ENERGY EFFICIENT AND EFFECTIVE LIGHTING SYSTEM

NORHANA BINTI MD NASIR

ELECTRICAL AND ELCTRONICS ENGINEERING

UNIVERSITI TEKNOLOGI PETRONAS

JUNE 2005

ENERGY EFFICIENT AND EFFECTIVE LIGHTING SYSTEM

By

NORHANA BINTI MD NASIR

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

ENERGY EFFICIENT AND EFFECTIVE LIGHTING SYSTEM

by

Norhana binti Md Nasir

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:

(Ir. Perumal Nallagownden)
Final Year Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Norhana binti Md Nasir

ABSTRACT

Lighting is a principal user of electrical energy in commercial buildings that directly affects economy. Typically, lighting requires about 30 percent of energy consumption in commercial sector. Energy efficient and effective lighting may be achieved by using all the facilities that are upgraded with advanced hardware, but the definition and distinction between efficient and effective should be well understood.

The significance of this project is to conduct the project workflow within power system studies and analysis area. The results of lighting design are used to size protection device such as miniature circuit breaker (MCB). The fundamental of lighting design is very important since engineers are responsible to ensure that the lighting design is effective in terms of light quality and cost effectiveness. Therefore, the selection of light fittings shall be based on illumination level requirement, application, and dimension of the area. The project also shall fulfill the project intent that is to have efficient and effective lighting system as well as maintaining high quality in lighting performance.

Since the project intent is to learn and design the lighting system by using systematic approach, the lighting design software package namely CALCULUX is used for this project. The methodology to be used in this project is outlined as follows:

i) Conceptual design
ii) Gathering of necessary data and manual calculations
iii) Lighting simulation
iv) Lighting circuiting
v) Lighting panel schedule
vi) Design calculation of MCB

ACKNOWLEDGEMENTS

First and foremost, all praise to Allah s.w.t for granting me the opportunity to complete this final year project.

It is with pleasure that I express my heartfelt thanks to all who have assisted me either directly or indirectly during the course of this project. My gratitude goes to my project supervisor, Ir. Perumal Nallagownden, who helped me achieve my training objectives. I would like to acknowledge that without his motivation and guidance, all my efforts would not have been fruitful.

I would also like to thank Mr. Khairil Hatta, who provided valuable information on standard practices in OGP Technical Sdn. Bhd. He gives me full support and motivation to going through this project till the end. To Mr. Zuki, the FYP coordinator, thank you for your help in explaining all the proper procedures for this project.

Finally, I forward my special thanks to my friends and family for their unwavering support during this project. Not to forget anyone whose name I did not mention here. Your contribution is greatly valued.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Ballast	an electrical device for starting and regulating fluorescent and discharge lamps
RMS	a statistical measure of the magnitude of a varying quantity. The name comes from the fact that it is the square root of the mean of the squares of the values.
IEC	International Electrotechnical Commission
PTS	PETRONAS Technical Standards
KVA	kilovolt-ampere
KW	kilowatt

Abbreviations used for lighting calculations

E	Desired illumination level (lux)
L	Length of room area
W	Width of room area
N	Number of light fittings required
CU	Coefficient of utilization
η	Number of lamps per light fittings
F	Lamp output (lumen)
LLF	Light loss factor
K	room index

CHAPTER 1
INTRODUCTION

1.1 Background of Study

In recent days, electrical energy has dominated the current world energy scene, due to its practicality and the existence of wide range of efficient electrical equipment. Lighting, which is the largest electricity user in commercial buildings, requires about 30 percent of consumption in commercial sector. This represents a significant opportunity to save energy in commercial building.

The latest lighting technology available in the market practically reduced energy usage by 30 to 50 percent. Almost all facilities can be upgraded with advanced hardware that will increase efficiency and improve lighting quality, but the distinction between efficient and effective must first be understood. "Efficient" lighting systems can be described in engineering terms of performance, which is measured in lumens per watt and watts per square foot. "Effective" lighting is described in terms of how appropriate the lighting is for the function it is performing. Lighting performance measured by Lumens per watt (LPW), which is describes the efficacy, or efficiency, of components such as lamps or lamp and ballast combinations. [1]

1.2 Problem Statement

1.2.1 Problem Identification

The purpose of the project is to learn and design the lighting system using systematic approach. In this project, the understanding of lighting system is important including safety, visual quality and light pollution (also known as glare).The project intent is to have efficient and effective lighting system as well as maintaining high quality in lighting performance.

To further understand the characteristics of the main components of a lighting system, a lighting design produced serves as a tool for conducting tests or experiments to understand the design itself. The lighting design simulation is implemented based on codes and standard as stated in PETRONAS Technical Standard. The software being used in this project for that purpose is CALCULUX, lighting software provided by PHILIPS.

