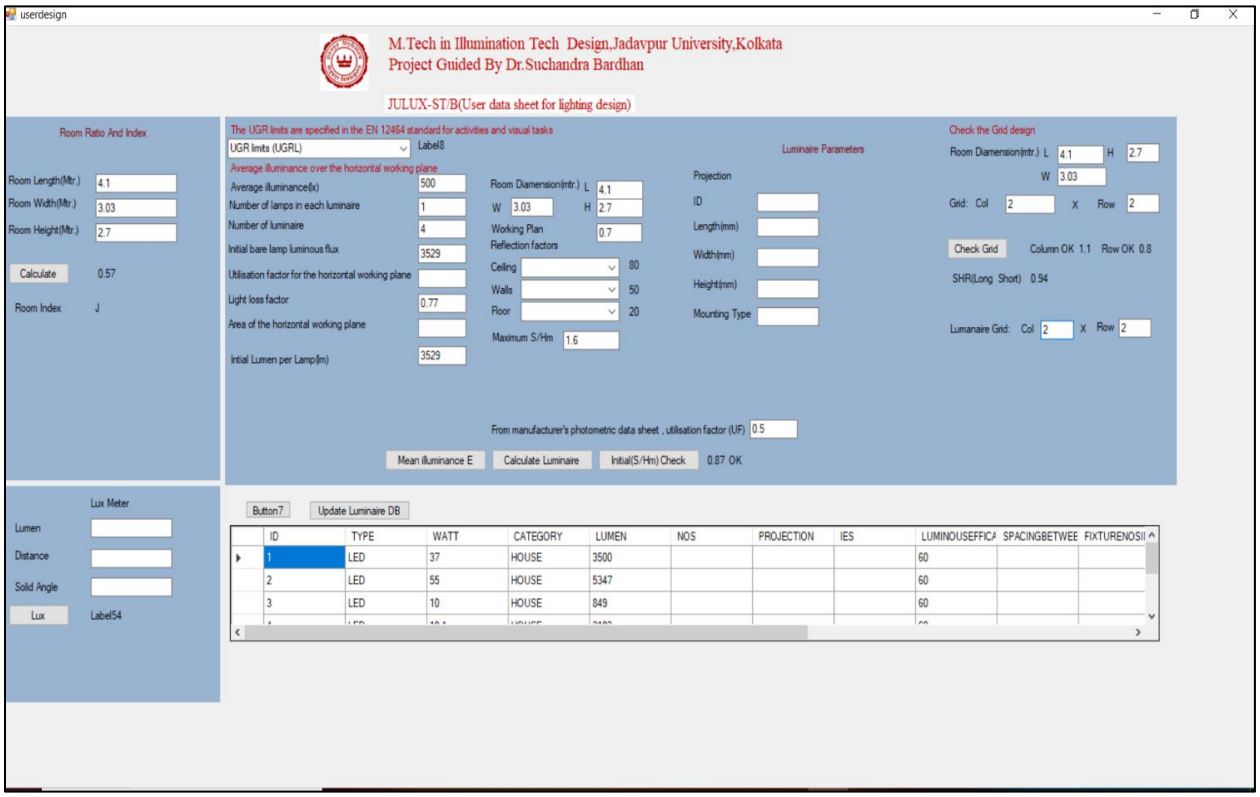
Position of surface in room:
Marked point:
(-27.019 m, 6.779 m, 0.700 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
546	262	713	0.481	0.368

6.3.4. Case: - IV JU-LUX output data of Room 2 with “sparkle ultra 28w cw” led luminaire: -

JU-LUX output:



JULUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM NO :02 (Luminaire Name: LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW)	
Room Dimension(m): 4.1 x 3.03 x 2.7 Lux level: 500 lux No of Luminaire required: 04 Nos.(Field arrangements 2 x 2)	Room Dimension(m): 4.1 x 3.03 x 2.7 Lux level: 463 lux No of Luminaire required: 04 Nos.(Field arrangements 2 x 2)

DIALux Output: -

Project 1

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20.05.2019

Operator
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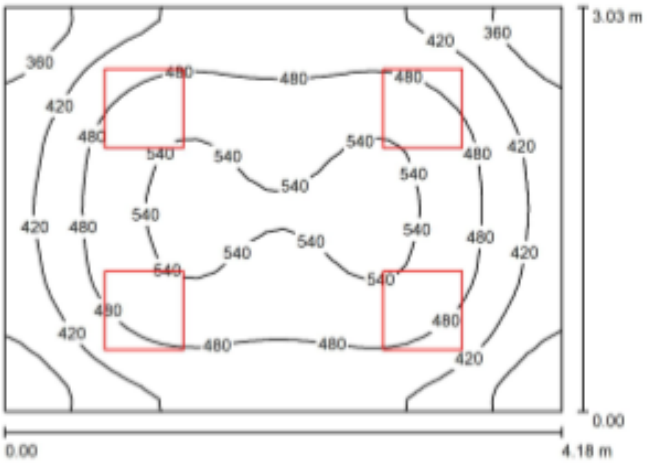
e-Mail

Room 2 / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.70

Values in Lux, Scale 1:39

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	463	301	556	0.651
Floor	20	368	258	438	0.701
Ceiling	80	108	66	133	0.617
Walls (4)	50	283	108	586	/

Workplane:
Height: 0.700 m
Grid: 32 x 32 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.674, Ceiling / Working Plane: 0.232.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	4	LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW (1.000)	3529	3529	27.3
			Total: 14116	Total: 14116	109.2

Specific connected load: 8.65 W/m² = 1.87 W/m²/100 lx (Ground area: 12.63 m²)

Page 1

Project 1

DIALux
20.05.2019

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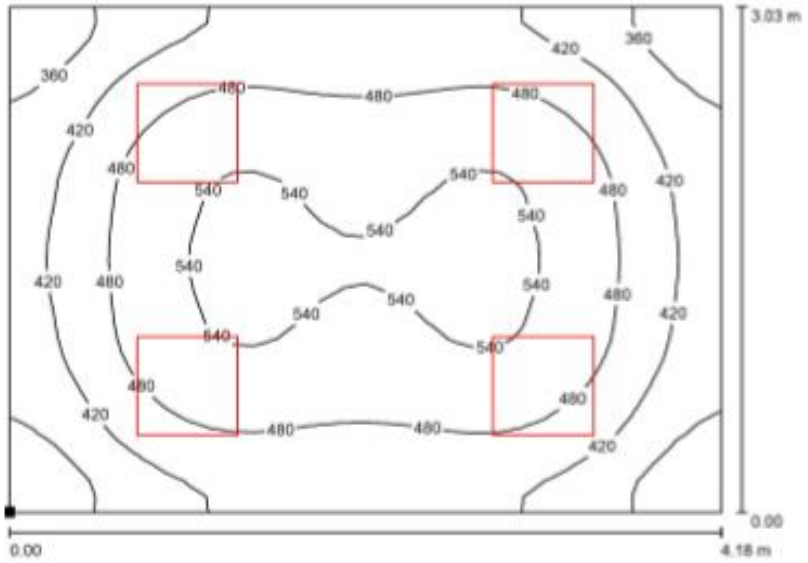
e-Mail

Room 2 / Workplane / Isolines (E)



Values in Lux, Scale 1 : 30

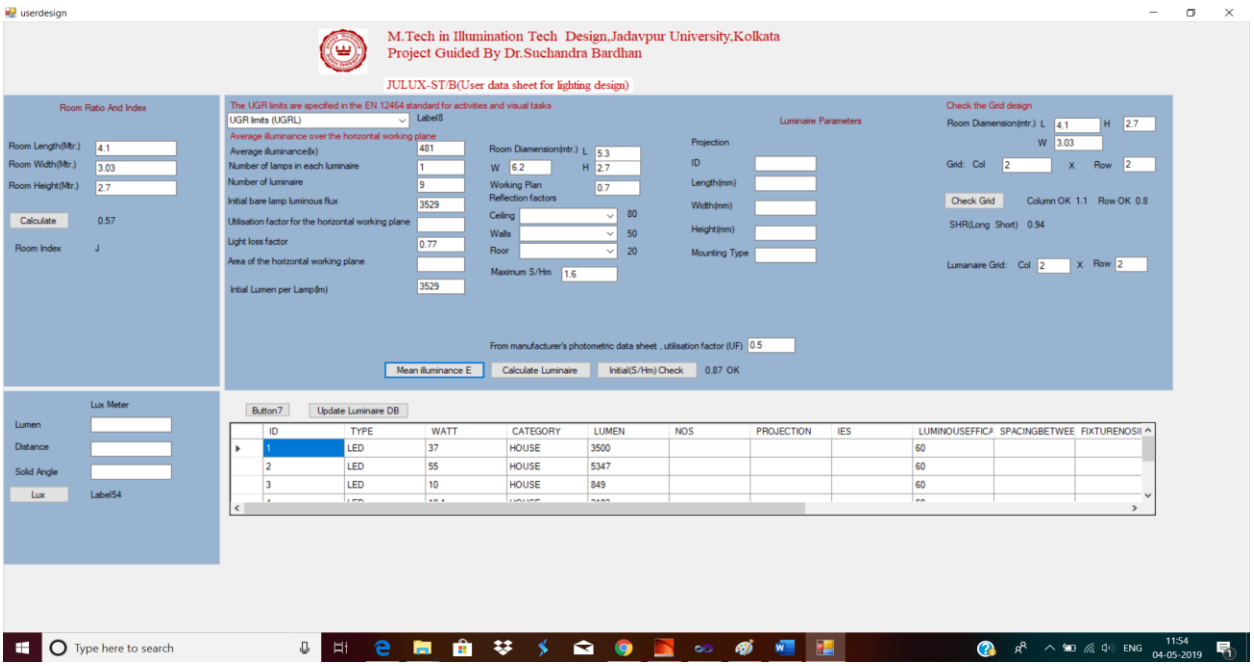
Position of surface in room:
Marked point:
(-21.469 m, 1.854 m, 0.700 m)

Grid: 32 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
463	301	556	0.651	0.543

6.3.5. Case: - V JU-LUX output data of Room 3 with “sparkle ultra 28w cw” led luminaire: -

JU-LUX OUTPUT:



JULUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM NO :03 (Luminaire Name: LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW)	
No. of lamp per luminaire:01 No. Room Dimension(m): 4.1 x 3.03 x 2.7 Lux level: 488 lux No of Luminaire required: 09 Nos. (Field arrangements 3 x 3)	No. of lamp per luminaire:01 No. Room Dimension(m): 5.3x 6.2 x 2.7 Lux level: 595 lux No of Luminaire required: 07 Nos. (Field arrangements as per the curvature of the room)

DIALux OUTPUT:

Project 1

DIALux
20.05.2019

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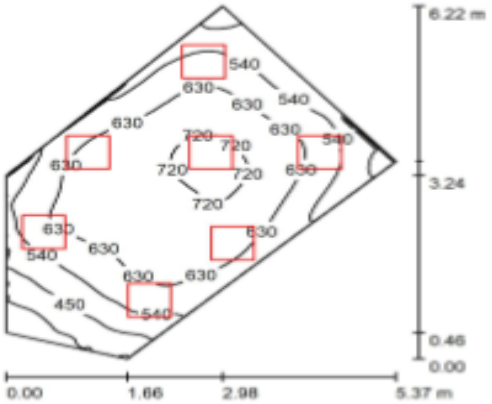
Fax
e-Mail

Room 3 / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.70

Values in Lux, Scale 1:80

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	595	296	741	0.497
Floor	20	488	322	594	0.659
Ceiling	80	131	53	242	0.410
Walls (5)	50	369	135	1385	/

Workplane:
Height: 0.760 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.673, Ceiling / Working Plane: 0.219.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	7	LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW (1.000)	3529	3529	27.3
			Total: 24704	Total: 24704	191.1

Specific connected load: 10.15 W/m² = 1.71 W/m²/100 lx (Ground area: 18.83 m²)

Page 1

Project 1

DIALux
20.05.2019

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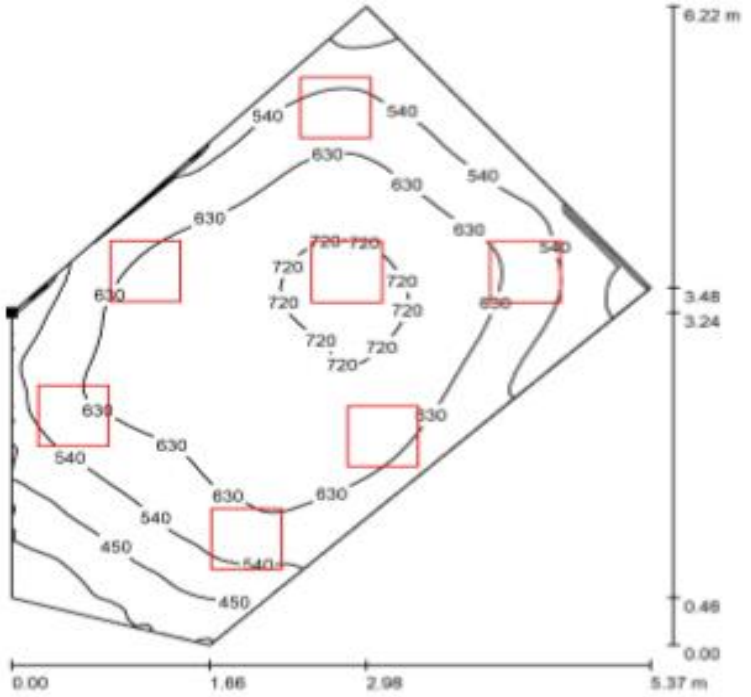
e-Mail

Room 3 / Workplane / Isolines (E)



Values in Lux, Scale 1 : 49

Position of surface in room:
Marked point:
(-21.719 m, 11.902 m, 0.760 m)

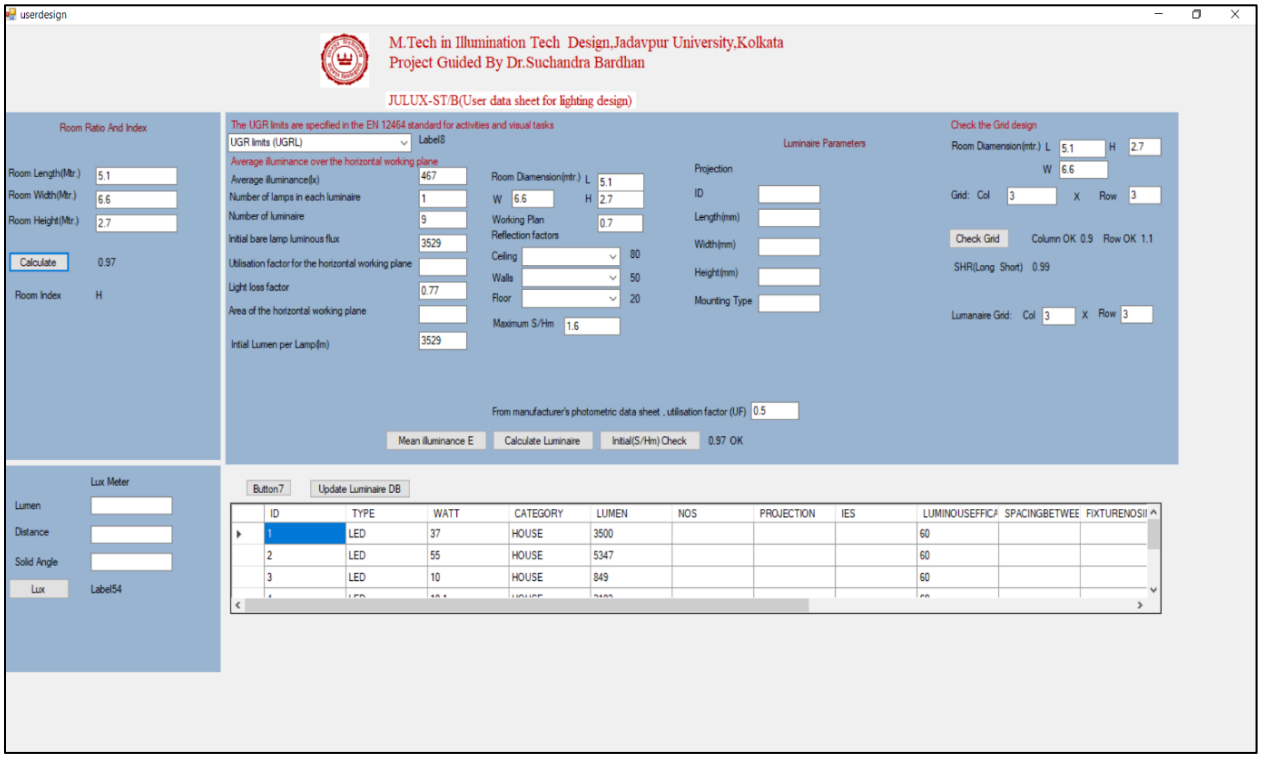
Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
595	296	741	0.497	0.399

Page 1

6.3.6. Case: - VI JU-LUX output data of Room 4 with “sparkle ultra 28w cw” led luminaire:-

JU-LUX OUTPUT:



JULUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM NO :04 (Luminaire Name: LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW)	
Room Dimension(m): 5.1 x 6.6 x 2.7 Lux level: 467 lux No of Luminaire required:09 Nos. (Field arrangements 3x 3)	Room Dimension(m): 5.1 x 6.6 x 2.7 Lux level: 597 lux No of Luminaire required:07 Nos. (Field arrangements as per the room curvature)

DIALux OUTTPUT:-

Project 1

DIALux
20.05.2019

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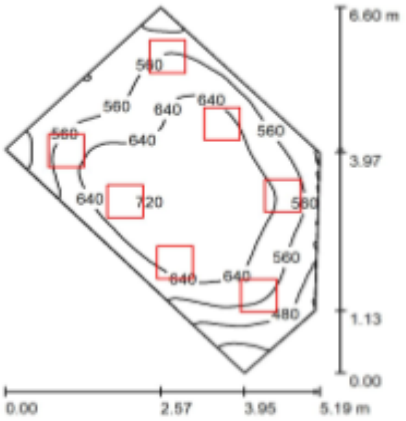
e-Mail

Room 4 / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.70

Values in Lux, Scale 1:85

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	597	331	722	0.554
Floor	20	488	320	584	0.656
Ceiling	80	133	58	214	0.434
Walls (6)	50	374	134	1069	/

Workplane:
Height: 0.760 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.676, Ceiling / Working Plane: 0.222.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	7	LIGHTING TECHNOLOGIES S02857RP00 SPARKLE ULTRA 28W CW (1.000)	3529	3529	27.3
			Total: 24704	Total: 24704	191.1

Specific connected load: 10.20 W/m² = 1.71 W/m²/100 lx (Ground area: 18.74 m²)

Page 1

Project 1

DIALux
20.05.2019

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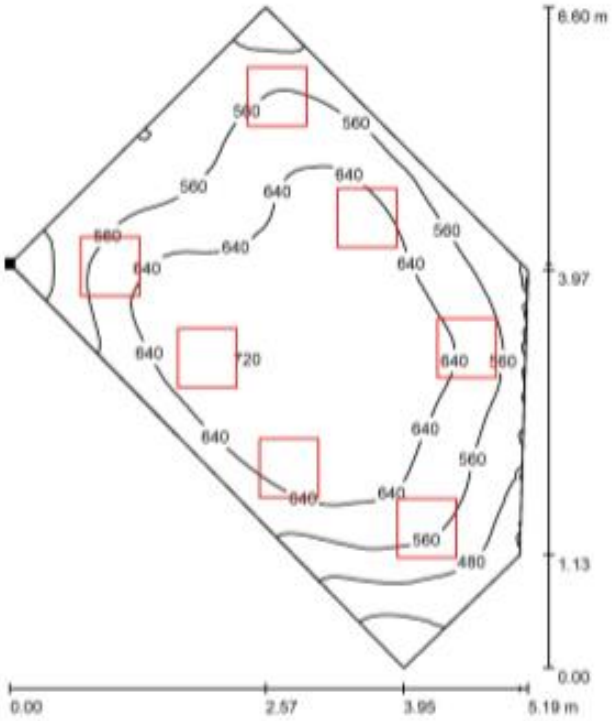
e-Mail