The simulation in CALCULUX is complemented with drawing plan by using VISIO. CALCULUX is used only to simulate lighting design and find the amount of lighting load required, VISIO shall be used to illustrate the whole lighting system inside the building. The drawings by VISIO make ease to perform some calculations on miniature circuit breaker (MCB) sizing. The lighting power is then provide data for miniature circuit breaker (MCB) sizing calculation or other equipment i.e. generator and transformer. However, in this project the calculation is focus on miniature circuit breaker only. Indirectly, this may help the engineer produce cost estimates based on the calculated equipment size.

1.2.2 Project Significance

Many building owners and energy managers view lighting systems as just one of several large building systems that use too much energy, produce too little light, and consume a large portion of the maintenance budget. Lighting is seen as a large part of the overhead cost of operating the building. When the focus is only on the lighting systems, the building occupants and the reason for the lighting fade from view and become secondary or nonexistent. [1]

This project is a significant step towards a more efficient way of conducting power system studies and analysis. Using the results of lighting design, the sizing of equipment such as miniature circuit breaker can be done. The fundamental of lighting design is very important since engineers are responsible to ensure that the lighting design is effective in terms of light quality and cost effective. Therefore, the selection of light fittings shall be based on illumination level requirement, application, and dimension of the area. The improvement of lighting in a space or reducing energy may prevent from over-budgeting for maintenance as well as to obtain the right illumination coverage and to prevent excessive light so called glare.

Energy management is important to ensure the electrical installation for a building in line with the procedure that has been regulated. In this project, the main focus are the electrical installation system and the application of lighting design tools that include selection of lamp, ranging from simple spreadsheets to advanced computer programs that take into account the impact of light in buildings. Work on simple and integrated design tools will include validation as well as the improvement of user interface and optimization of calculation procedures. Work on analysis methods focuses on short-term measurements and on the comparison of audit procedures and evaluation measures. [2]

1.3 Objective and Scope of Study

1.3.1 Objectives

The objectives of this project are:

i) To prepare lighting calculation on each room/area inside the building and to compare with the simulation results.
ii) To prepare load power schedule that represent total load of the system
iii) To prepare miniature circuit breaker (MCB) sizing.
iv) To finalize all the works done and present a complete lighting system.

1.3.2 Scope of study

The scope of this project is only limited to designing the proposed lighting and electrical installation system for the office building. This project does not involve any constructing and installing the electrical system due to expensive cost. According to the scope that is defined in the introduction part, this project has been developed in order to meet the requirement of the problem statement. In order to make the scope of project well defined in the introduction part, several literature reviews have been done during first semester of Final Year Project (FYP I). The lighting simulation also begins during this period.

The studies of literature reviews of lighting and self-learning of software design application proceed during the second part of this project. Besides, the studies on protection devices in power distribution system also essential for further understanding in protection devices such as miniature circuit breaker (MCB), and residual current circuit breaker (RCCB) and electrical installation such as socket outlet. The project workflow continues with alteration of lighting design, preparation of lighting circuiting, lighting panel schedule and sizing the protection devices.

CHAPTER 2
LITERATURE REVIEW AND THEORY

The literature review of this project is encompasses to two parts; lighting simulation, and protection device.

2.1 Lighting Simulation

2.1.1 Luminous flux

Luminous flux notated by Ø also known as lumen (lm). The light emitted by a source, or received by a surface. The quantity is derived from radiant flux (power in watts) by evaluating the radiation in accordance with the relative luminous efficiency of the 'standard' eye.

2.1.2 Luminous intensity

The quantity that describes the power of a source or illuminated surface to emit light in a given direction. The unit of luminous intensity is candela (cd).

2.1.3 Luminance

The intensity of the light emitted in a given direction per projected area of a luminous or reflecting surface. The unit is candela per square meter.

2.1.4 Illumination

Illumination is defined as the distribution of light on a horizontal surface. It describes the luminous flux density at a point on a surface.

2.1.5 Efficacy

Efficacy is the ratio of light output from a lamp to the electric power it consumes and it is measured in lumens per watt (LPW).

2.1.6 Working plane

The area whereby assumed to the height of working area. Normally, the illumination level measured on this area. However, for some room, the illumination level calculated on the floor plan. The illumination level is provided entirely by the luminaries used in the design and measured up to 1m above the floor level in a horizontal plane.

2.1.7 Maintenance factor

When a lighting scheme installed, the illumination will decline from the first day. The mathematical expression for maintenance factor is as follows:

MF = LLMF x LSF x LMF x RSMF

where

LLMF = lamp lumen maintenance factor

LSF = lamp survival factor

LMF = luminaire maintenance factor

RSMF = room surface maintenance factor

LLMF and LSF vary with the type of lamp being used and LMF and RSMF vary with the type of luminaire, the location and the frequency of cleaning.

Lighting was often designed for a set of average conditions. This could introduce large errors into the final lighting simulation results. In order to prevent this problem, a more accurate prediction as the followings must be provided:

a) The initial illumination when the lamps are new and the luminaries and room surfaces clean.
b) The maintained illumination below the actual illumination should not fall. This value must be based on a program of replacement and cleaning.

Hence, maintenance factor is actually dependent on a few elements as mentioned above.

Since lighting product are varies, the manufacturers normally will produce their own tables in accordance to some general data provided by *Chartered Institution of Building Services Engineers*, CIBSE 1994 Lighting Code. According to some lighting design simulation software, the value of maintenance factor is provided automatically without calculating it manually. Therefore, the calculation for maintenance factor is not required in this part of project.

2.2 Protection Device

2.2.1 Miniature Circuit Breaker

A circuit breaker is a mechanical switching device that breaks any fault current flowing in the circuit before such current causes danger due to thermal or mechanical effects produced in the circuit before such current causes danger due to thermal or mechanical effects produced in the circuit or the associated connections. Typically, the characteristics of the circuit breakers shall satisfy the condition that the breaking capacity should be greater than or equal to the prospective short-circuit current or earth fault current at the point at which the breaker is installed.

In recent days, the design of miniature circuit breakers (MCB) has been improved to make them suitable in many ways for loads up to 100A at 240V. This type of protection device able to determine the operation of an MCB itself after the installation and subject to manufacturer's approval, to use it for normal switching operation. The circuit breaker also applicable to be used as fuses. The protective features of MCB include magnetic-hydraulic, thermal-magnetic and bimetal tripping mechanisms which provide time-delay characteristics and suitable for overload and short circuit protection. The major function of MCB in a building installation is for the protection of final circuits because of it does relatively short-circuit capacity, although models are available with rating up to 25kA.

CHAPTER 3
METHODOLOGY/PROJECT WORK

3.1 Project Methodology

3.1.1 Procedure Identification

The flow of activities is illustrated in the flowchart as the followings:

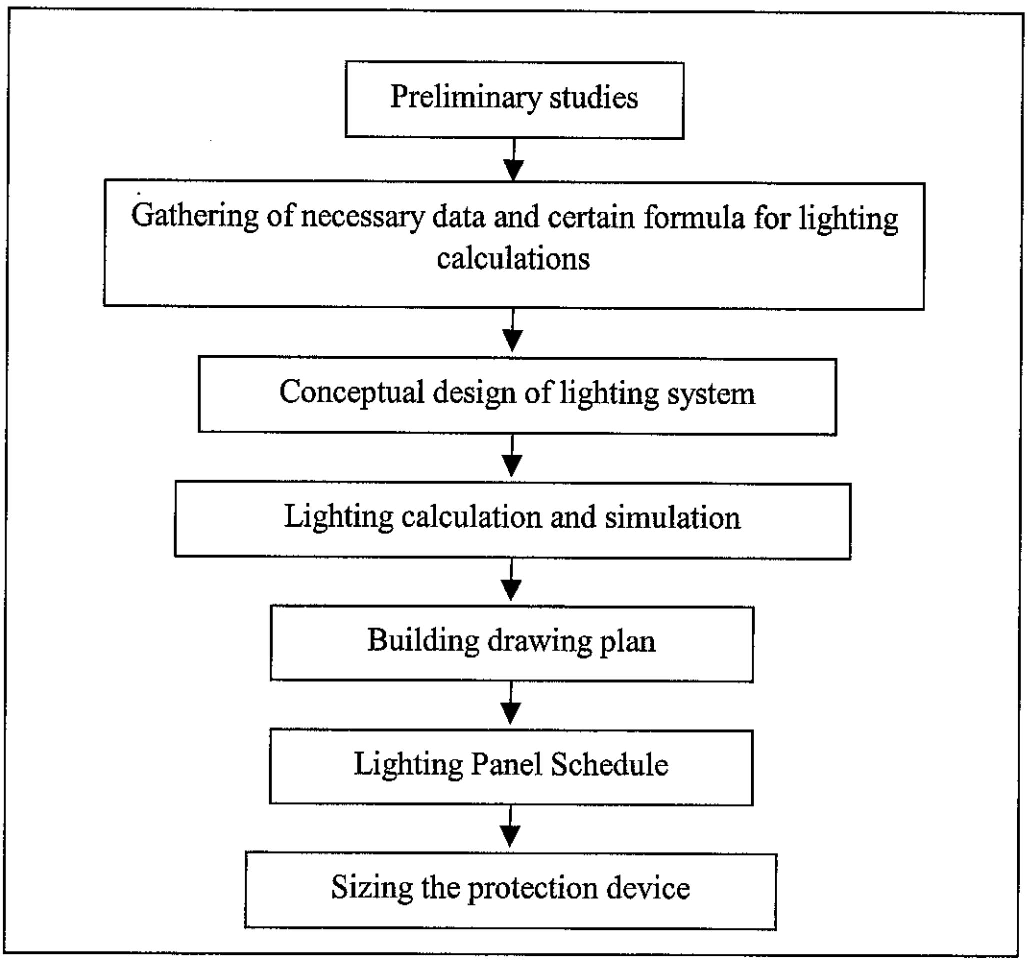


Figure 1 Project activities flowchart

3.1.2 Lighting calculation and light's price

This task requires the author to find the light's price according to the market price. The objective of this task is to observe the price of light fittings so that the light fittings used in the most economical way as well as to fulfill the standards requirement. The lighting calculations are prepared to verify the lighting simulation. In some cases, the lighting simulation is not in line with lighting calculation. Therefore, the total light fittings used are decided according to the lighting simulation.