Room 4 / Workplane / Isolines (E)



Values in Lux, Scale 1 : 52

Position of surface in room:
Marked point:
(-32.381 m, 12.140 m, 0.760 m)

Grid: 64 x 64 Points

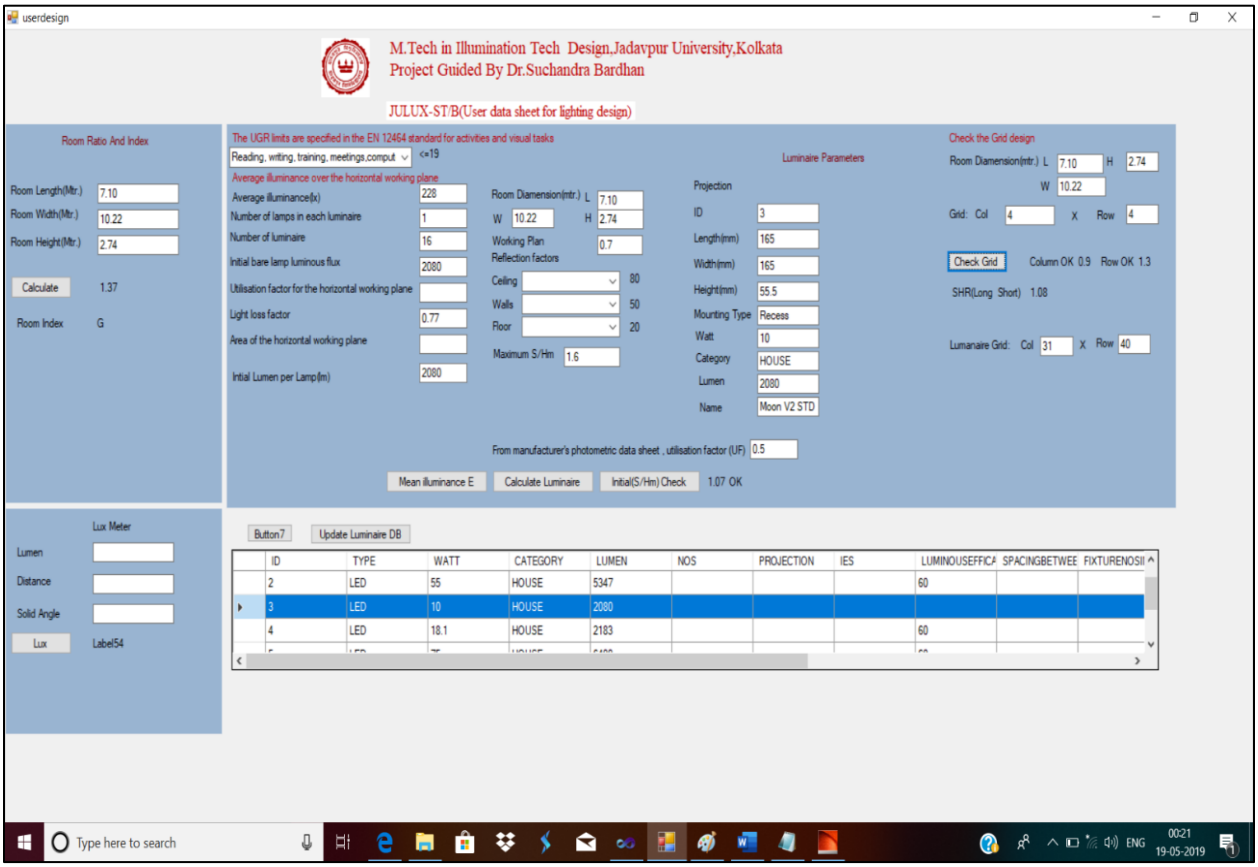
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
597	331	722	0.554	0.458

6.3.7 Case: -VII Validation of JU-LUX on Residential Plan (AutoCAD drawing) with the moon lighting of "Lighting Technology" through DIALux lighting Software:-

Drawing space with extra extended are

Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD

JU-LUX output of the Drawing space with extra extended area lighting design



DIALux output (Summary)of the Drawing space with extra extended area lighting design: -

Project 1

DIALux
19.05.2019

Operator
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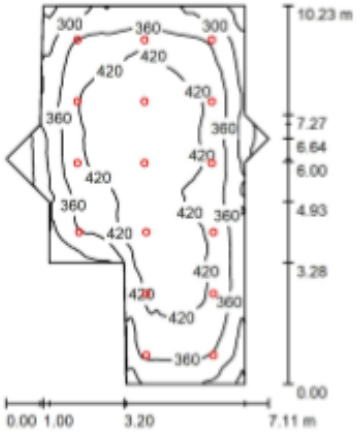
e-Mail

Drawing Room-with extended Drawing area / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.70

Values in Lux, Scale 1:132

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	378	182	471	0.481
Floor	20	333	191	418	0.572
Ceiling	80	84	67	134	0.796
Walls (14)	50	201	78	589	/

Workplane:
Height: 0.700 m
Grid: 128 x 128 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.559, Ceiling / Working Plane: 0.221.

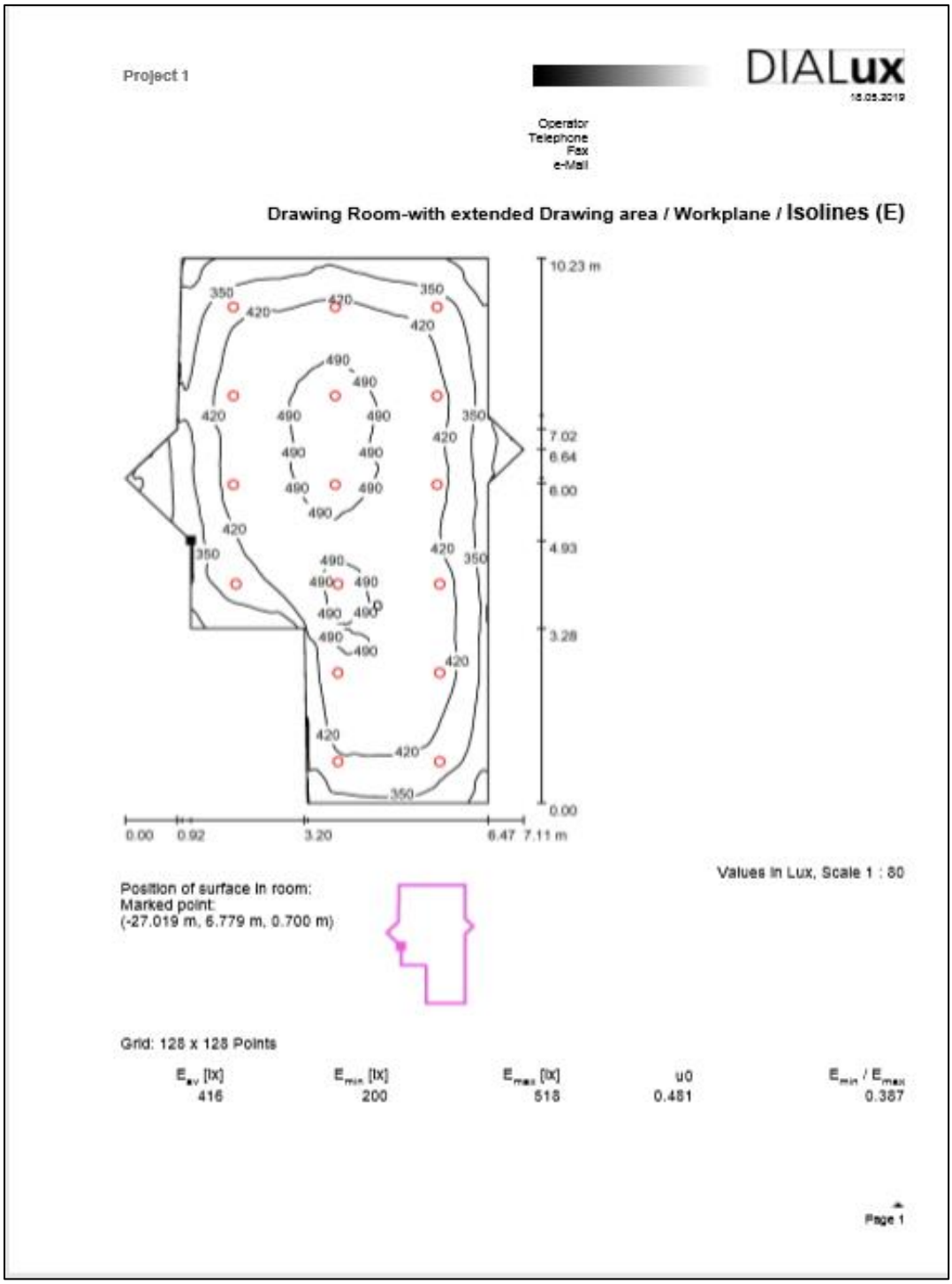
Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	16	LIGHTING TECHNOLOGIES MV1857RS00 MOON V2 STD 18W CW (1.000)	2079	2079	17.9
			Total: 33263	Total: 33262	286.4

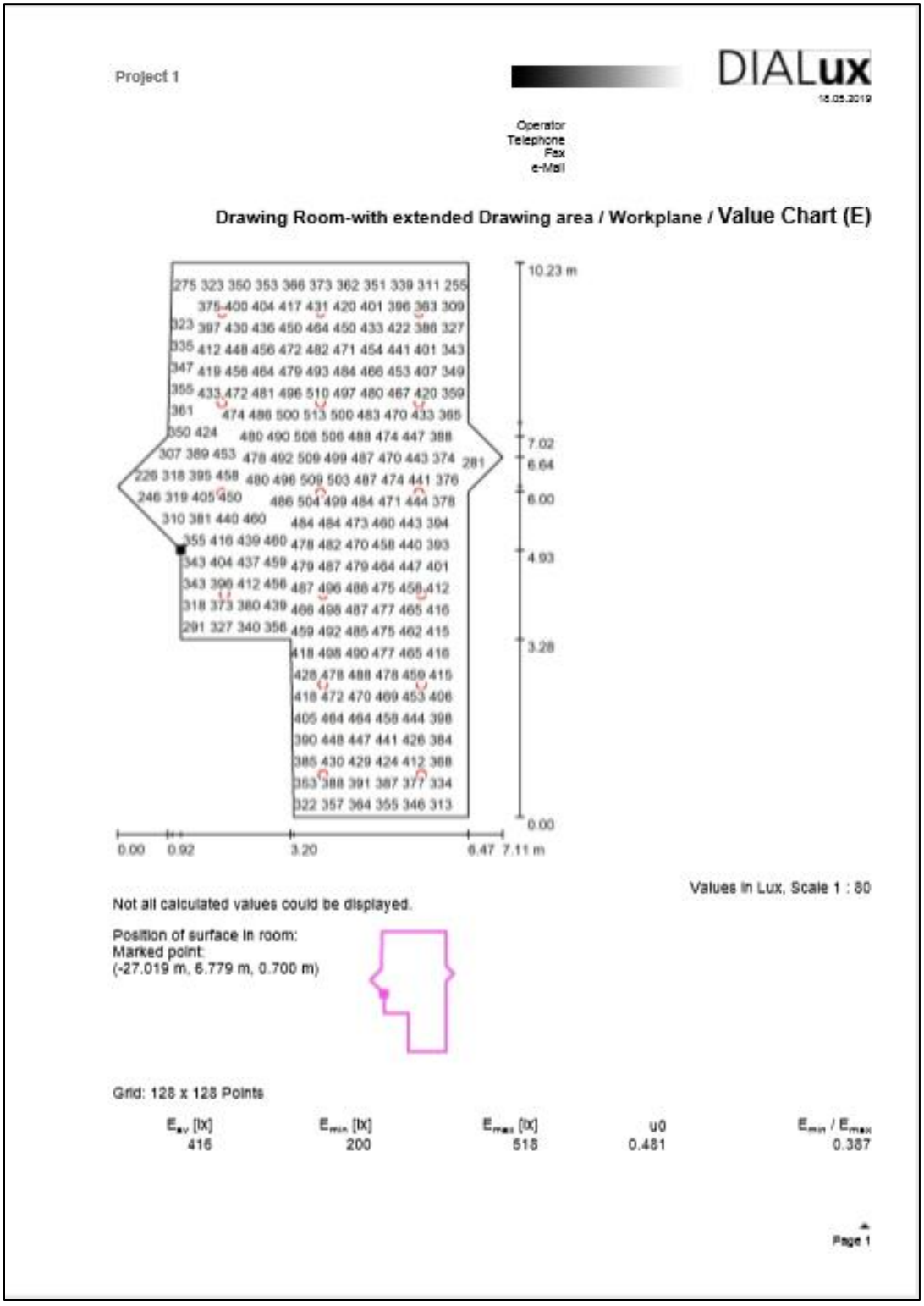
Specific connected load: 5.74 W/m² = 1.52 W/m²/100 lx (Ground area: 49.90 m²)

Page 1

DIALux output (ISOlines) of the Drawing space with extra extended area lighting design: -



DIALux output (Value Chart) of the Drawing space with extra extended area lighting design:-



Project 1

DIALux
16.05.2019

Operator
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e-Mail

Drawing Room-with extended Drawing area / Workplane / Value Chart (E)

Values in Lux, Scale 1 : 80

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(-27.019 m, 6.779 m, 0.700 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
416	200	516	0.481	0.387

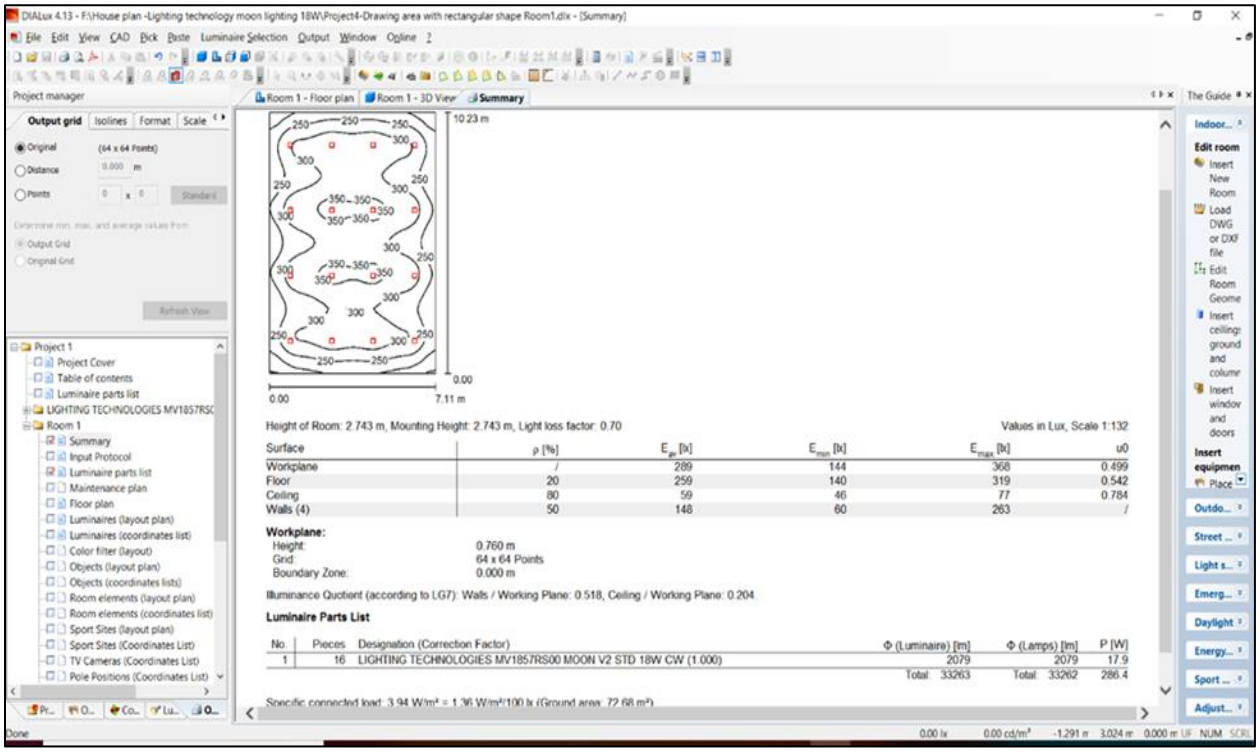
Page 1

6.3.7.1 Case: - VII (Special Consideration of Architectural Drawing)

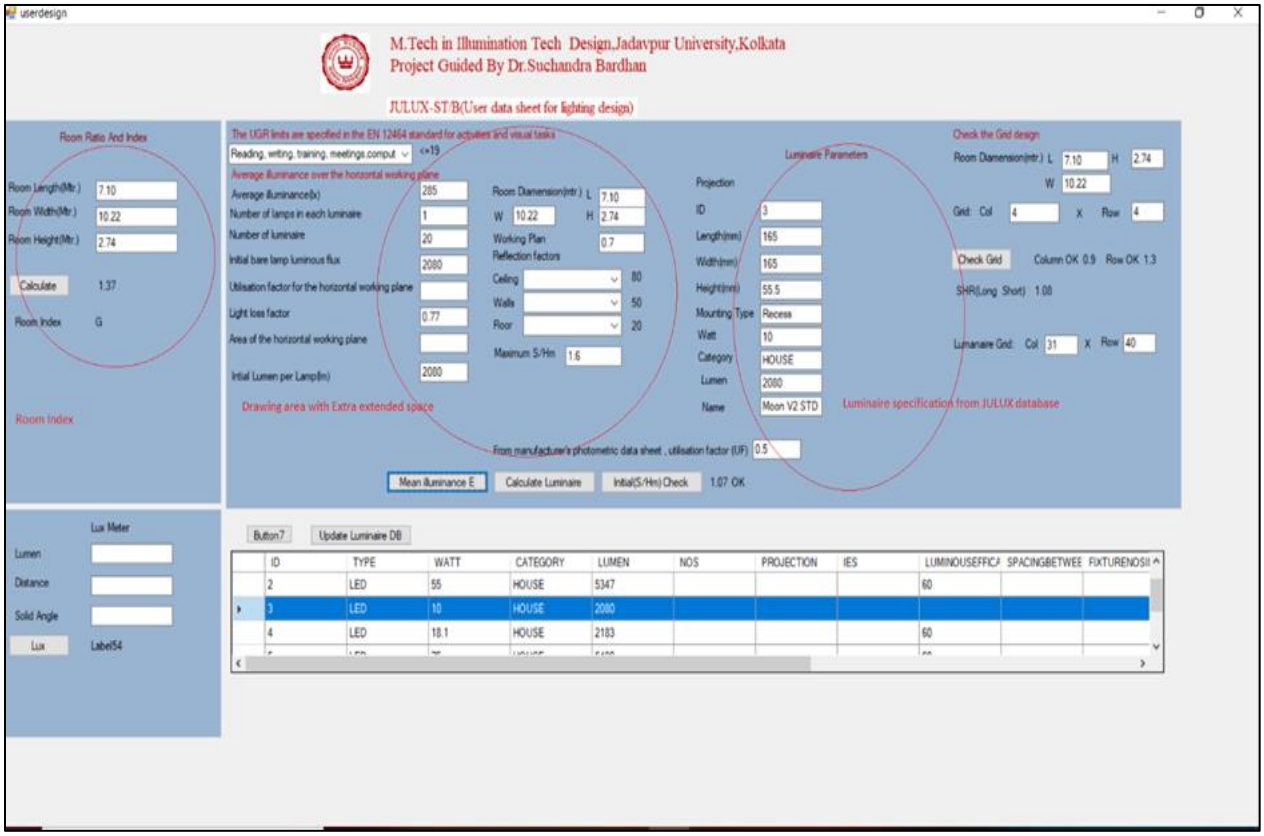
Drawing space with proper rectangular shape area lighting design

JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Drawing space with extra extended area converted to perfect rectangular room (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m): 7.10 x 10.22 x2.7 Lux level: 280 lux No of Luminaire required: 16 Nos.	Room Dimension(m): 7.1 x 10.22 x2.7 Lux level: 280 lux No of Luminaire required: 16 Nos. (with 4x 4 field arrangements)

DIALux output of the Drawing space with proper rectangular shape area lighting design:-



JU-LUX output of the Drawing space with proper rectangular shape area lighting design:-

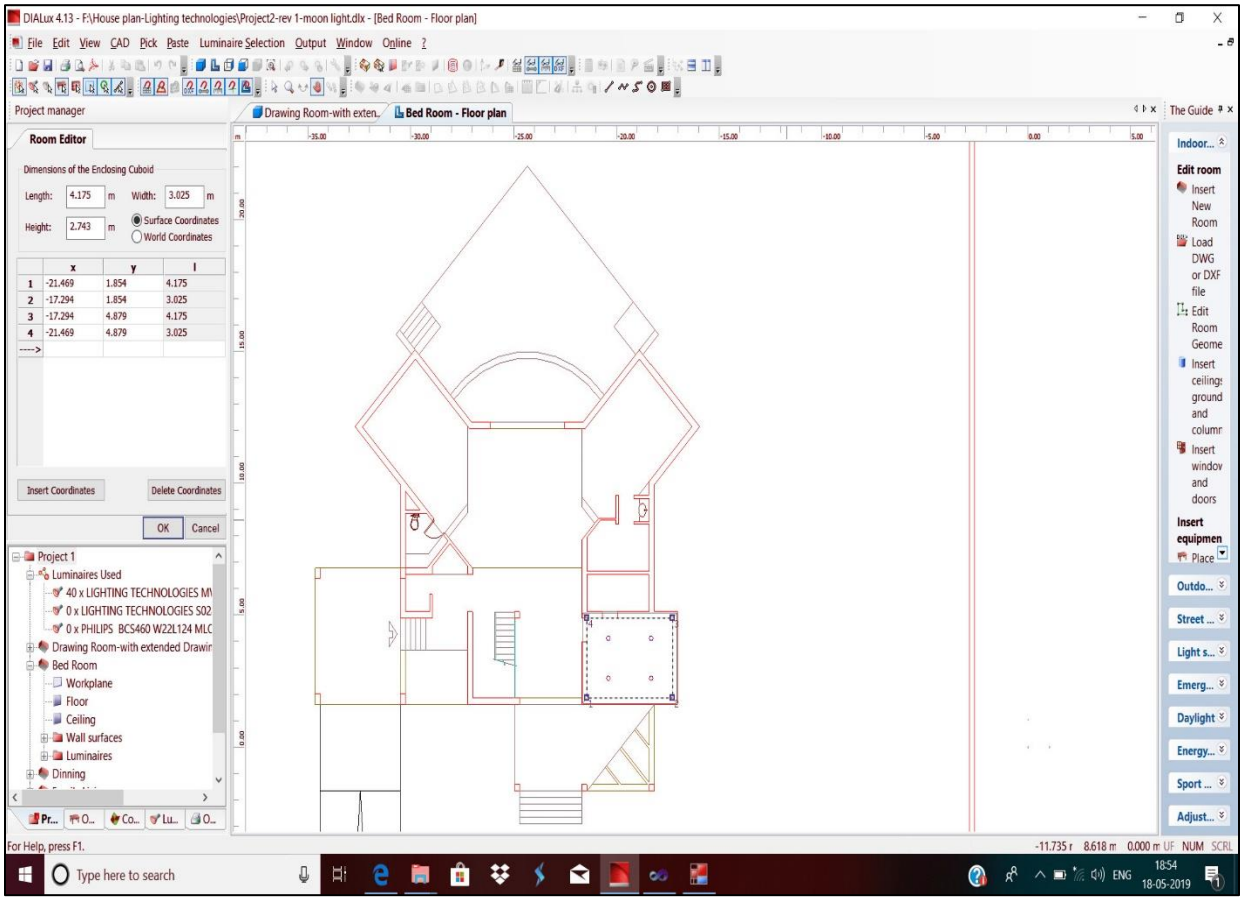


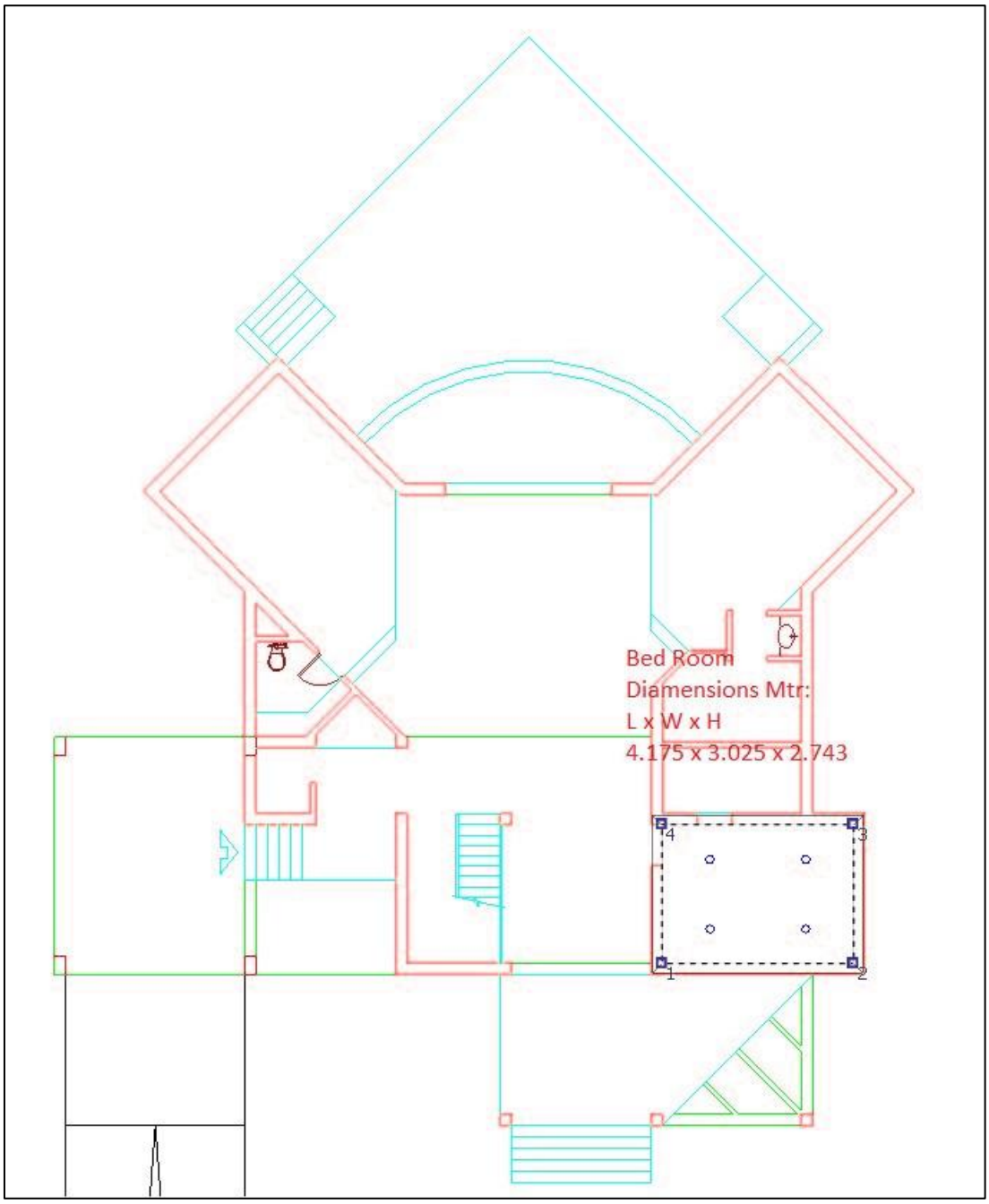
6.3.8 Case: - VIII Validation of JU-LUX in Bed Room lighting design: -

Validation of JU-LUX in Bed Room lighting design parameter: -

JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Bed Room Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m):4.175 x 3.025 x 2.74 Lux level: 320 lux No of Luminaire required: 04 Nos.	Room Dimension(m): 4.175 x 3.025 x 2.74 Lux level: 317 lux No of Luminaire required: 04 Nos. (with 4x 4 field arrangements)

1.Bed room lighting layout: -



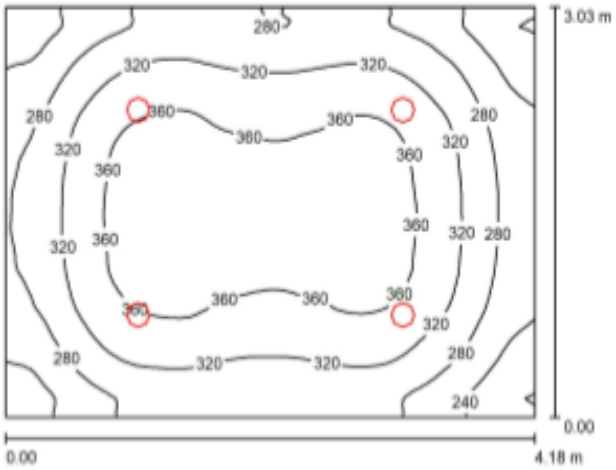

Bed Room
Diamensions Mtr:
L x W x H
4.175 x 3.025 x 2.743

Project 1

DIALux
16.05.2019

Operator
Telephone
Fax
e-Mail

Bed Room / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.77

Values in Lux, Scale 1:39

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	317	194	387	0.612
Floor	20	253	172	304	0.677
Ceiling	80	78	55	91	0.699
Walls (4)	50	182	72	365	/

Workplane:
Height: 0.700 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.624, Ceiling / Working Plane: 0.247.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	4	LIGHTING TECHNOLOGIES MV1857RS00 MOON V2 STD 18W CW (1.000)	2079	2079	17.9
			Total: 8316	Total: 8316	71.6

Specific connected load: 5.67 W/m² = 1.79 W/m²/100 lx (Ground area: 12.63 m²)

Project 1

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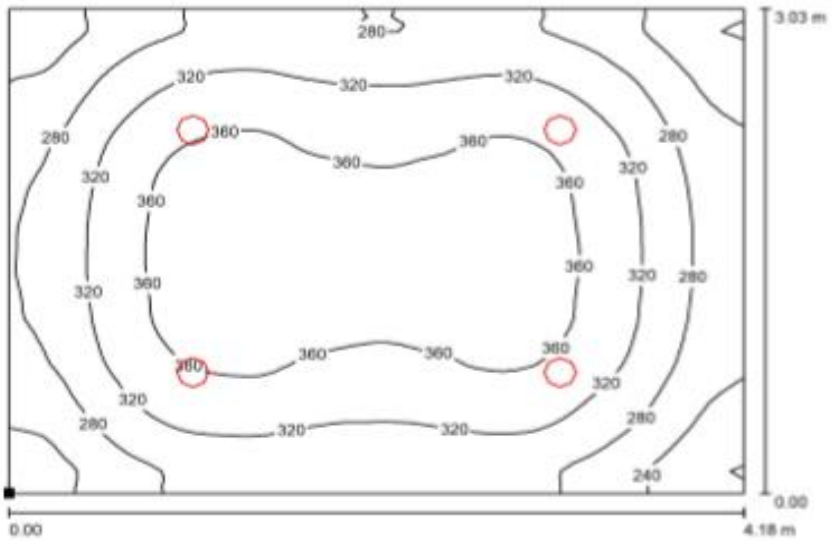
Bed Room / Workplane / Isolines (E)



Values in Lux, Scale 1 : 30

Position of surface in room:
Marked point:
(-21.469 m, 1.854 m, 0.700 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
317	194	387	0.612	0.502

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Project 1

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Bed Room / Workplane / Value Chart (E)

211	224	239	258	270	282	282	286	278	277	276	276	278	279	282	275	267	251	237	216	195
224	237	255	277	288	301	301	304	296	296	293	294	296	297	300	293	286	268	252	229	208
243	253	273	299	311	324	323	326	317	313	314	312	316	317	322	317	309	290	271	245	224
251	262	283	310	321	334	336	338	330	326	326	325	329	330	333	327	319	300	282	253	231
262	275	299	328	339	352	355	354	346	343	341	342	345	348	351	346	337	314	296	266	243
270	284	309	337	349	361	365	365	354	352	349	351	354	358	363	356	345	323	304	273	252
278	292	316	344	358	371	373	377	365	363	361	360	366	368	371	365	352	331	311	281	258
283	295	321	349	365	379	379	382	369	366	365	364	371	373	379	373	360	337	314	285	261
284	298	324	350	366	380	379	384	370	371	366	368	373	374	380	371	359	338	316	287	263
285	300	326	352	368	381	380	386	372	370	370	369	374	377	383	373	360	340	318	288	263
286	299	326	352	369	383	382	385	373	372	369	371	376	376	383	375	363	341	318	288	264
285	300	326	352	368	382	381	386	372	371	370	369	375	377	382	372	361	340	318	288	263
284	297	324	350	366	381	380	382	369	370	366	368	371	373	379	373	360	338	316	286	263
283	296	321	348	362	378	379	382	370	369	367	365	373	373	378	370	358	337	315	285	261
276	291	317	345	357	373	373	375	362	360	358	358	362	367	371	364	354	331	310	279	256
273	286	311	339	351	364	368	367	356	355	352	354	356	361	364	357	346	323	305	274	254
261	273	296	325	335	347	348	349	341	338	336	337	341	343	346	342	330	309	291	261	239
253	265	287	315	327	337	339	339	331	327	326	327	331	333	337	333	321	300	281	253	231
235	250	270	293	306	316	318	318	310	309	309	309	312	313	318	311	300	280	263	239	215
226	240	257	279	291	302	300	304	296	295	294	295	298	298	302	295	284	266	251	228	207
226	236	252	271	283	294	293	296	287	290	287	289	291	290	294	288	277	259	245	224	204

3.03 m

0.00

0.00

4.16 m

Values in Lux, Scale 1 : 30

Not all calculated values could be displayed.

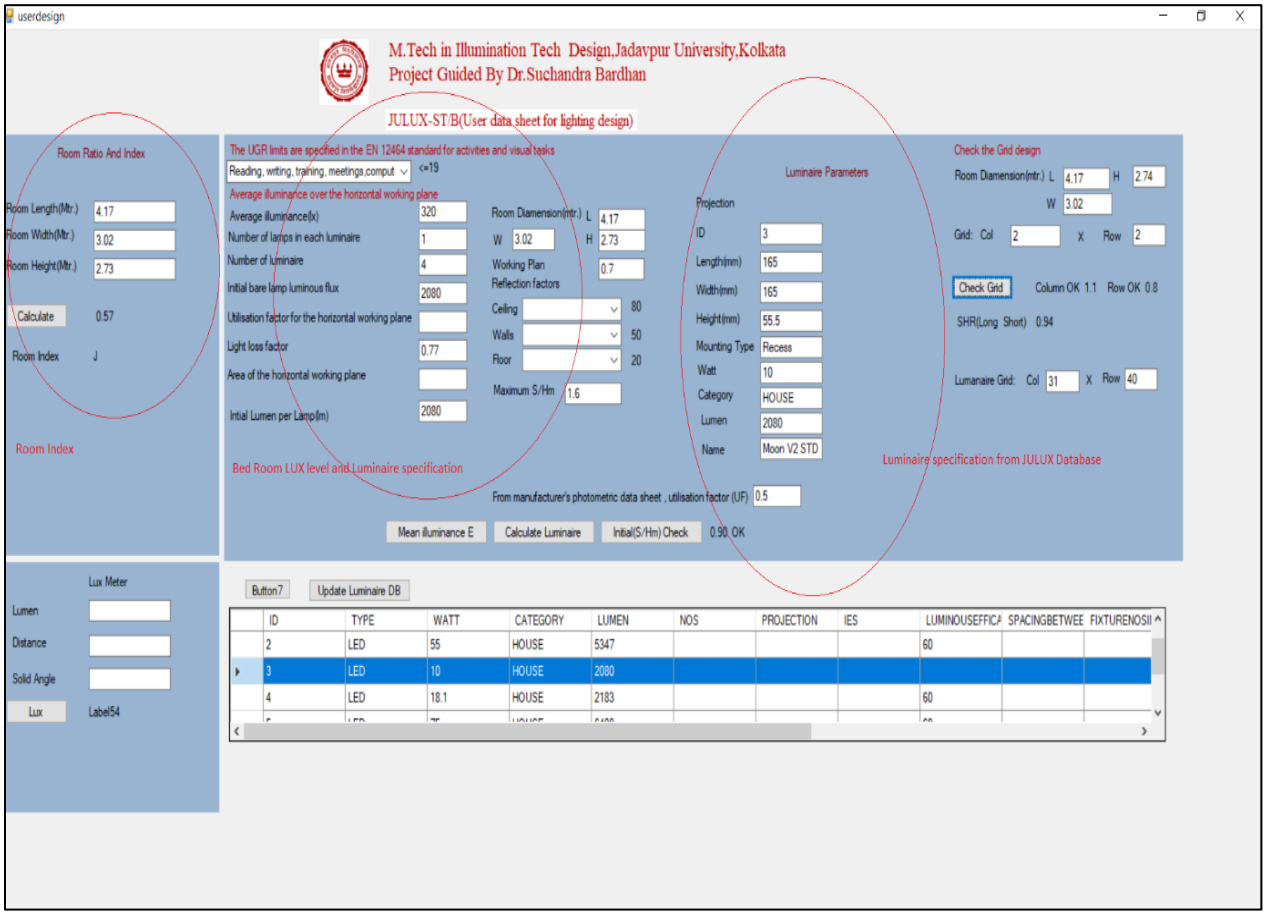
Position of surface in room:
Marked point:
(-21.469 m, 1.854 m, 0.700 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
317	194	387	0.612	0.502

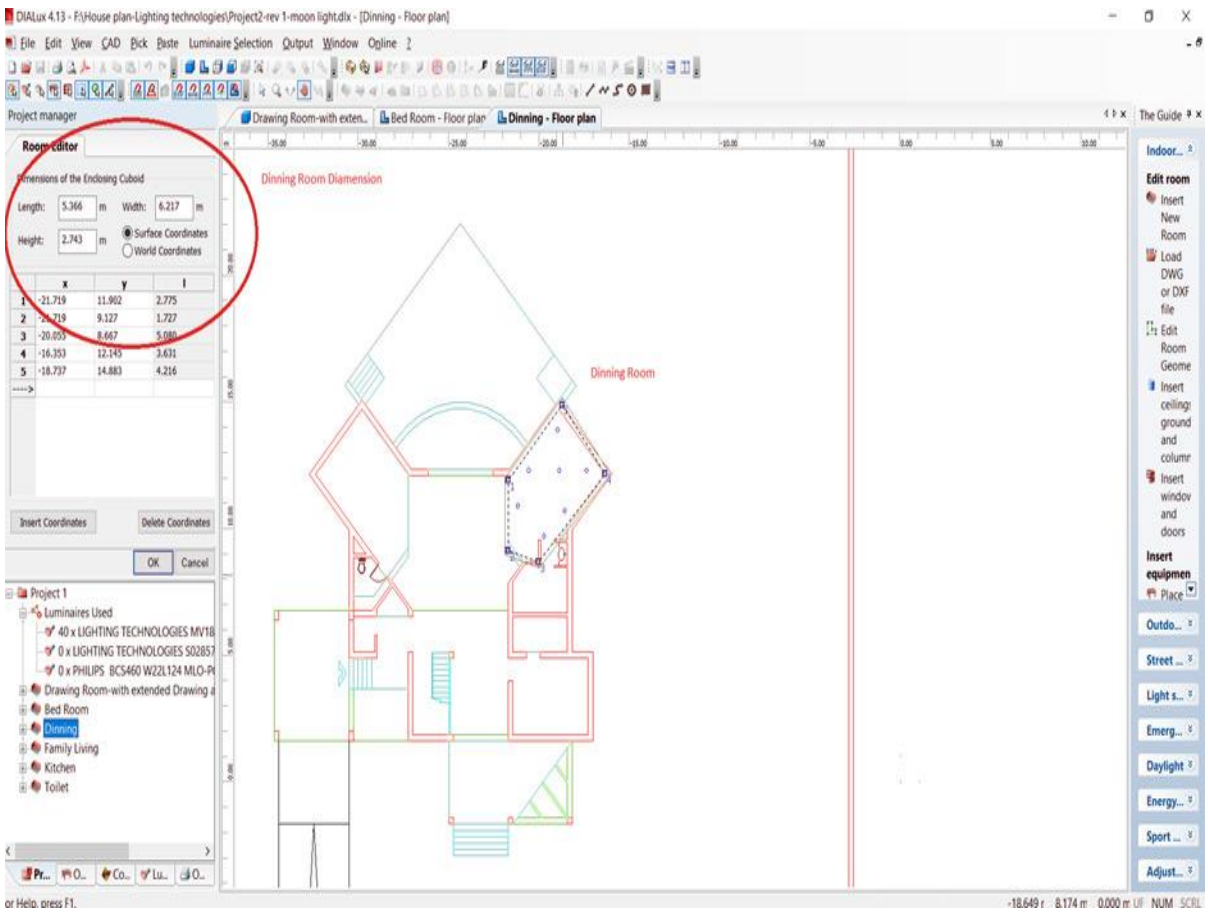
Page 1

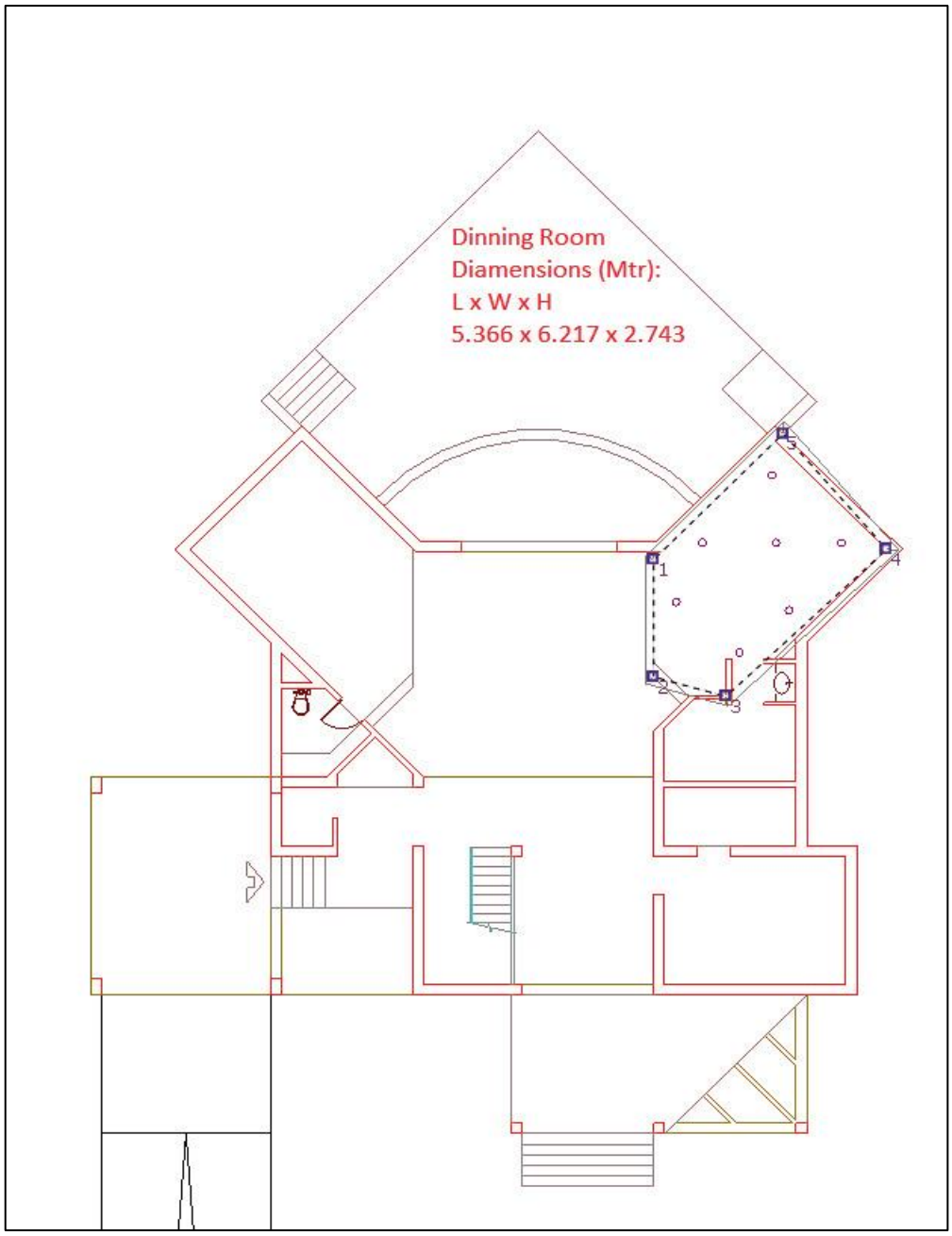
1.1 JU-LUX output of the Bed Room lighting design parameter: -



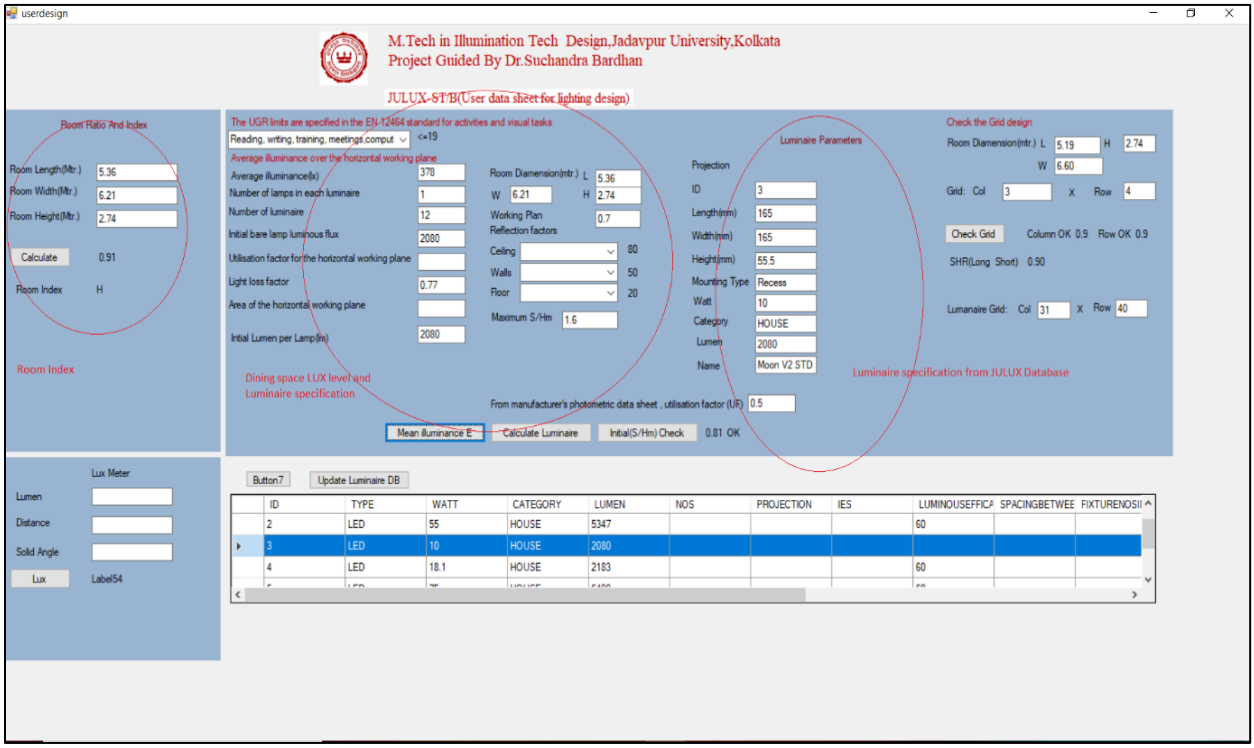
6.3.9 Case: - IX Validation of JU-LUX in Dining Room:-

1.0 Validation of JU-LUX in Dining Room (with extra curvature) lighting design parameter Dining Room:-

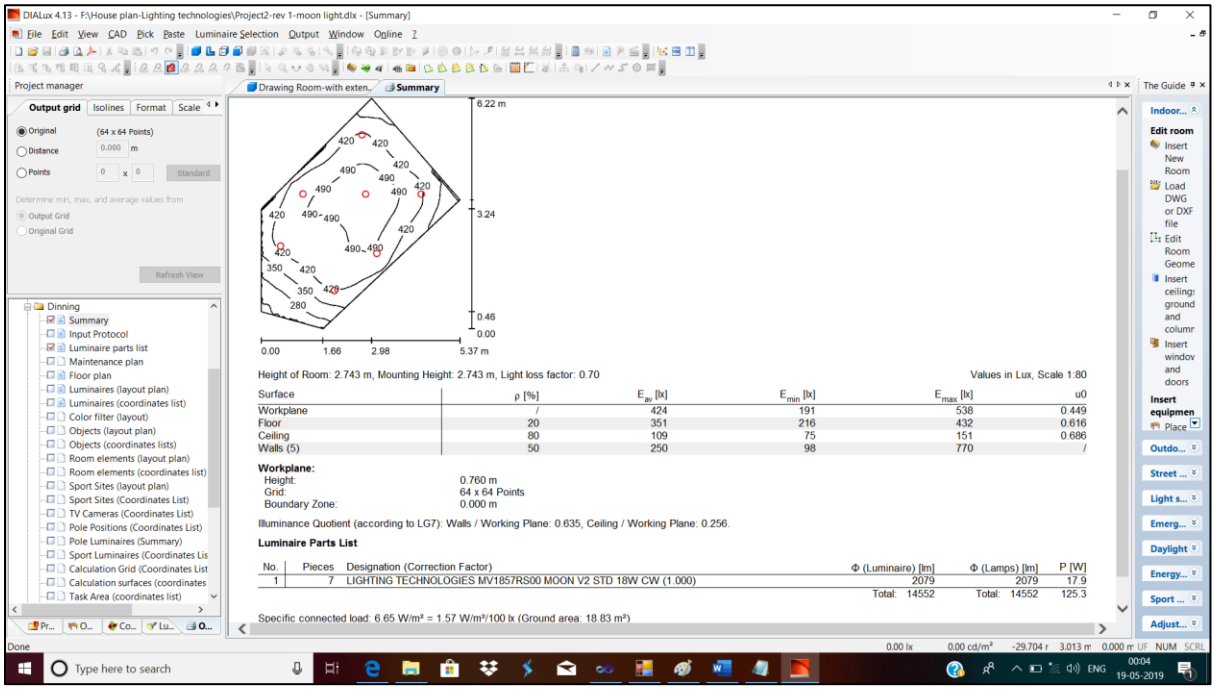
JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Dining Room Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m):5.366 x 6.217 x 2.74 Lux level: 378 lux No of Luminaire required: 12 Nos.	Room Dimension(m): 5.366 x 6.217 x 2.74 Lux level: 424 lux No of Luminaire required: 07 Nos. (with 4x 4 field arrangements)
	


Dinning Room
Diamensions (Mtr):
L x W x H
5.366 x 6.217 x 2.743

1.1 JU-LUX output of the Dining Room (with extra curvature) lighting design parameter: -



1.2 DIALux output of the Dining Room (with extra curvature) lighting design parameter: -



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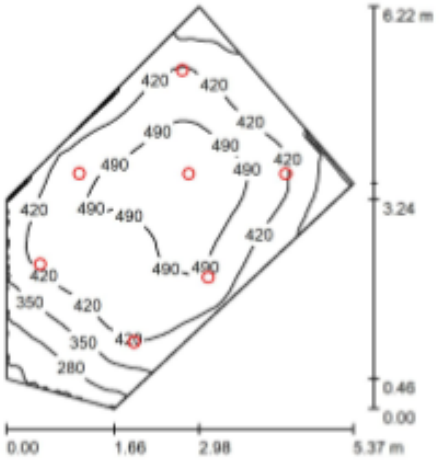

Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.70

Values in Lux, Scale 1:80

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	424	191	538	0.449
Floor	20	351	216	432	0.616
Ceiling	80	109	75	151	0.686
Walls (5)	50	250	98	770	/

Workplane:
Height: 0.760 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.635, Ceiling / Working Plane: 0.256.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	7	LIGHTING TECHNOLOGIES MV1857RS00 MOON V2 STD 18W CW (1.000)	2079	2079	17.9
			Total: 14552	Total: 14552	125.3

Specific connected load: 6.65 W/m² = 1.57 W/m²/100 lx (Ground area: 18.83 m²)

Page 1

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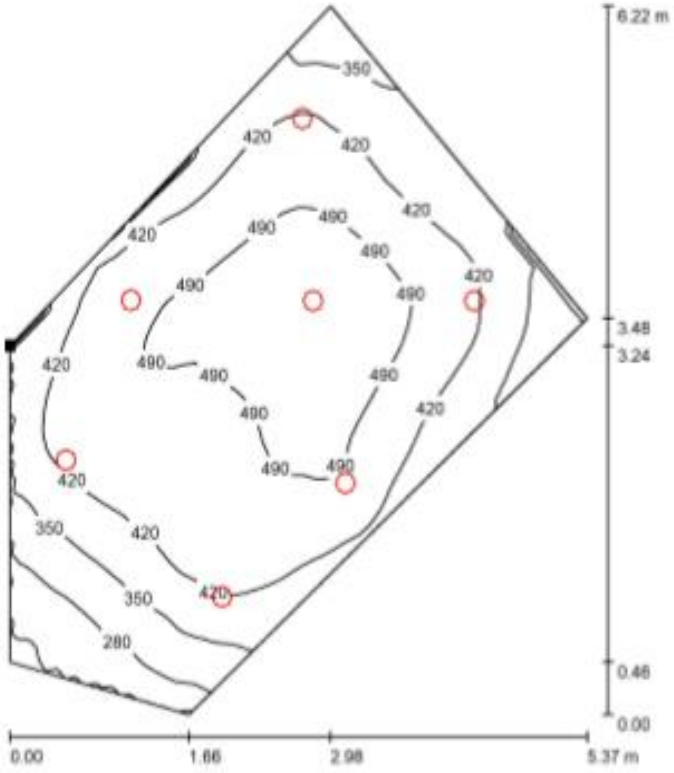
Dinning / Workplane / Isolines (E)



Values in Lux, Scale 1 : 49

Position of surface in room:
Marked point:
(-21.719 m, 11.902 m, 0.760 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
424	191	538	0.449	0.354

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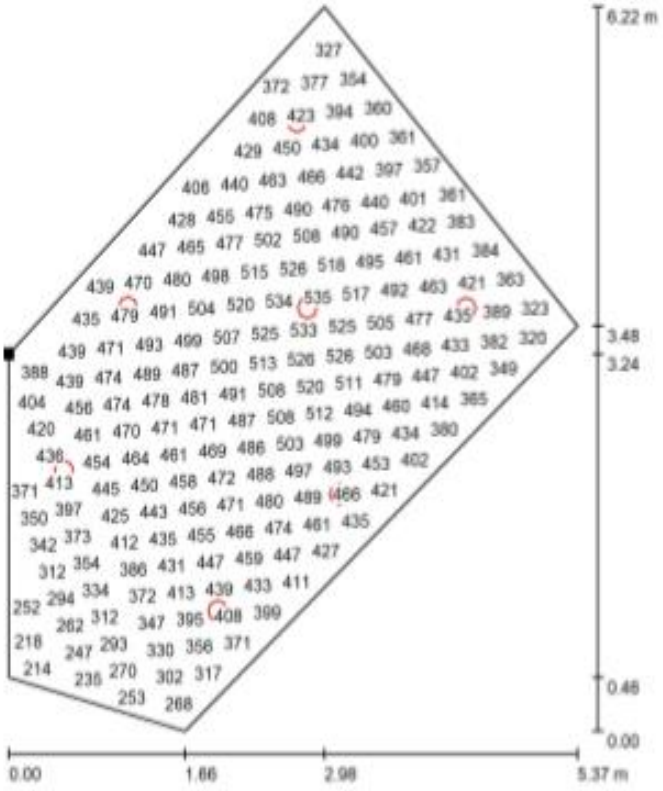
Dinning / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 49

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(-21.719 m, 11.902 m, 0.760 m)

Grid: 64 x 64 Points

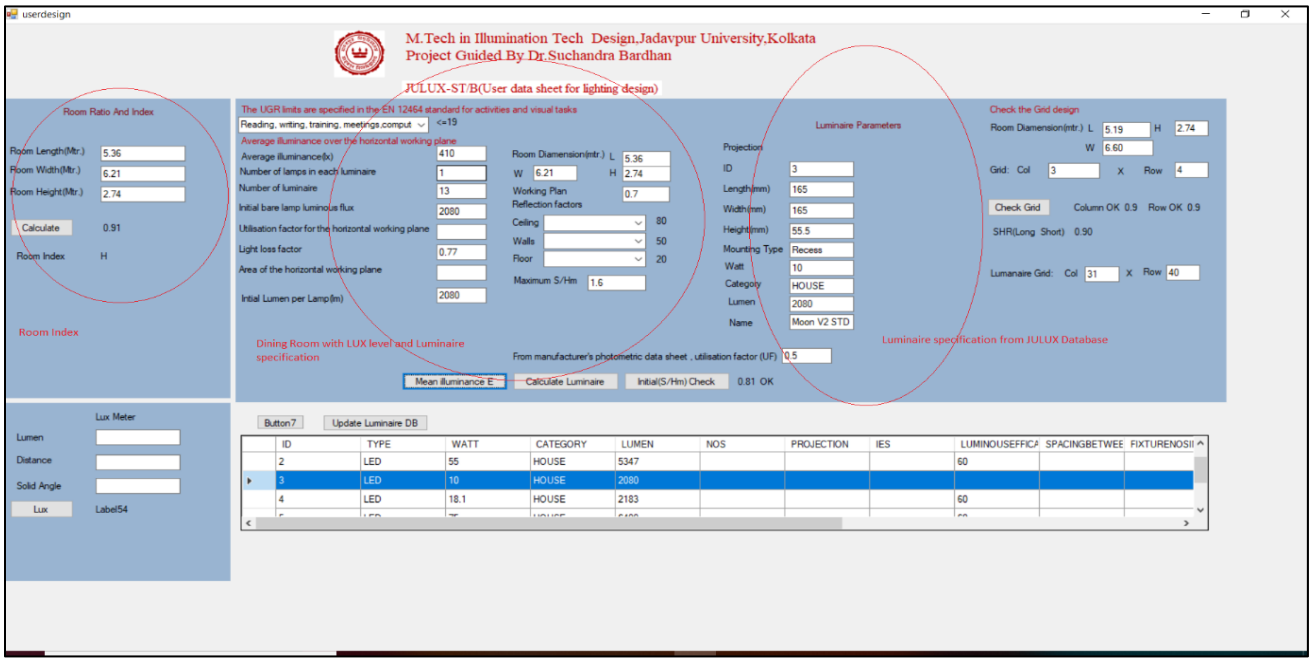
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
424	191	538	0.449	0.354