3.1.3 Lighting design simulation

The lighting design simulations are made in order to achieve the illumination level according to standards and codes by PETRONAS Technical Standard (PTS 33.64.10.10 – GEN (Illumination Level)). The standards and codes in PTS are almost the same with Basic of Design HVAC Main Control Room Standard provided by MLNG.

After looking into several considerations, the case study of lighting design carries out from minor projects of Malaysia LNG (MLNG Sdn. Bhd) in Bintulu. Initially, the building was an old control room building that renovated and upgraded to become an office building. The building has existing distribution boards but since the whole lighting system is replaced to the new one, therefore the new lighting circuit required.

The purpose of lighting simulation is to get the number of light fittings required inside the building. The lighting simulations were done according to the design criteria and fulfill some standards. The interior lighting design can be implemented by using a lighting design software package namely CALCULUX, that provided by PHILIPS. This software application is not limited to interior lighting design only but it is also can be used for exterior lighting design, such as roadway and plant areas. The plant area lighting has different area classification that encompasses of hazardous area and non-hazardous area. The interior lighting design depends on type of room inside the building because each room has different specification. In this project, the focus is emphasis on interior lighting design only. The procedures of lighting design are represented in the flowchart as the followings:

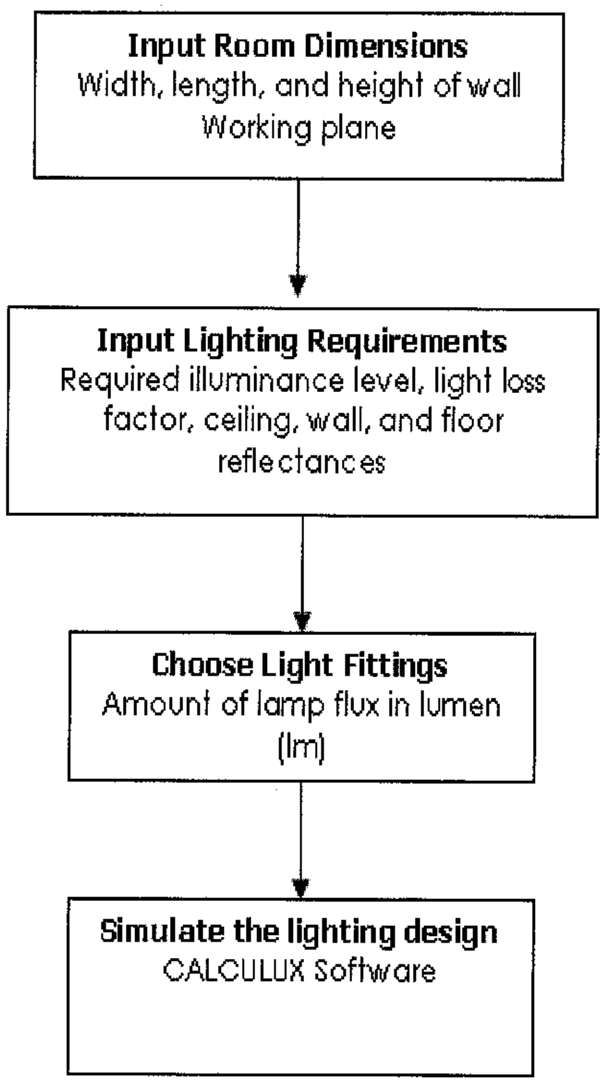


Figure 2 Flowchart of procedure of lighting design

The lighting simulation is done for each room because each room has different desired illumination level. The desired illumination level also referred to PTS 33.64.10.10 and tabulated in the table as follows:

Table 1 Illumination level provided by PTS 33.64.10.10

Room designation	Design illuminance level
▪ Office cubicle ▪ Meeting room ▪ Filing room ▪ Laboratory ▪ Library	400 lux
▪ Pantry ▪ Fit apparel ▪ DCS counter	300 lux
▪ Store room	150 lux
▪ Prayer room ▪ Toilet	100 lux

The actual datasheet of PTS 33.64.10.10 is as per in **Appendix A.**

The dimension of each room is taken from the existing building drawing plan. To begin the simulation, some of the data required such as:

- room dimension
- desired illumination level
- height of working plane
- percentage of ceiling, walls and floor reflectance

3.1.4 Lighting power schedule

The lighting power schedule represents total lighting load of the system. The total wattage calculated in kilowatt (kW) and kilovolt-ampere (KVA). This task shall be accomplished after the lighting design finalized whereby the number of light fittings used obtained.

3.1.5 Calculation on miniature circuit breaker (MCB) sizing

The purpose of these tasks is to decide the right size of miniature circuit breaker (MCB) to be used.

3.2 Tools Required

For lighting simulation purposes (whenever required), the lighting design software package to be used for this project is CALCULUX, which is developed by PHILIPS. The purpose of lighting simulation is to determine the quantity of lamp fixtures required for building or certain areas. In order to provide better illustration of lighting system in an office building, a software VISIO is used to create the building plan.

CHAPTER 4
RESULTS AND DISCUSSION

This chapter is encompasses into few parts; findings from researches, software application, conceptual design, building drawing plan, lighting circuit, lighting power schedule, socket outlet installation and finally miniature circuit breaker (MCB) sizing calculation. Each part will discuss about findings and results obtained during the project progress. In lighting simulation and calculation, the procedure of lighting simulation is well described from calculation to the simulation process.

4.1 Findings from researches

4.1.1 Lamp selection

The finding fact from numerous websites stated that T8 lamps (fluorescent) are a popular choice because they provide 98% as much light as standard lamps and use about 40% less energy when installed with electronic ballast. Electronic ballasts operate at higher frequencies and this allows the lighting system convert power to light more efficiently. They also operate 75% more quietly than conventional magnetic ballasts, and eliminating the familiar flicker.

In recent days, cost of electronic ballasts has slowly decreased and this makes them comparable to magnetic ballasts. The T8 fluorescent lamps with electronic ballasts can operate at 20 000 to 60 000 Hz whereby magnetic ballast can only operate at line frequency (60 Hz). Although electronic ballasts may introduce harmonic distortion or noise into the electric lines within the building, it is normally not cause any harm for facilities with heavy lighting loads and a large number of electronic ballasts. For facilities with strict requirements on power quality, such as hospitals and some laboratory or testing facilities, electronic ballasts with total harmonic distortion of five percent or less can be used.

Electronic ballasts weigh up to 50% less than electromagnetic ballasts, resulting in lower shipping costs, easier handling in lower shipping costs, easier handling and installation, and less stress on ceiling supports. Electronic ballasts feature cooler operation usually in range 30 degrees C (54 degrees F) cooler than standard ballasts.

Typically, the most popular type of lamp used for an office building is mounted recessed fluorescent that have 4 bulb of 18 W each. The same type of bulb can be used for emergency light. Besides, specular reflectors can increase the efficiency of a typical lighting unit by about 10 percentage points by reflecting additional light into the work space. The specular reflectors are able to remove half the existing fluorescent tubes with a minimal reduction in light levels, whereby may decrease light costs by 50%. Moreover, specular reflectors installed with energy-efficient fluorescent lamps and electronic ballasts can reduce lighting energy costs by as much as 70%. [3]

The efficiency also affected by the reflector of the lamp. The reflector directs the emitted light from the lamps towards the surface or area where the illumination is intended. A measure known as reflectivity is the percent of incident light that is reflected by the reflector. The standard reflectors in fluorescent fixtures which painted white produce diffuse, scattered and distribution of incident light with a reflectivity around 70 to 80 percent. Nowadays, the new reflector materials which have a mirror permits more precise redirection of incident light rays.

In this project, the selection of lamp is done by referring to the library in the lighting software application. The designations and specifications of lamps vary by manufacturers.

4.1.2 Energy Saving Method

Luminaire performance can be improved by fixture cleaning, specular reflectors, a lens or louver upgrade, and new, efficient luminaires with a higher coefficient of utilization. In this project, the luminaries are selected not based on the coefficient of utilization because it may sacrifice lighting control. Controlling luminaire light output is necessary to achieve high quality in lighting performance. Instead, the coefficient of utilization is determined by doing some calculation in order to find the quantity of light fittings. Space efficiency is improved when lighter colored room surfaces are used, decreasing the room cavity ratio, and increasing the coefficient of utilization of the luminaire.

Lighting controls ensure that lighting systems are shut off, or turned down, when not in use. It can reduce the electrical energy used in lighting systems in two ways: reducing the lighting power, kilowatts, or by reducing the hours of use. Since electricity is paid for per kilowatt hour, reducing either will reduce electric costs. In fact, turning off fluorescent lights saves energy, extends overall lamp life, and reduces replacement costs.

However, there is another believe that turning off the lights also shorten lamp life. Actually, fluorescent lamps will run more hours if operated continuously, but they will last for more years if they are turned off when not in use. Although the average rated life of fluorescent lamps is shortened by switching, calendar life is lengthened. Calendar life is the time between lamp changes and includes the time the lamp is off. For example, standard 4-foot T8 lamps operated continuously result in a rated lamp life of 34,000 hours, a calendar life of 3.9 years. Turning off 4-foot T8 lamps for 12 hours each day decreases the average rated lamp life to 30,000 hours, but extends calendar life to 6.8 years. Therefore, the theory about turning off lights is saving the energy is proven right. [1]

Another ways to reduce operating hours are by using control strategies such as switching, occupancy sensors, scheduling controls, or photocells. All the control strategies mention above have their own operating principle and available numerously in the market. However, in this project, the lighting design shall follow some requirements stated in codes and standard. The scheduling, photocells, and tuning and dimming control may be effective in saving energy but this type of lamp will be not used in this project.