6.3.9.1 Case: - IX Validation of JU-LUX (Special Consideration in Architectural Drawing):-

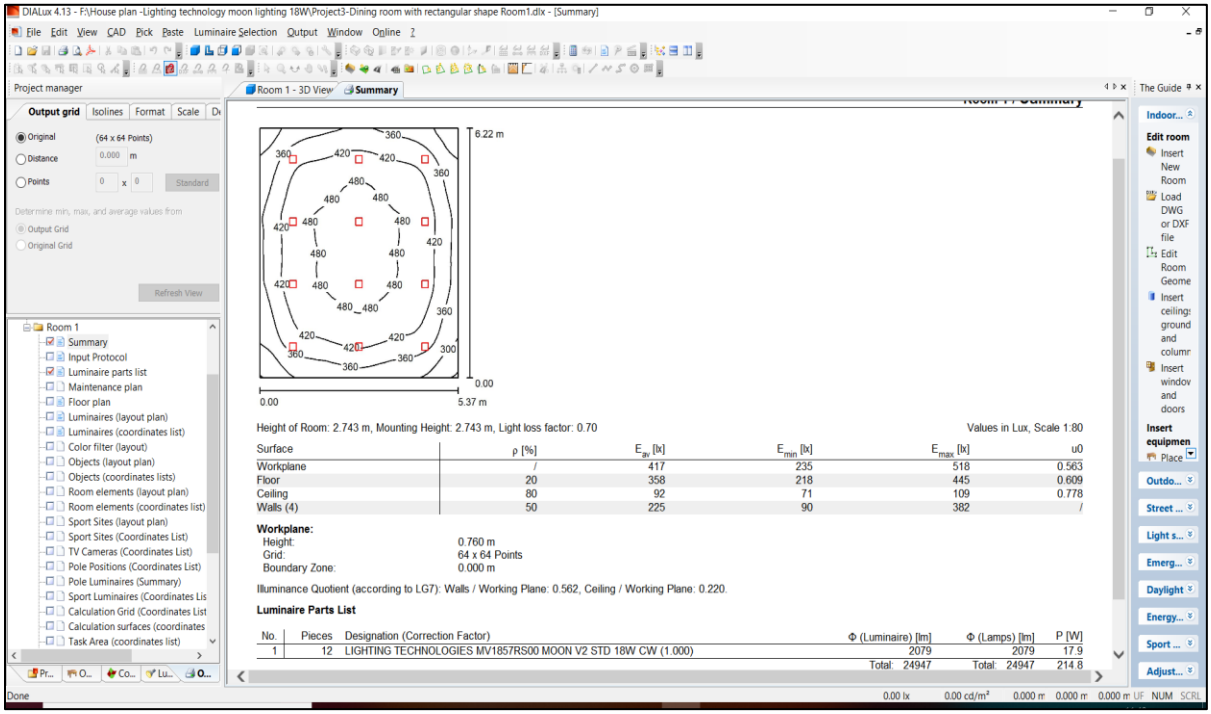
1.0 Validation of JU-LUX in Dining Room (with proper rectangular shape) lighting design parameter:-

JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Dining Room Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension (m):5.366 x 6.217 x 2.74 Lux level: 410 lux No of Luminaire required: 13 Nos.	Room Dimension (m): 5.366 x 6.217 x 2.74 Lux level: 417 lux No of Luminaire required: 12 Nos. (with 4x 4 field arrangements)

1.1 JU-LUX output of the Dining Room (with proper rectangular shape without extra curvature) lighting design parameter: -



1.2 DIALux output of the Dining Room (with proper rectangular shape without extra curvature) lighting design parameter:-

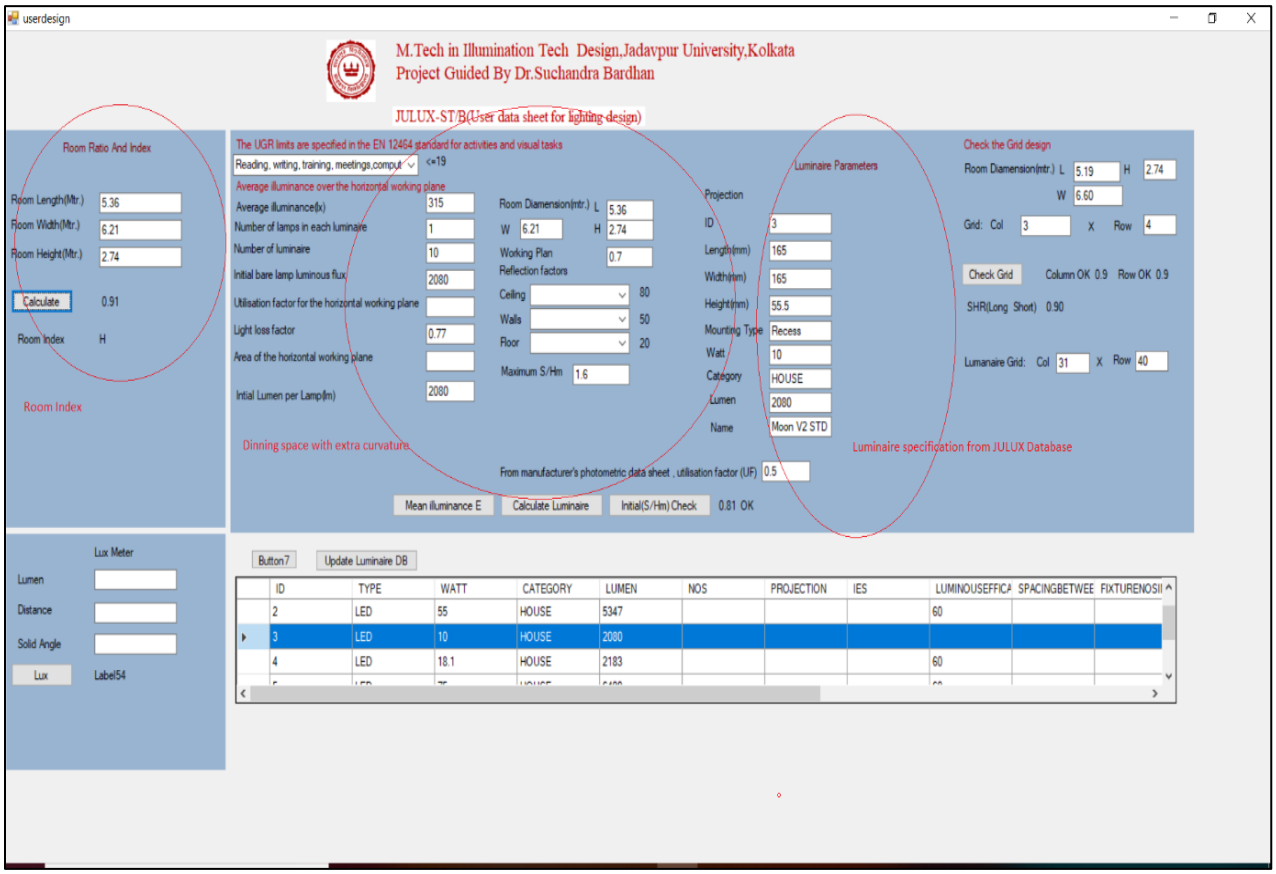


6.3.10 Case:-X Validation of JU-LUX in Family Living: -

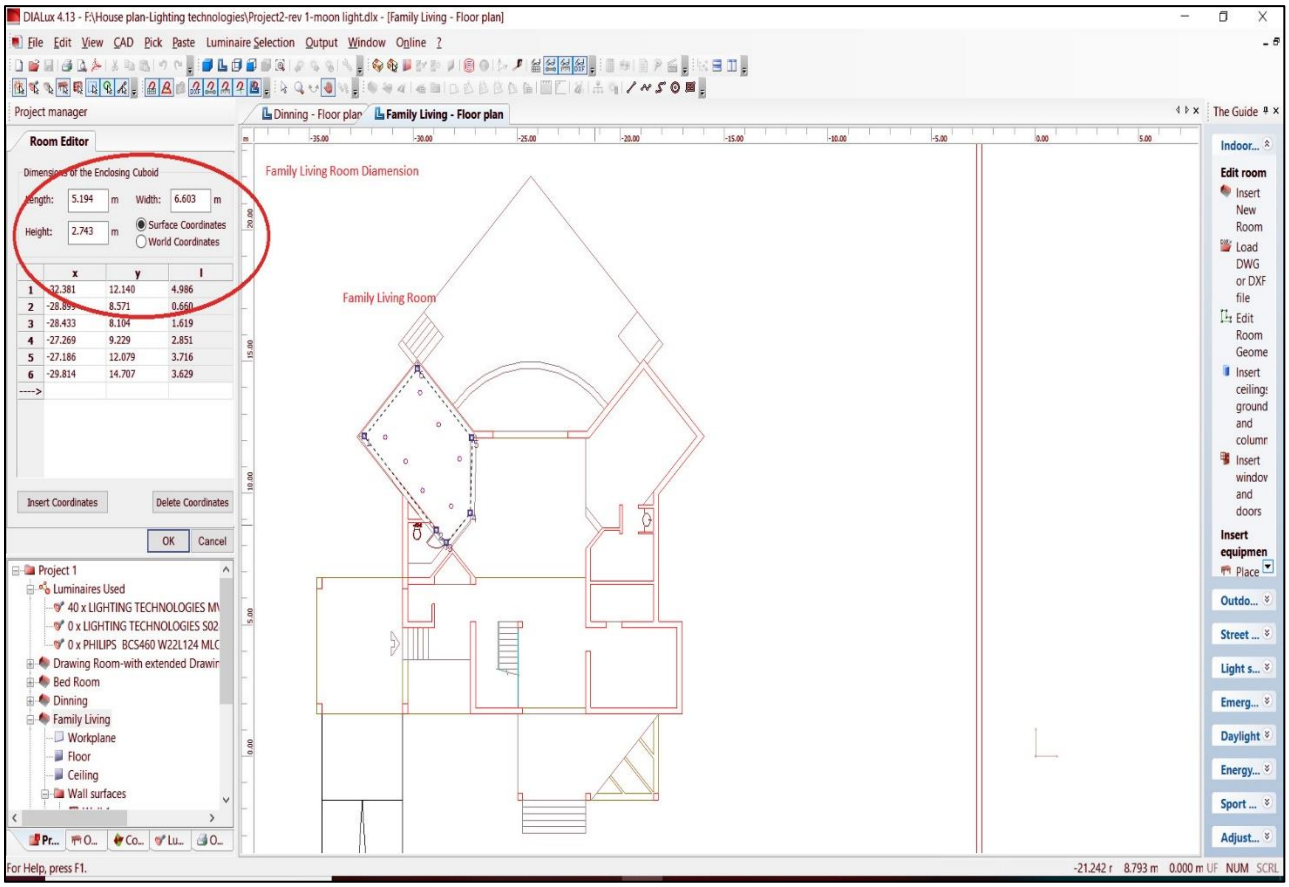
1.0 Validation of JU-LUX in Family Living (with extra curvature) lighting design: -

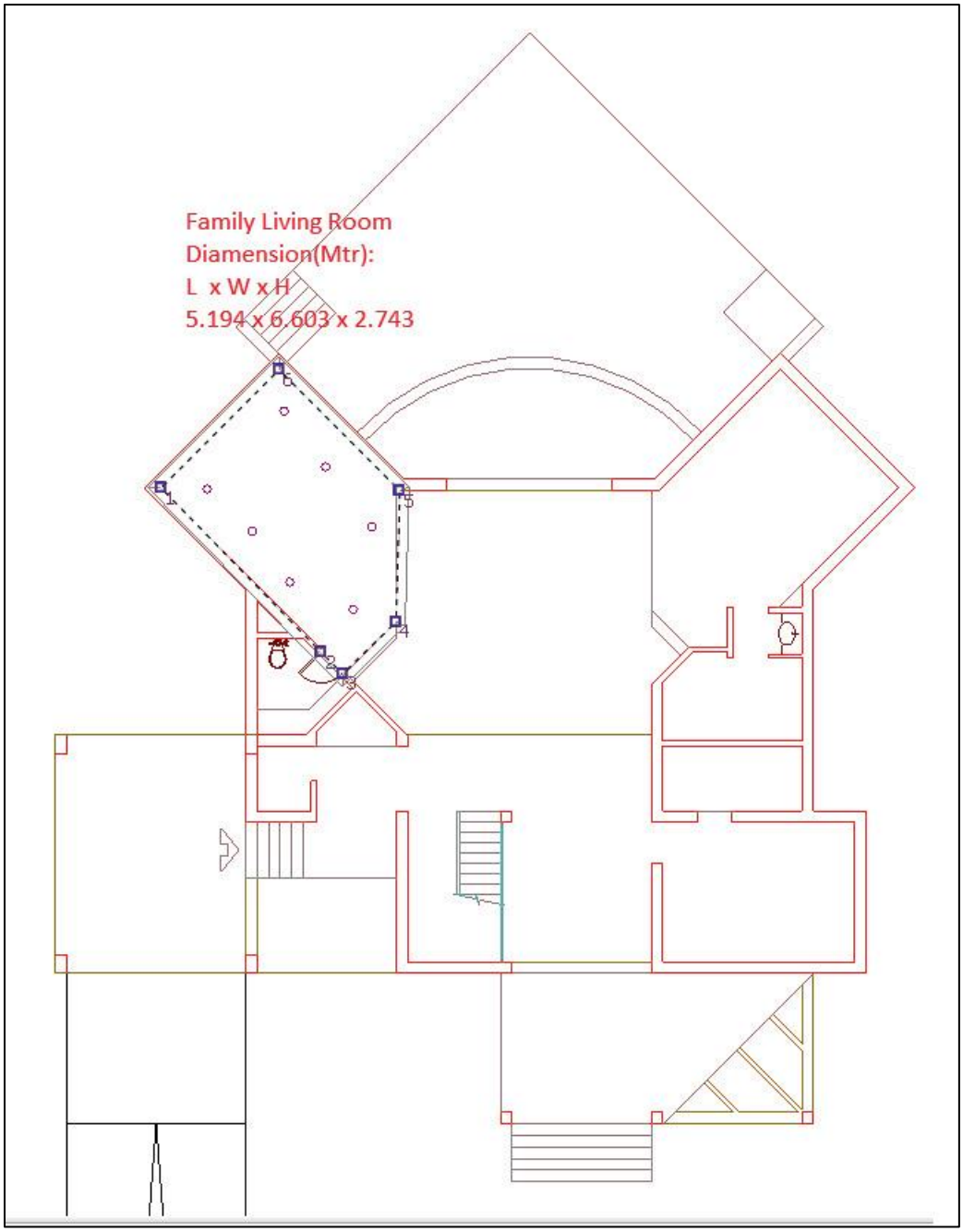
JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Family Living Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m):5.194 x 6.603 x 2.74 Lux level: 315 lux No of Luminaire required: 10 Nos.	Room Dimension(m): 5.194 x 6.603 x 2.74 Lux level: 426 lux No of Luminaire required: 07 Nos. (with 4x 4 field arrangements)

1.1 JU-LUX output of the Family Living (with extra curvature) lighting design parameter:-



1.2 Family Living Room on DIALux :-




Family Living Room
Diamension(Mtr):
L x W x H
5.194 x 6.603 x 2.743

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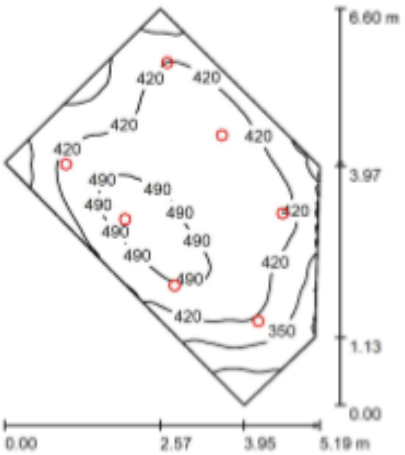
Family Living / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.80

Values in Lux, Scale 1:85

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	426	213	519	0.499
Floor	20	350	214	423	0.612
Ceiling	80	109	73	159	0.676
Walls (6)	50	252	95	654	/

Workplane:
Height: 0.760 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.638, Ceiling / Working Plane: 0.255.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	7	LIGHTING TECHNOLOGIES MV1857RS00 MOON V2 STD 18W CW (1.000)	2079	2079	17.9
			Total: 14552	Total: 14552	125.3

Specific connected load: 6.69 W/m² = 1.57 W/m²/100 lx (Ground area: 18.74 m²)

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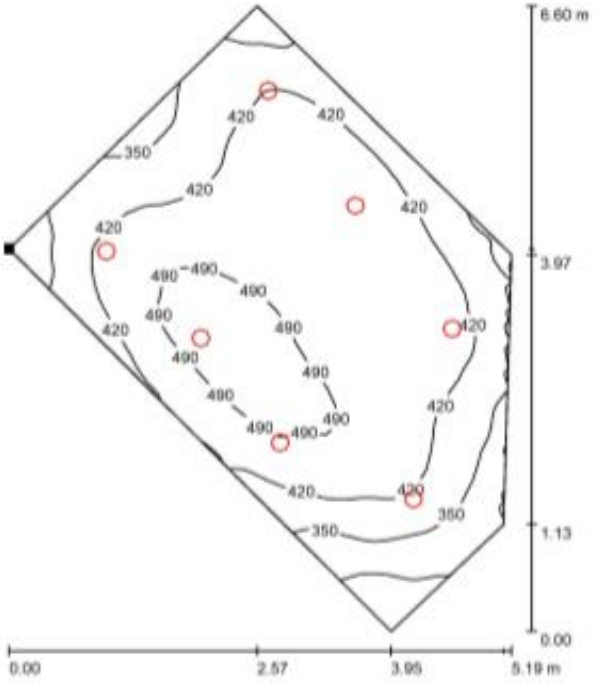
Family Living / Workplane / Isolines (E)



Values in Lux, Scale 1 : 52

Position of surface in room:
Marked point:
(-32.381 m, 12.140 m, 0.760 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
426	213	519	0.499	0.410

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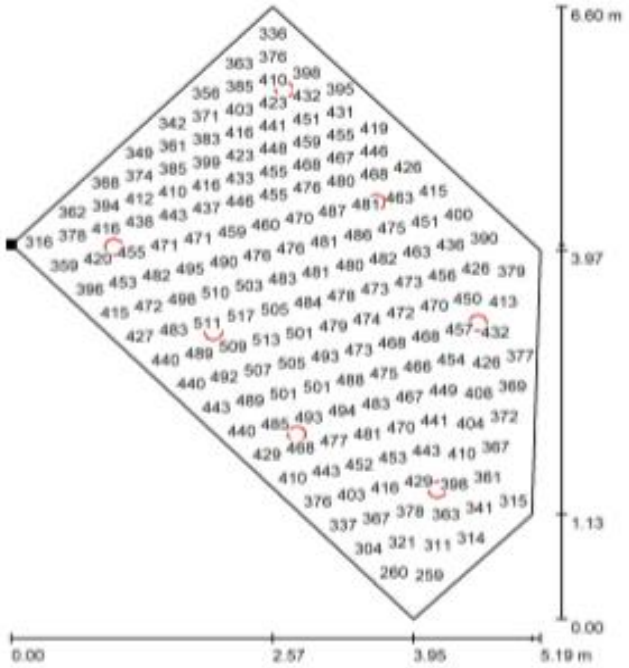
Family Living / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 52