4.2 Software application

CALCULUX is lighting design software application package provided by PHILIPS, one among biggest lamp's manufacturer. This software allows lighting design and planning engineer to create lighting design quickly and it can be done for both interior and exterior buildings. The designing process is timely operation under user defined and the result is automatically provided. Besides, the databases of all lamps are provided in the software to ease the designing process. Almost all types of lamps inside the database are available in local market and some of the products are commonly used in Malaysia.

4.3 Conceptual Design

4.3.1 Definition of important parameters used in lighting software

While performing the calculations, the following inputs were taken into consideration:

(According to Electrical Engineering Guidelines PTS 33.64.10.10)

- Ceiling reflectance factor
- Wall reflectance factor
- Floor reflectance factor

These surfaces reflect light with different percentage of reflections. The light reflections are ranged from 0 to 1. Usually, ceiling reflectance factor used is 70%, wall 50% and floor 30%.

- Utilization factor, UF

The ratio of the luminous flux (lumens) from a luminaire calculated as received on the work-plane to the luminous flux emitted by the luminaire's lamps alone. It is also known as coefficient of utilization (CU). The term used may vary according to the manufacturer of lighting products.

- Light Loss Factor, LLF

A factor used in calculating illumination after a given period of time and under specified conditions. It also considered the dirt accumulation on luminaires and room surfaces, lamp depreciation, maintenance procedures, and atmosphere conditions.

- Workplane

The plane at which work usually is performed, and on which the illumination is specified and measured. Working plane is usually assumed to be 1m above ground level or nearly 1 m (i.e: 0.70 m).

- Maintenance factor

When a lighting scheme installed, the illumination will decline from the first day. The detail description about maintenance factor can be referred in literature reviews (clause 2.1.7).

4.3.2 Example of Design Calculation for Room 16

Area: Room 16
Type of lamp: Downlight with 2 x 18W bulb per lamp fixtures
Workplane height: 0 meter
Illumination level required: 100 lux
Dimension:
Length: 8.0 m
Width: 5.0 m

Lumen Method

The objective of Lumen method is to find the number of luminaires required for a specific room when the amount of illuminance required is given. The dimension room 16 is as follows:

$L = 8.0$ m

$W = 5.0$ m

$H_1 = 3.0$ m

$H_0 = 0$ m

The room index, K

$$K = \frac{8.0 \times 5.0}{(3-0) \times (8.0+5.0)}$$

$$= 1$$

By referring to the table below, the CU is 0.50.

Table 2 Coefficient of Utilization

room index K	Reflectances (%) for ceiling, walls and working plane										
	80 50 30	80 50 10	70 50 30	70 50 20	70 50 10	70 30 10	50 30 10	50 10 10	30 30 10	30 10 10	0 0 0
0.60	0.39	0.37	0.39	0.38	0.37	0.33	0.33	0.31	0.33	0.30	0.29
0.80	0.46	0.44	0.46	0.44	0.43	0.39	0.39	0.37	0.39	0.36	0.35
1.00	0.52	0.48	0.51	0.50	0.48	0.44	0.44	0.42	0.44	0.41	0.40
1.25	0.57	0.52	0.56	0.54	0.52	0.49	0.48	0.46	0.48	0.46	0.45
1.50	0.61	0.55	0.60	0.57	0.55	0.52	0.51	0.49	0.51	0.49	0.48
2.00	0.66	0.59	0.65	0.62	0.59	0.57	0.26	0.54	0.55	0.54	0.52
2.50	0.70	0.62	0.68	0.64	0.61	0.59	0.58	0.57	0.57	0.56	0.55
3.00	0.72	0.63	0.70	0.66	0.63	0.61	0.60	0.59	0.59	0.58	0.57
4.00	0.75	0.65	0.73	0.68	0.64	0.63	0.62	0.61	0.61	0.60	0.59
5.00	0.76	0.66	0.74	0.69	0.65	0.64	0.63	0.62	0.62	0.61	0.60
	Suspension ratio: 0 Calculated acc. to CIE publication 40 LVW1077000-00										

Number of light fittings, N

$$N = \frac{8.0 \times 5.0 \times 100}{0.50 \times 2 \times 1400 \times 0.8}$$

= 4 unit of light fittings

By using CALCULUX, the drawing layout for Room 16 is as follows:

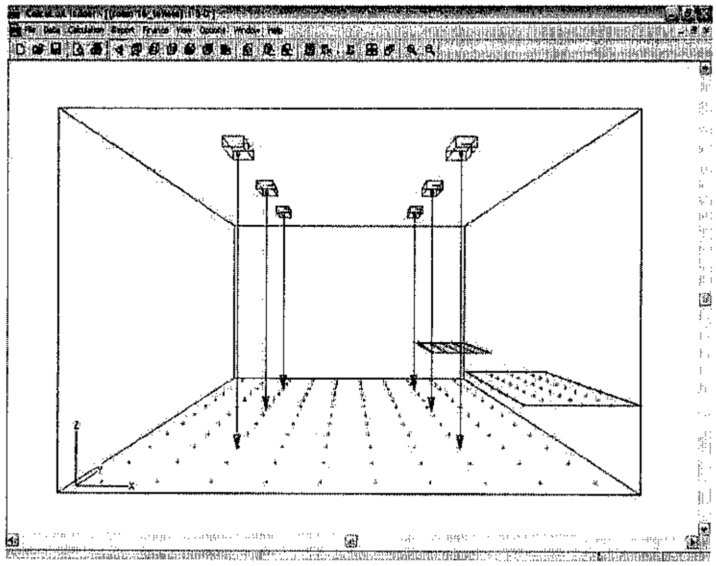


Figure 3 Room 16 with calculation grid on workplane height and washing areas

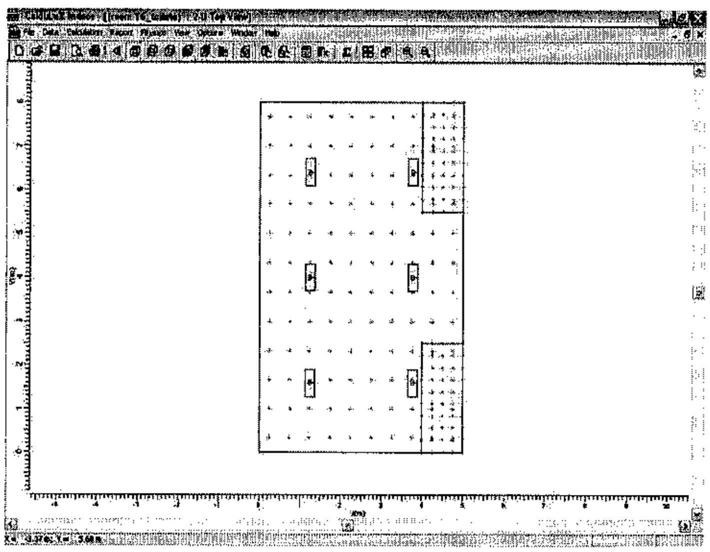


Figure 4 Top view of room 16

Washroom may have some wall partitions but it is normally not touching the ceiling. However, the numbers of lamp are not adequate for the area with such dimension. The calculation grid is taken on the floor and washing area's height. Since the wall partition can be created by using CALCULUX, some analysis and observation are made to encounter this problem. Normally, for an area with such dimension, the assumption is made by putting 6 units of light fittings into the lighting design simulation. This assumption is gained from the observation of lighting fixture at hostel's washroom. The drawing of rectangular objects at workplane height in **Figure**

5 represents the washing area (sink) inside the toilet. The calculation grid also has been set for the washing areas (sink).

Standards used:

The lighting design is simulated in accordance of PETRONAS Technical Standard (PTS 33.64.10.10). This standard have not much different with international lighting standard such as *Chartered Institution of Building Services Engineers*, CIBSE 1994 Lighting Code.

The lamp selected in this design is applicable in real life. The usage of fluorescent lamp with electronic ballast has several advantages. In terms of energy saving and efficiency, the fluorescent lamp provides 98% as much light as standard lamps and use about 40% less energy when installed with electronic ballast. The research done on type of lamps and energy saving method has proved that electronic ballasts operate at higher frequencies than conventional electromagnetic ballasts. By doing so, the lighting systems convert power to light more efficiently.

4.3.3 Example of Design Calculation for Room 11

Area: Room 10 and 11

Type of lamp: Surface recessed luminaries with 2 x 18W bulb per lamp fixtures

Workplane height: 0 meter

Illumination level required: 100 lux

Dimension:

Length: 7.0 m

Width: 4.0 m

Lumen Method

L = 7.0 m

W = 4.0 m

H_1 = 3.0 m

H_0 = 0 m

The room index, K

$$K = \frac{7.0 \times 4.0}{(3-0) \times (4.0+4.0)}$$

$= 0.8$

By referring to the table 3 above, the CU is 0.44

Number of light fittings, N

$$N = \frac{7.0 \times 4.0 \times 100}{0.44 \times 2 \times 1400 \times 0.8}$$

= 3 unit of light fittings

The simulation result shows that three light fittings give average illumination of 157 lux.