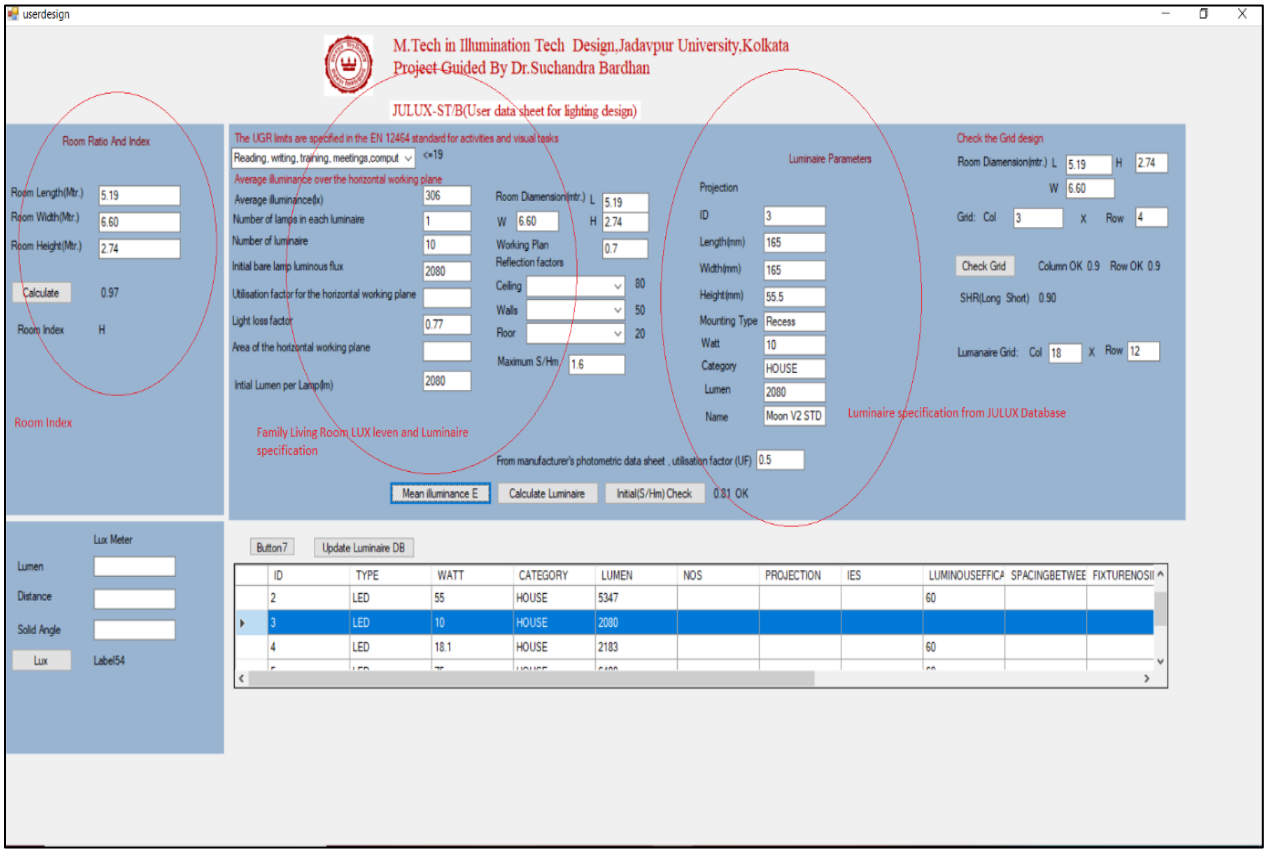
Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(-32.381 m, 12.140 m, 0.760 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
426	213	519	0.499	0.410

1.3 JU-LUX output of the Family Living (with extra curvature) lighting design parameter:-

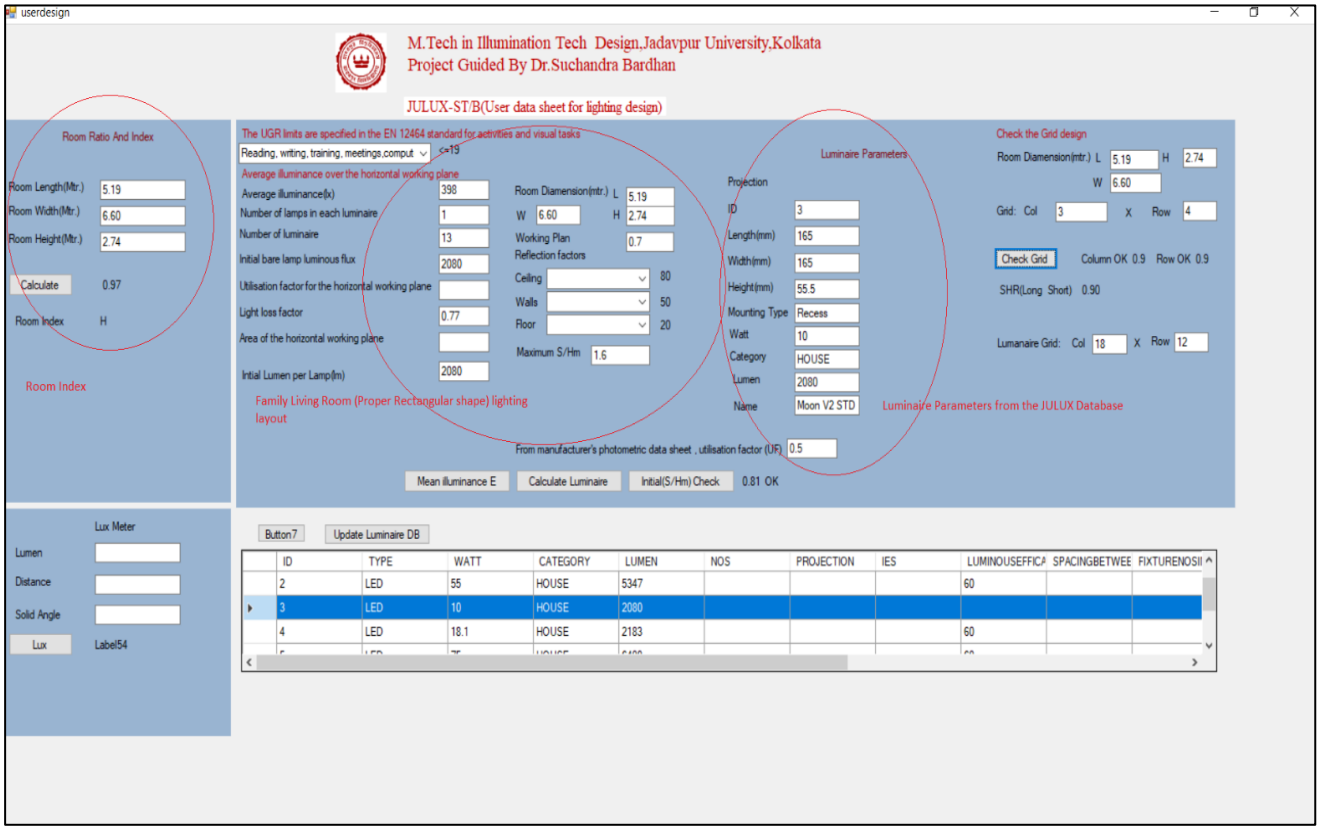


6.3.10.1 Case: - X Validation of JU-LUX (Special consideration in Architectural Design)

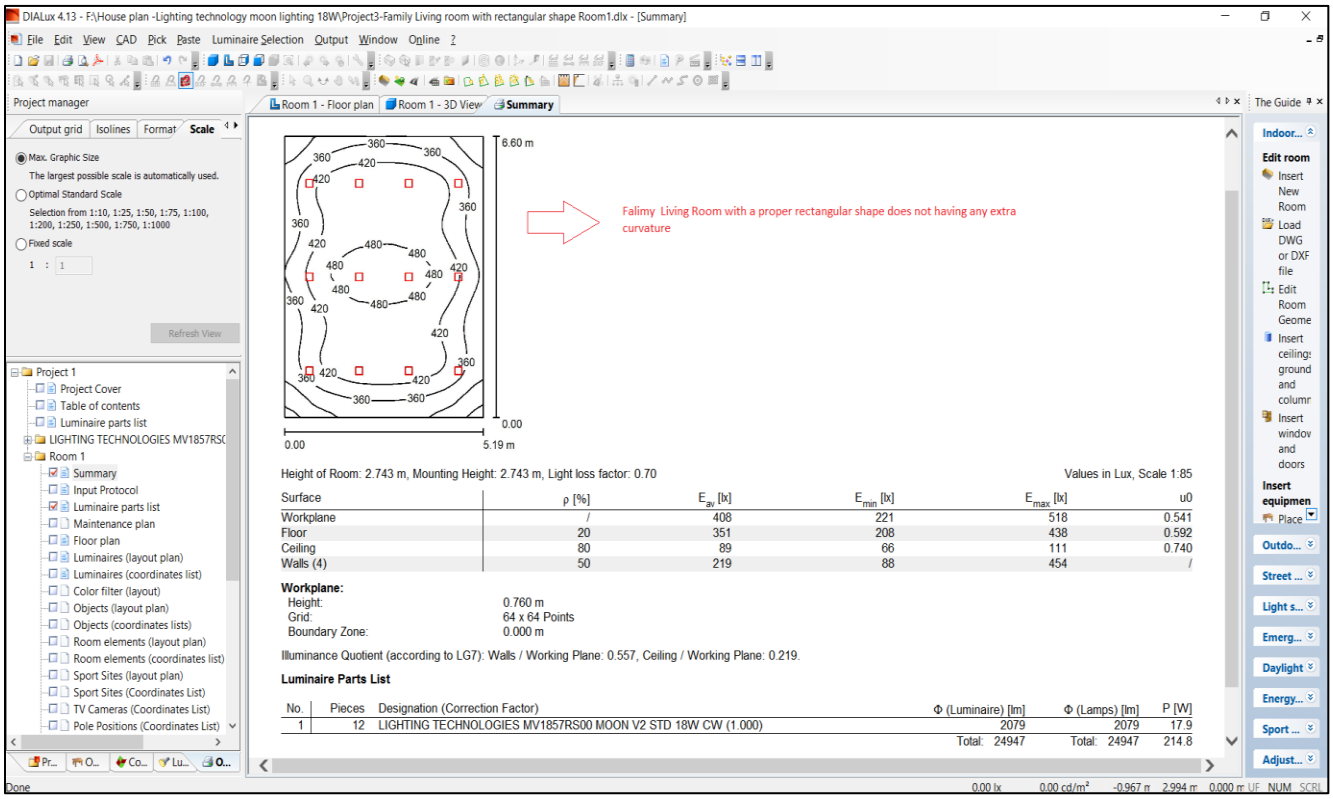
Validation of JU-LUX in Family Living (Proper Rectangular area does not have any extra curvature) lighting design

JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Family Living Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m):5.194 x 6.603 x 2.74 Lux level: 386 lux No of Luminaire required: 13 Nos.	Room Dimension(m): 5.194 x 6.603 x 2.74 Lux level: 408 lux No of Luminaire required: 12 Nos. (with 4x 4 field arrangements)

1.0 JU-LUX output of the Family Living (Proper Rectangular area does not have any extra curvature) lighting design parameter: -



1.1 DIALux (Summary) output of the Family Living (Proper Rectangular area does not have any extra curvature) lighting design parameter: -

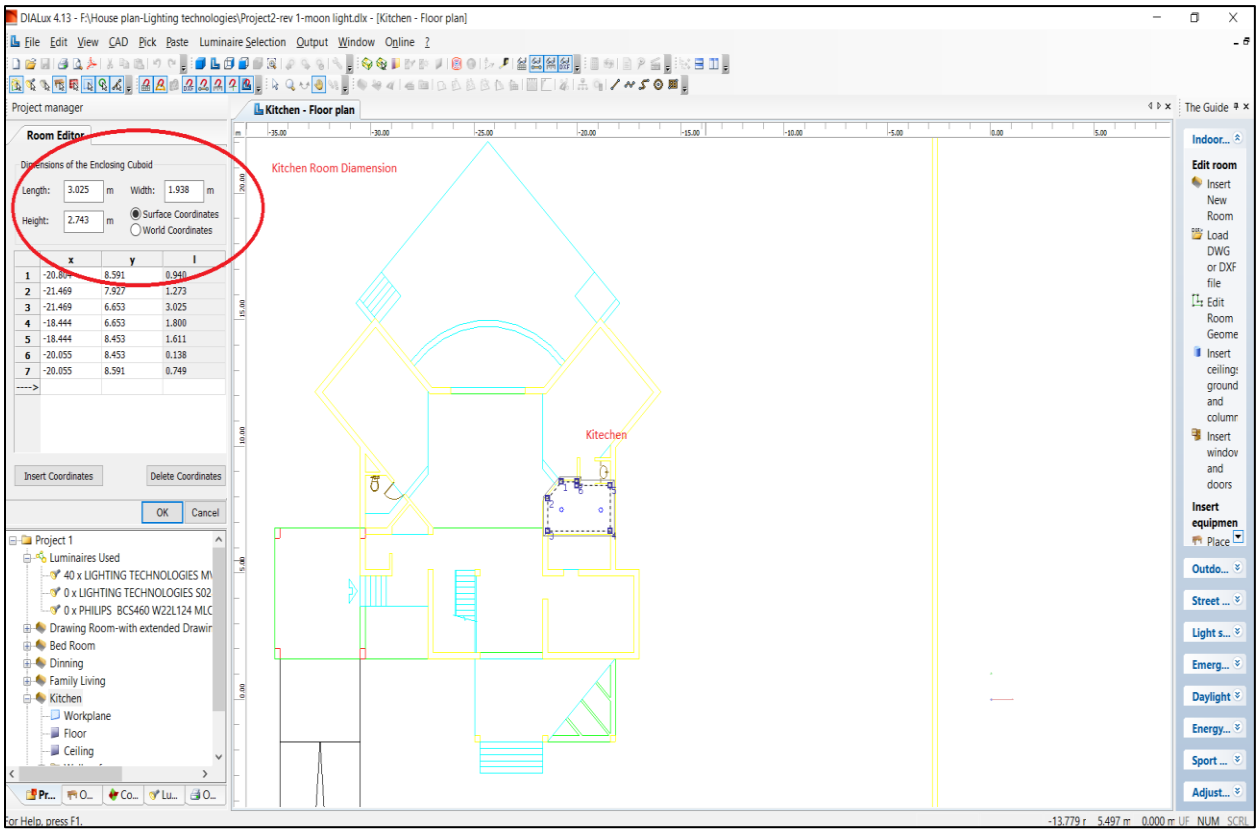


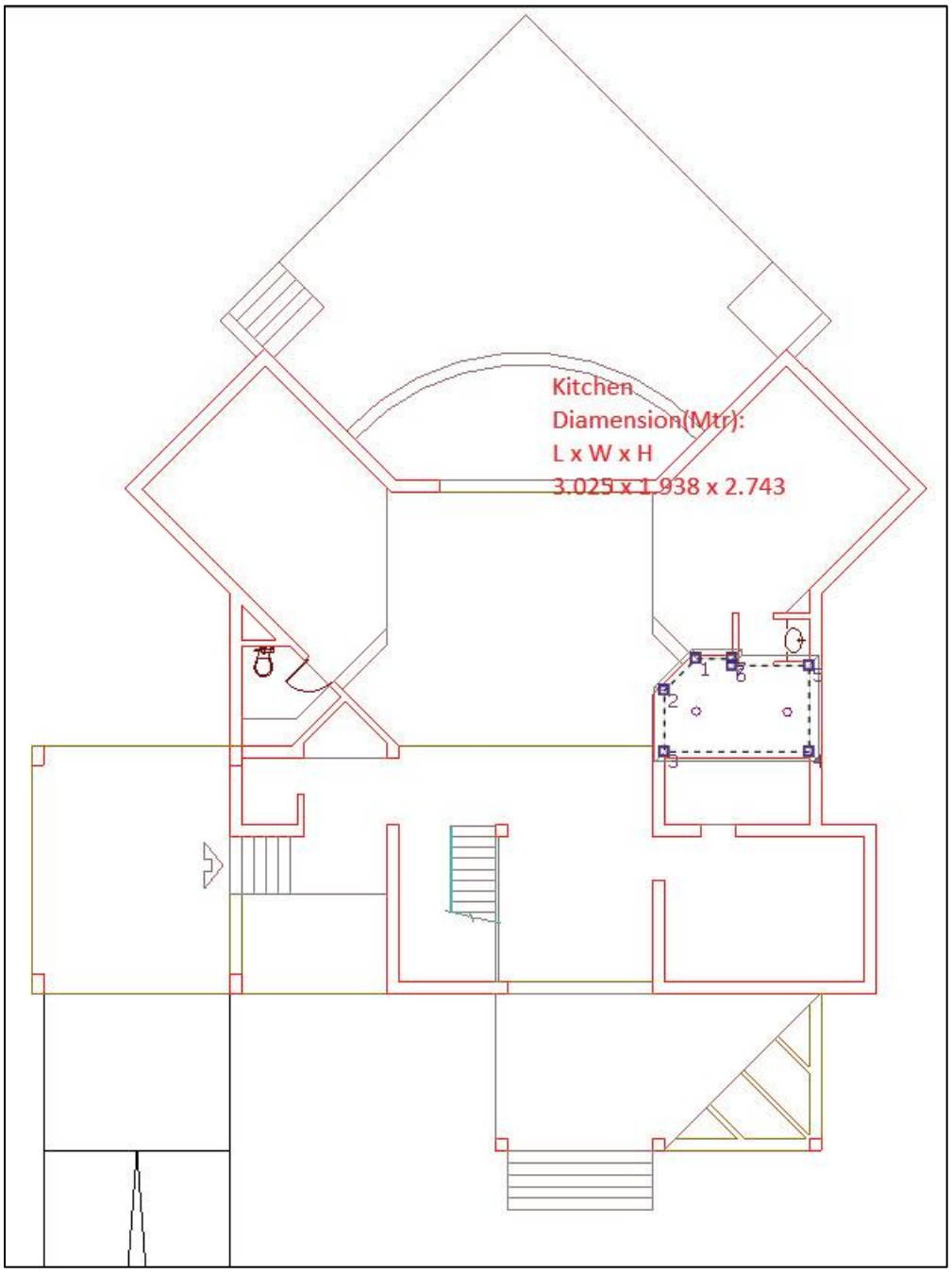
6.3.11 Case: - XI Validation of JU-LUX in Kitchen area

1.0 Validation of JU-LUX in Kitchen area (Proper Rectangular area does not have any extra curvature) lighting design: -

JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Kitchen area Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m):3.025 x 1.938 x 2.74 Lux level: 278 lux No of Luminaire required: 02 Nos.	Room Dimension(m): 3.025 x 1.938 x 2.74 Lux level: 278 lux No of Luminaire required: 02 Nos. (with 4x 4 field arrangements)

1.1 Kitchen room in DIALux as shown: -




Kitchen
Diamension(Mtr):
L x W x H
3.025 x 1.938 x 2.743

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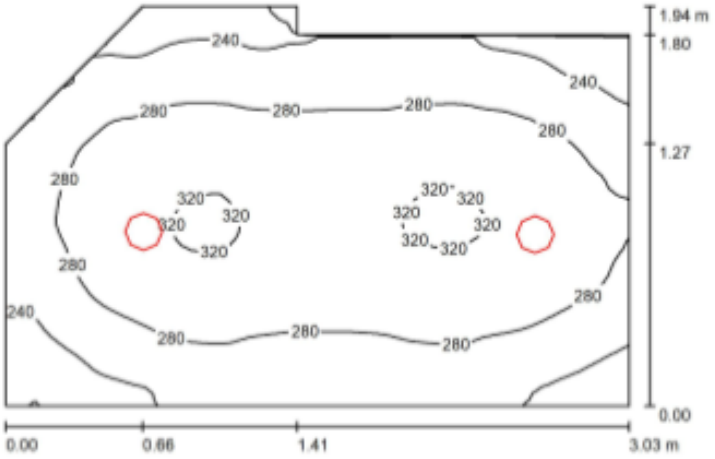

Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.80

Values in Lux, Scale 1:25

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	278	170	326	0.610
Floor	20	197	140	224	0.709
Ceiling	80	91	61	169	0.672
Walls (7)	50	180	69	817	/

Workplane:
Height: 0.760 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.742, Ceiling / Working Plane: 0.326.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	2	LIGHTING TECHNOLOGIES MV1857RS00 MOON V2 STD 18W CW (1.000)	2079	2079	17.9
			Total: 4158	Total: 4158	35.8

Specific connected load: 6.61 W/m² = 2.37 W/m²/100 lx (Ground area: 5.42 m²)

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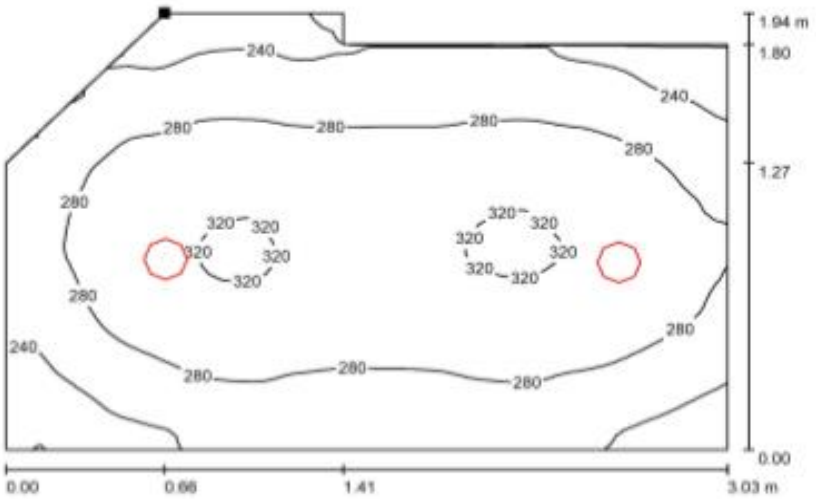

Values in Lux, Scale 1 : 22

Position of surface in room:
Marked point:
(-20.804 m, 8.591 m, 0.760 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
278	170	326	0.610	0.521

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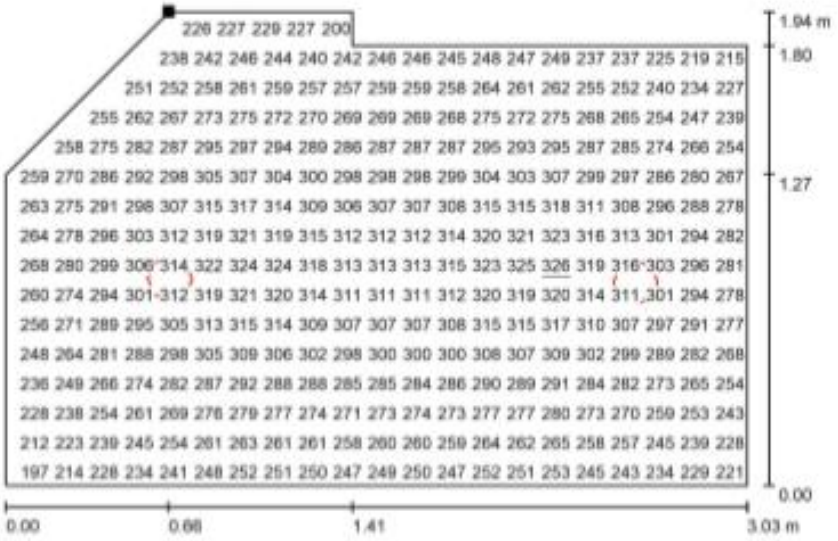
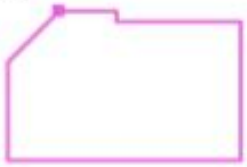
Kitchen / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 22

Not all calculated values could be displayed.

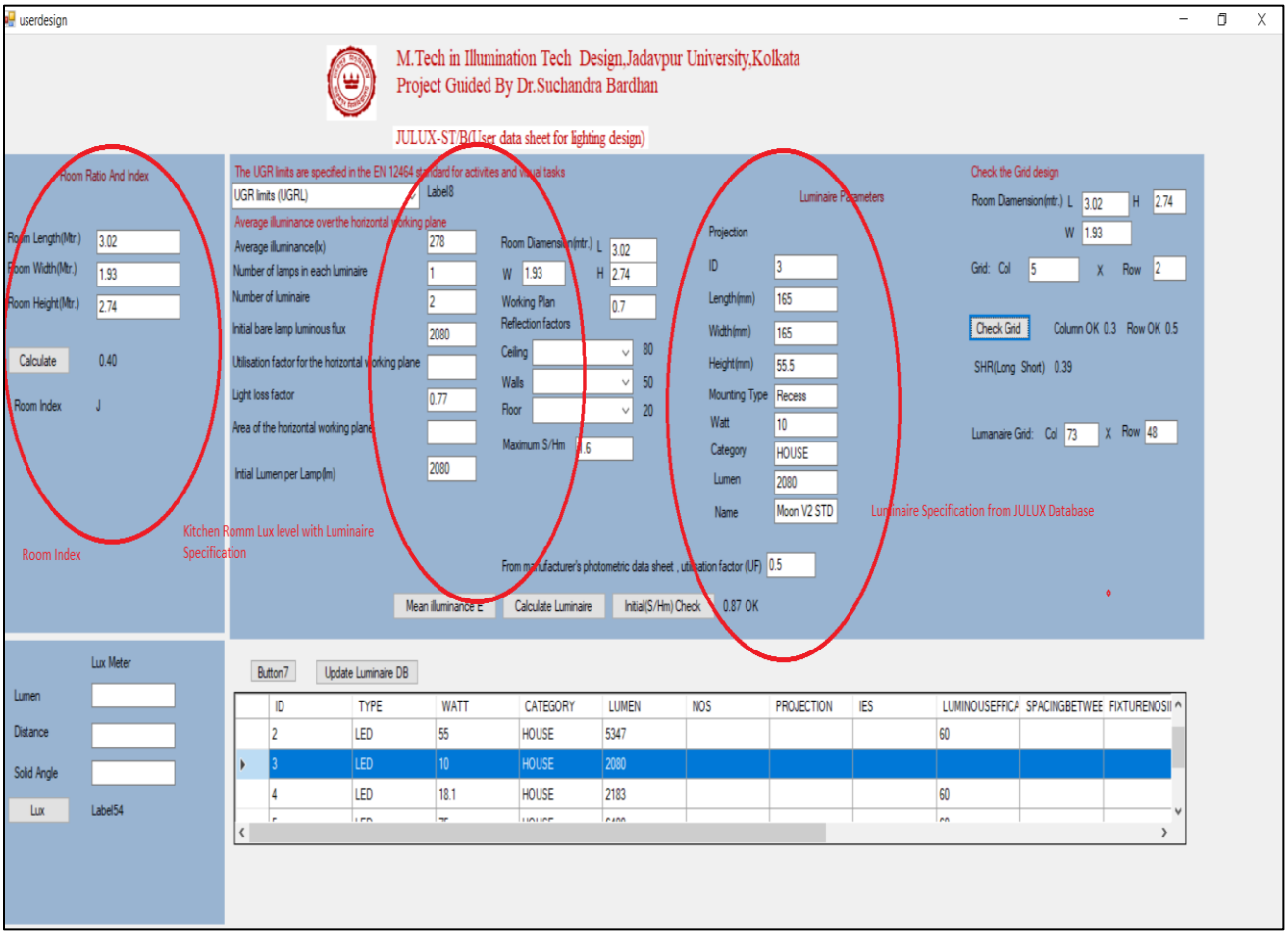
Position of surface in room:
Marked point:
(-20.804 m, 8.591 m, 0.760 m)



Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
278	170	326	0.610	0.521

1.2 JU-LUX output of the Kitchen area lighting design parameter: -

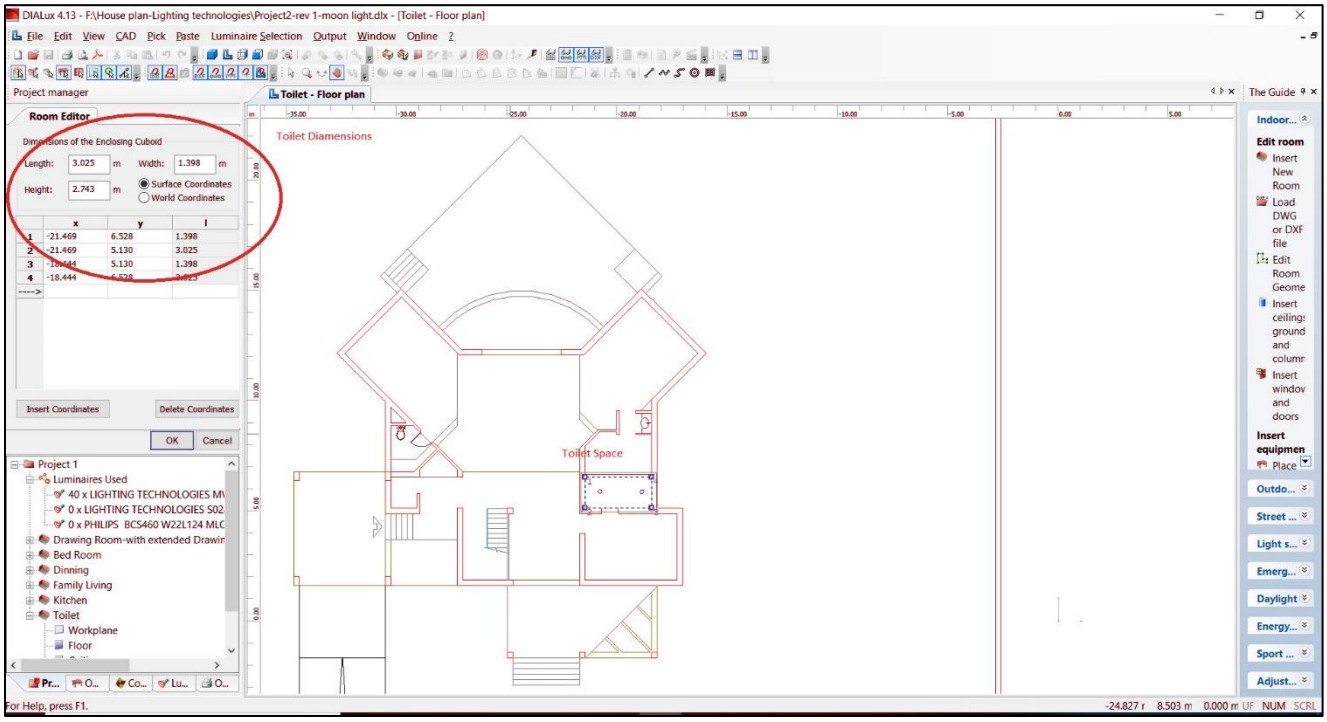


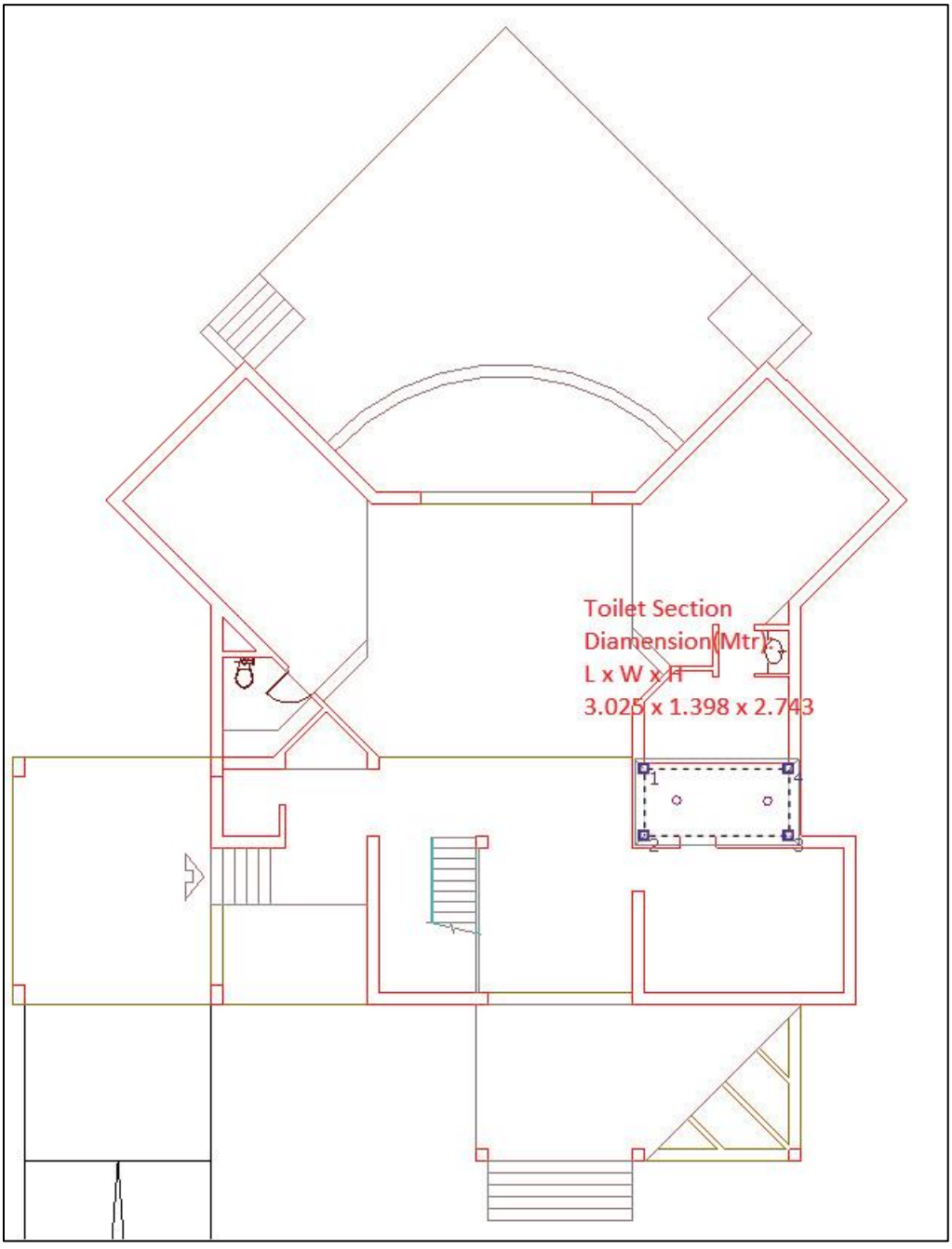
6.3.12 Case: -XII Validation of Toilet area

1.0 Validation of Toilet area (Proper Rectangular area does not have any extra curvature) lighting design: -

JU-LUX PARAMETERS AS DERIVED	DIALux PARAMETERS AS DERIVED
ROOM: Toilet space Lighting Layout (Luminaire Name: LIGHTING TECHNOLOGIES MOON V2 18W CW STD)	
Room Dimension(m):3.025 x 1.938 x 2.74 Lux level: 320 lux No of Luminaire required: 02 Nos.	Room Dimension(m): 3.025 x 1.938 x 2.74 Lux level: 300 lux No of Luminaire required: 02 Nos. (with 4x 4 field arrangements)

1.1 Toilet area / space shown in DIALux:-




Toilet Section
Diamension (Mtr.)
L x W x H
3.025 x 1.398 x 2.743

Project 1

DIALux
16.05.2019

Operator
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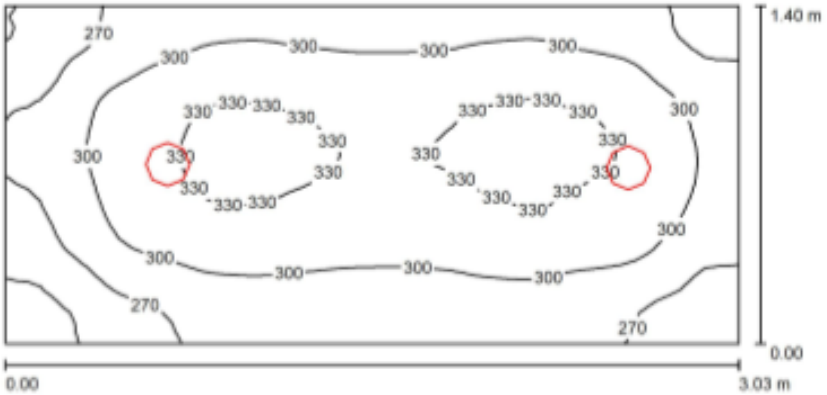
Fax
e-Mail

Toilet / Summary



Height of Room: 2.743 m, Mounting Height: 2.743 m, Light loss factor: 0.80

Values in Lux, Scale 1:22

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	300	219	341	0.731
Floor	20	205	166	228	0.813
Ceiling	80	111	73	150	0.653
Walls (4)	50	208	82	847	/

Workplane:
Height: 0.760 m
Grid: 64 x 32 Points
Boundary Zone: 0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.816, Ceiling / Working Plane: 0.371.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	2	LIGHTING TECHNOLOGIES MV1857RS00 MOON V2 STD 18W CW (1.000)	2079	2079	17.9
			Total: 4158	Total: 4158	35.8

Specific connected load: 8.47 W/m² = 2.82 W/m²/100 lx (Ground area: 4.23 m²)

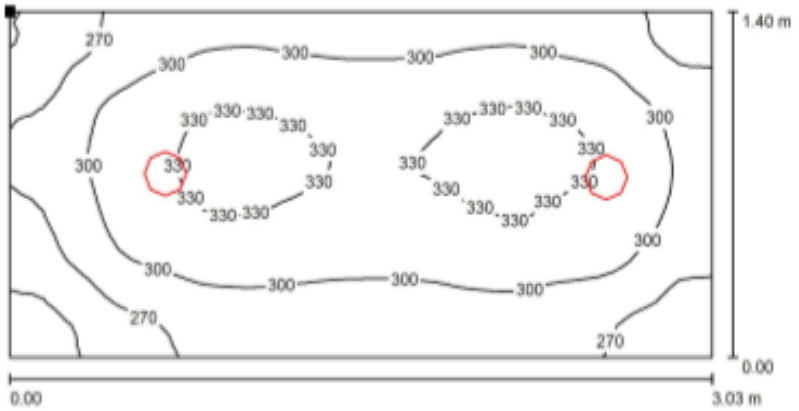
Page 1

Project 1

DIALux
18.05.2019

Operator
Telephone
Fax
e-Mail

Toilet / Workplane / Isolines (E)



Values in Lux, Scale 1 : 22

Position of surface in room:
Marked point:
(-21.469 m, 6.528 m, 0.760 m)

Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
300	219	341	0.731	0.643

Page 1

DIALux
16.05.2019

Operator
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Toilet / Workplane / Value Chart (E)

243	254	265	281	288	297	299	299	297	295	293	294	294	298	299	300	295	290	287	270	255
259	270	283	298	305	315	315	315	312	310	309	309	310	313	315	316	313	310	305	290	274
272	282	295	314	320	331	332	331	329	326	324	324	326	330	332	334	330	325	320	302	289
276	287	300	321	326	334	337	335	332	329	328	328	330	333	336	339	335	332	327	307	294
275	286	299	320	326	335	338	336	333	330	328	329	330	333	335	338	335	332	327	307	295
270	279	292	312	317	328	331	330	328	325	323	324	324	328	330	331	327	324	321	304	290
264	272	285	305	312	323	324	323	321	318	316	316	317	321	323	325	322	319	315	297	284
247	258	270	286	292	303	303	304	302	301	299	299	301	304	305	306	302	298	295	282	267
238	247	257	272	279	289	290	291	289	287	286	287	287	290	293	293	290	284	282	269	255
229	237	247	264	270	279	280	281	280	279	279	278	280	282	283	283	280	275	273	258	244

1.40 m
0.00
0.00
3.03 m

Values in Lux, Scale 1 : 22

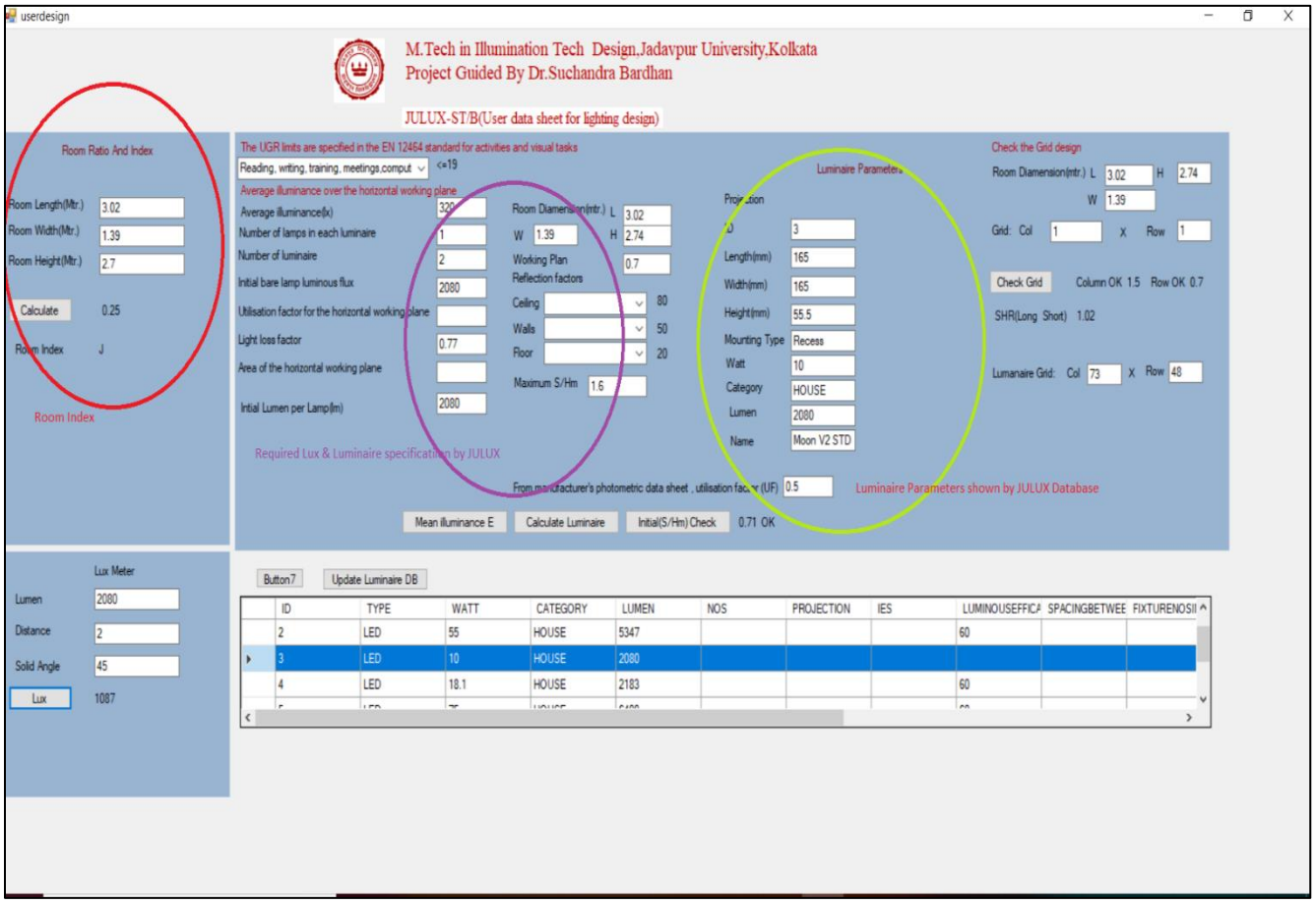
Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(-21.469 m, 6.528 m, 0.760 m)

Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
300	219	341	0.731	0.643

1.2 JU-LUX output of the Toilet area lighting design parameter:-



6.3.13 Consolidated conclusions / Experimental Outcomes: -

The conclusions have been made from the above experiments where a residential plan has been validated by JU-LUX in respect to DIALux. The architectural design of the residence is such that the drawing space, family living room and dining room are of different geometries consisting of extra spaces with curvature, thus making the room's shape non-rectangular.

JU-LUX has been developed with the fundamental calculation of 'Lumen Method', which follows the rule of lighting design of a proper rectangle or square shaped room.

As a result, the above validation exercises show the difference of lux level and the quantity of luminaire required for the lighting layout by the outcome of DIALux and JU-LUX

The above differences are also due to other various factors such as LLF (Light loss factors, Reflectance of the wall, ceiling and floor) etc.

The afore mentioned validation of JU-LUX has again been worked out separately, by a special experimental example shown in sections 6.3.7.1, 6.3.9.1 & 6.3.10.1 above where the non-rectangular rooms have been altered to have a proper rectangular shape, when the output of DIALux and JULUX showed similar results.

Since the bed room, kitchen and the toilet space have a proper rectangular shape according to the architectural design, the validation results of JU-LUX for these rooms perfectly matched the output of DIALux.

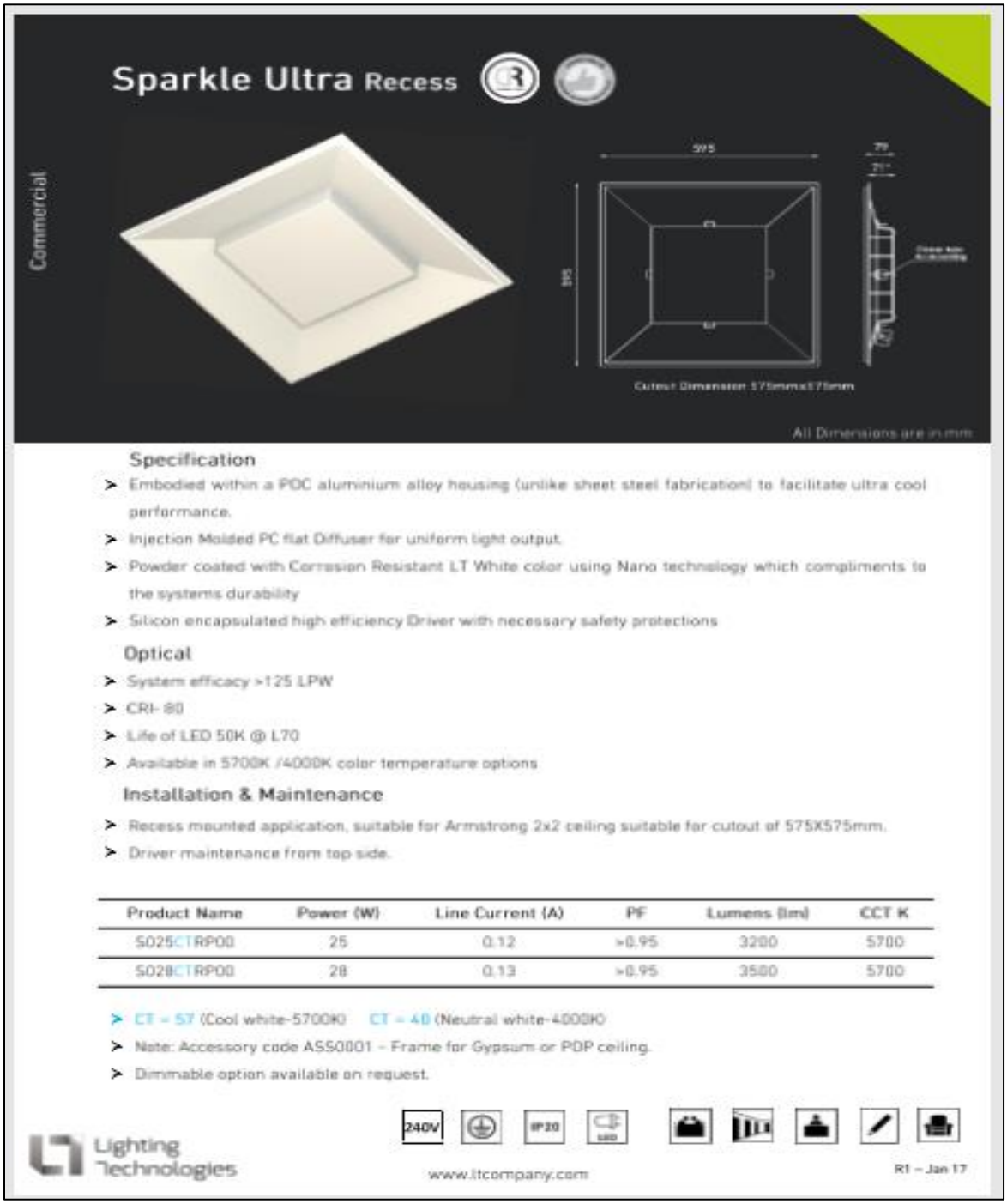
All the above validation exercises and experiments on the different room spaces of the residential plan are explained in details in sections 6.3.7 to 6.3.12 of this chapter.

In future work, the graphical representation of JU-LUX can be incorporated for the flexibility of the lighting layout designing as per the room's shape (other than the rectangular design) and considering the objects inside the room, thereby minimizing the error of calculation as well as enhancing the features of JU-LUX functionality.

6.4.14 Luminaire specifications used in case study:-

Validation of DIALux and JU-LUX on the Residential plan (AutoCAD) drawing fitted by lighting technology luminaires

Selected Luminaire Specification for the Residential plan Indoor lighting:



Sparkle Ultra Recess

Commercial

All Dimensions are in mm

Specification

- Embodied within a PDC aluminium alloy housing (unlike sheet steel fabrication) to facilitate ultra cool performance.
- Injection Molded PC flat Diffuser for uniform light output.
- Powder coated with Corrosion Resistant LT White color using Nano technology which compliments to the systems durability
- Silicon encapsulated high efficiency Driver with necessary safety protections

Optical

- System efficacy >125 LPW
- CRI- 80
- Life of LED 50K @ L70
- Available in 5700K /4000K color temperature options

Installation & Maintenance

- Recess mounted application, suitable for Armstrong 2x2 ceiling suitable for cutout of 575X575mm.
- Driver maintenance from top side.

Product Name	Power (W)	Line Current (A)	PF	Lumens (lm)	CCT K
S025CTRP00	25	0.12	>0.95	3200	5700
S028CTRP00	28	0.13	>0.95	3500	5700

- CT – 57 (Cool white-5700K) CT – 40 (Neutral white-4000K)
- Note: Accessory code ASS0001 – Frame for Gypsum or PDP ceiling.
- Dimmable option available on request.

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R1 – Jan 17

Selected Moon light Luminaire Specification for the Residential Plan for Indoor lighting:-

Moon V2 STD- Recess

Commercial / Retail

Cutout Dimension is ⌀165mm

All Dimensions are in mm

Specification

- Moon is made of pressure die cast aluminium Alloy housing to facilitate ultra-cool performance
- Specially formulated injection molded PC diffuser, for high caliber light transmission
- LT White Corrosion resistant Powder coating using Nano Technology
- Silicon encapsulated high efficiency Driver with necessary safety protections

Optical

- System efficacy >110 LPW
- CRI- 80
- Life of LED 50K @ L70
- Available in 5700K /4000K/3000K color temperature options

Installation & Maintenance

- Recess mounted application, suitable for POP and gypsum ceilings
- Easy Maintenance
- Remote Driver

Product Name	Power (W)	Line Current (A)	PF	Lumen (lm)	CCT(K)
MV10CTRS0X	10	0.05	>0.95	1170	(5700,4000,3000)K
MV15CTRS0X	15	0.07	>0.95	1685	(5700,4000,3000)K
MV18CTRS0X	18	0.09	>0.95	2080	(5700,4000,3000)K
MV24CTRS0X	24	0.12	>0.95	2600	(5700,4000,3000)K

- CT = 57 (Cool white-5700K) CT = 40 (Neutral white-4000K) CT = 30 (Warm white-3000K)
- Note : X=0 (for Standard ceiling of cut-out 165mm ; X=F (with Filler option for Ceiling cut-out up to185mm)
- Dimmable option available on request.

Lighting Technologies

240V IP20 LED

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R1 – Mar 18

CHAPTER: –VII Results, Limitations & Comparison

7.0. Results and Discussions: -

JU-LUX is a step of initiation to develop a lighting software based on lumen method and it has been validated by another popular software such as DIALux on a residential AutoCAD plan, the results of the validation are discussed in Chapter IV .

i. JU-LUX has some of the advanced features and some limitations as well.This has been discussed in Chapter VII.

ii. In future the advanced smart lighting features can be incorporated in JU-LUX which will enhance the functionality of the software, to make it more user friendly to lighting designers as well as users based on Indian standard lighting design.

iii. More in-depth analysis may be require related to lighting design criteria and its functionality for better and flexible enhancement of JU-LUX.

7.1. Advancement of JU-LUX:-

a) Advancement of JU -LUX has no limitation as such, as the development continues with the incessant ongoing research work and projects.

b) JU-LUX can be implemented as an website under the aegis and certified logo of our prestigious university- the Jadavpur university and in consequence this system is sure to find its place in the world of lighting designing sphere.

c) Graphical implementation is the next process of implementation in the software.

d) Advance Internet Of Things (IOT) Functionality has to be incorporated in future work.

e) Outdoor and spot lighting design are need to be validated by JU-LUX

f) JU-LUX must be incorporated with smart lighting features as discussed earlier.

7.2 Limitation of JU-LUX:-

At present graphical representation of JU-LUX is not available. It can be implemented with further development. The lighting design may vary with the cosine factor of the luminaire depending on the shape of the room other than the rectangular or square designed ones.

i. The software application is a prototype.
ii. The application depends on the successful lab tests parameters as per the resources used in our University.
iii. As the JU-LUX based on the lumen theory, there may be an error of margin regarding theoretical and practical calculations in lighting design parameters of Room geometries other than rectangles.
iv. Graphical representation is in progress
v. Advance internet of things (IOT) Functionality has to be incorporated in future work.
vi. Outdoor and spot lighting design are need to be validate by JU-LUX

7.3 Comparison between DIALux and JU-LUX:-

The proposed software JU-LUX features have been compared with the commonly used DIALux lighting software, with respect to major aspects as presented in para 7.3.1 below:

7.3.1Comparison between DIALux and JU-LUX

(a)Attempted and achieved: -

7.3.1.0 Reference

i. Reference of research Paper cannot be viewed in DIALux.
ii. Reference of related research Paper can be viewed by clicking on menu bar in JU-LUX.

7.3.1.1 Standard /Standardization

i. DIALux Based on the international standards, mostly of western countries
ii. JU-LUX Based on the Indian standard (ECBC 2018/ IS3646)

7.3.1.2 Customize

i. **DIALux** cannot be customized as per the choice of university testing factor
ii. **JU-LUX** can be customized as per the choice of university testing factor

7.3.1.3 Parameter

i. **DIALux** works on the lighting parameter of luminaries ies file

ii. **JU-LUX** based on lumen method it has the database of luminaires parameters from which calculation can be deduced.

7.3.1.4 Calculation of Wattage Consumption

i. **DIALux** does not have any option to calculate the wattage of consumption considering burning hours monthly / yearly basis.

ii. **JU-LUX** has the option to calculate the wattage of consumption on monthly / yearly basis.

7.3.1.5 Option for Energy consumption units calculation

i. **DIALux** has no option to calculate the unit consumption for calculating the rating on Electricity bill as per the Indian standard.

ii. **JU-LUX** has the option of calculating the unit calculation from which we can calculate the rating of the Electricity bill as per the Indian standard (Ref.of CESC ratings.)

7.3.1.6 Editing / Updating options

i. **DIALux** has the Luminaire database of .ies file, without any option of updating or editing ies file.

ii. **JU-LUX** has the option of Luminaire database showing all the details of the luminaire as per the selection basis with editing and updating options.

7.3.1.7 DEF /UDI calculations as per ECBC'2017

i. **DIALux** has no option to calculate the
   (a) Day Light Factors (DEF)
   (b) Building Parameters for calculating daylight meeting UDI

ii **JU-LUX** has the option to calculate both the *(Annexure III)*

(a) Day Light Factors (DEF)

(b) Building Parameters for calculating daylight meeting UDI

(b) Future work of JU-LUX

i. Graphical Representation can be plotted in DIALux
ii. Internet of things not available in DIALux

i. Graphical Representation in process of development in JU-LUX
ii. Internet of things are in process of development in JU-LUX

7.4 Conclusion: -

JU-LUX is the indigenous lighting designing software developed on the basis of Indian standard. It has been compared with the most popular and vastly used lighting designing software such as "DIALux" that is used in our university for lighting design (Indoor / Outdoor).

This developed software JU-LUX is not exactly a complementary of '**DIALux'** but it is a step towards developing a lighting software for Indian lighting designers and consumers.

DIALux is the proprietary software of a renowned lighting manufacturing company having a proprietary functionally in-built software application, which cannot be changed or modified as per the criteria of our Indian Standard Protocol of Lighting design without the help of the OEM.

JU-LUX has been made to fill up the gap to some extent, so that an appropriate lighting design can be made as per the Indian Standardized modification protocol. This can be progressively customised as per the University's indigenous endeavor to further develop and facilitate further research work related to lighting.

On the way of development, the undersigned has gone through the reference papers of scholars for the standard mathematical calculation and has tried to effect a union between the software applications. Further extensive and intensive studies based on in-depth research for more optimization of the application needs to be done.

CHAPTER: -VIII Summary, Conclusion & Future areas of work

8.0 Summary and Conclusion: -

The following information can be obtained from this report by the author: -

a. Replacement / Retrofitting with energy efficient lamps for energy saving and operating cost saving

b. JU-LUX is made to be a simple, flexible lighting software for lighting designers and users following Indian Lighting Standard Protocol.

c. Reduction of the excess light level to the required level with good uniformity and minimizing glare

d. More research work is needed to read the pattern of lighting distribution functionality from the .ies files of luminaire manufacturers.

The Annex 45 *(EBC_Annex_45*_Guidebook) suggests that clear international initiatives (by the IEA, EU, CIE, IEC, CEN and other legislative bodies) have been taken for upgrading lighting standards and recommendations, integrating values of lighting energy density (kWh/m2) into building energy codes, monitoring and regulating the quality of innovative light sources, pursuing research into fundamental human requirements for lighting (visual and non-visual effects of light) and stimulating the renovation of inefficient old lighting installations by targeted measures .The introduction of more energy efficient lighting products and procedures simultaneously provide better living and working environments, and well as contribute in a cost-effective manner to the global reduction of energy consumption and greenhouse gas emissions.

The author has attempted the above development based on his studied knowledge and experience of software designing within this short time of limitations.

By aiming on more research work on lighting design and related latest software technology, some more improved features can be added in JU-LUX.

JU-LUX is a small attempt by the author to make a customized flexible software application for all purposes in University as well as for lighting designers and users.

8.1 Future areas of work: -

This application can be developed as an integral part of the Jadavpur University's series of innovative endeavor. This attempt welcomes the researchers/scholars of all departments to use this technology as an informative portal to gain access to the various information related to the course subject taught in the university. Both the researchers and the scholars can not only lookout for the useful references, inferences as well as opinions expressed by the experts in their relative fields but can also express or leave their valuable opinions and comments there for the perusal of others, thereby creating a scope for further enriching advancement.

The application can be developed as a standalone structure for use within the University sphere or can be used as a Website for Global technology hunters.

Lighting system is controlled by manual buttons & switches. As new technology is growing day by day people are working on that making way for more innovation. In smart lighting, android Smartphone or PC are used with Bluetooth and Wi-Fi for controlling purpose. Smart lighting provides automatic load shedding and dimming in peak & non-peak energy demand hours. Smart lighting is one of the easiest ways to save energy in an open office or any other modern workspace where every light point is connected to an intelligent system that delivers high-quality, reliable illumination and sometimes even extraordinary value beyond illumination to the users. In future, smart lighting will be the key part of Internet of Things (IoT) that brings in the collaborative streaming of real-time data and artificial intelligence but the most striking feature is - it enables consumers to make better decisions thereby saving money. IoT is the concept of combining computers and networks to monitor and control devices to generate, exchange and consume data with minimal human intervention. So, internet of things (IoT) is a boon and challenge at the same time because integrating systems, getting them to communicate using a standard protocol and providing interoperability across devices.

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5. National Lighting Code (NLC):2010

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3. *http://www.continental-lighting.com*
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14. *http://www.iea-ebc.org/Data/publications/EBC_Annex_45_Guidebook.pdf.*
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