Room 10 is a female prayer room, located inside Room 11 which is a male prayer room. Here, the design emphasis on the uses of calculation grid. Since Room 10 is located in Room 11 and both are separated by a wall partition up to the ceiling level, the measurement of average illumination level is taken based on the calculation grid, shown as follows:

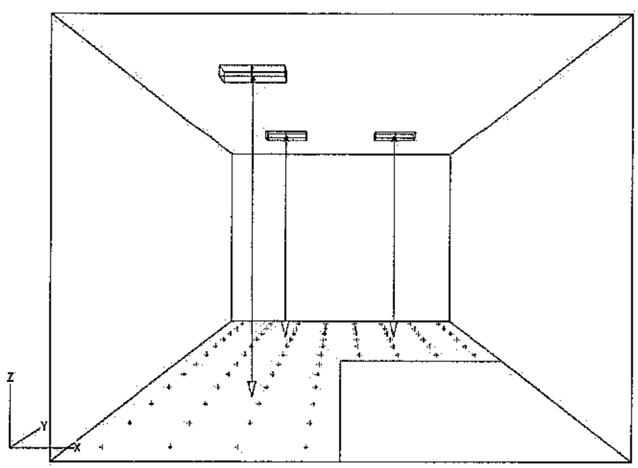


Figure 5 Room 11 with calculation grid on workplane height

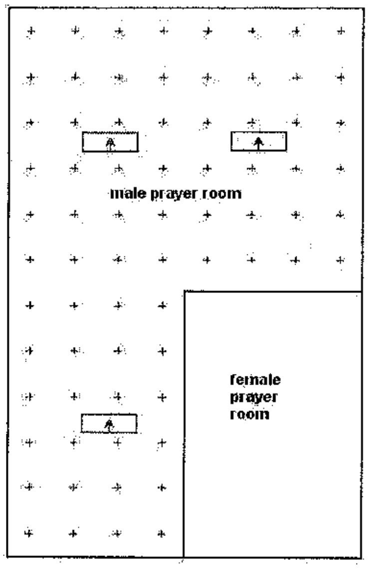


Figure 6 Top view of Room 11 and Room 10

Therefore, the average illumination level for Room 10 only can be obtained by simulating isolated lighting design by following the same procedures.

Standards used:

The specific illumination level for prayer room is actually not included in PETRONAS Technical Standards (PTS 33.64.10.10). In this matter, the illumination level required is based on the task / work carried out in that area. Hence, the illumination level of 100 lux is much sufficient to illuminate the whole room.

The lamp selected in this design is applicable in real life. The usage of fluorescent lamp with electronic ballast has several advantages. In terms of energy saving and efficiency, the fluorescent lamp provides 98% as much light as standard lamps and use about 40% less energy when installed with electronic ballast. The research done on type of lamps and energy saving method has proved that electronic ballasts operate at higher frequencies than conventional electromagnetic ballasts. By doing so, the lighting systems convert power to light more efficiently.

The printed lighting simulation output is included in **Appendix B**. The lighting simulation output is encompasses to summary, calculation results, luminaire details and installation data.

4.4 Building Drawing Plan

The lighting simulation is very important to ascertain the number of light fittings used in the building. The light fittings are then represented in building drawing plan, that created by using VISIO. The drawing plan enable author to identify each phase of circuit inside the building. This is because each room is assigned to two or three different circuit.

VISIO is software provided in Microsoft Office 2003. This software is the most convenient way to present the lighting arrangement and to identify the lighting circuiting. Since the lighting circuits are to be divided into three phases, all the circuiting is labeled to make it easy for reference. The circuiting also required before the estimation calculation proceed. Basically, the location taken for this project is an old building that previously uses to be the main control room. This building is renovated to become a one storey office building that encompasses of ground floor and basement. The building drawing plan created for both floor as shown in **Figure 9** (ground floor) and **Figure 10** (basement).

The actual building is a new office building that renovated from an old consists of main control room. The building has basement on the bottom floor and this level also included in the design. The building drawing plan is created so that it have 24 rooms/isolated areas whereby each area have different illumination level. The required illumination level is provided in PTS 33.64.10.10. The numbers of light fittings are obtained from the previous lighting simulation.

4.5 Lighting circuit

Lighting circuits are basically radial circuits. There are two distinct types of lighting, circuit the loop-in circuit and the older junction box circuit. Typically, both aspects of both types of circuits are combined for home lighting circuit. The loop-in circuit has a cable, running from light to light terminating at the last light as in the conventional radial circuits and then single cable run from the lights to the light switches.

The other type of lighting circuit has a junction box for each light. The cable runs from the consumer unit to the first junction box and then onto the next terminating at the last junction box. Another cable is run from each junction box to its light and another wire from the junction box to that light switch.

A 5amp fuse or 6amp MCB is used on the consumer unit for a lighting circuit. The maximum load for a lighting circuit is 1200 watts, which amounts to 12 x 100 watt lights. Another lighting circuit shall be used if more light fittings needed. The numbers of lighting circuits depend on the number of light fittings installed.

Therefore, the light fittings are arranged and labeled according to three phase circuit. The entire normal lighting are encompasses to three phase circuit, while emergency lights assigned to two phases circuit only (each phase is able to cater emergency lighting for each floor).

The lighting circuits are labeled for each room as shown as the followings:

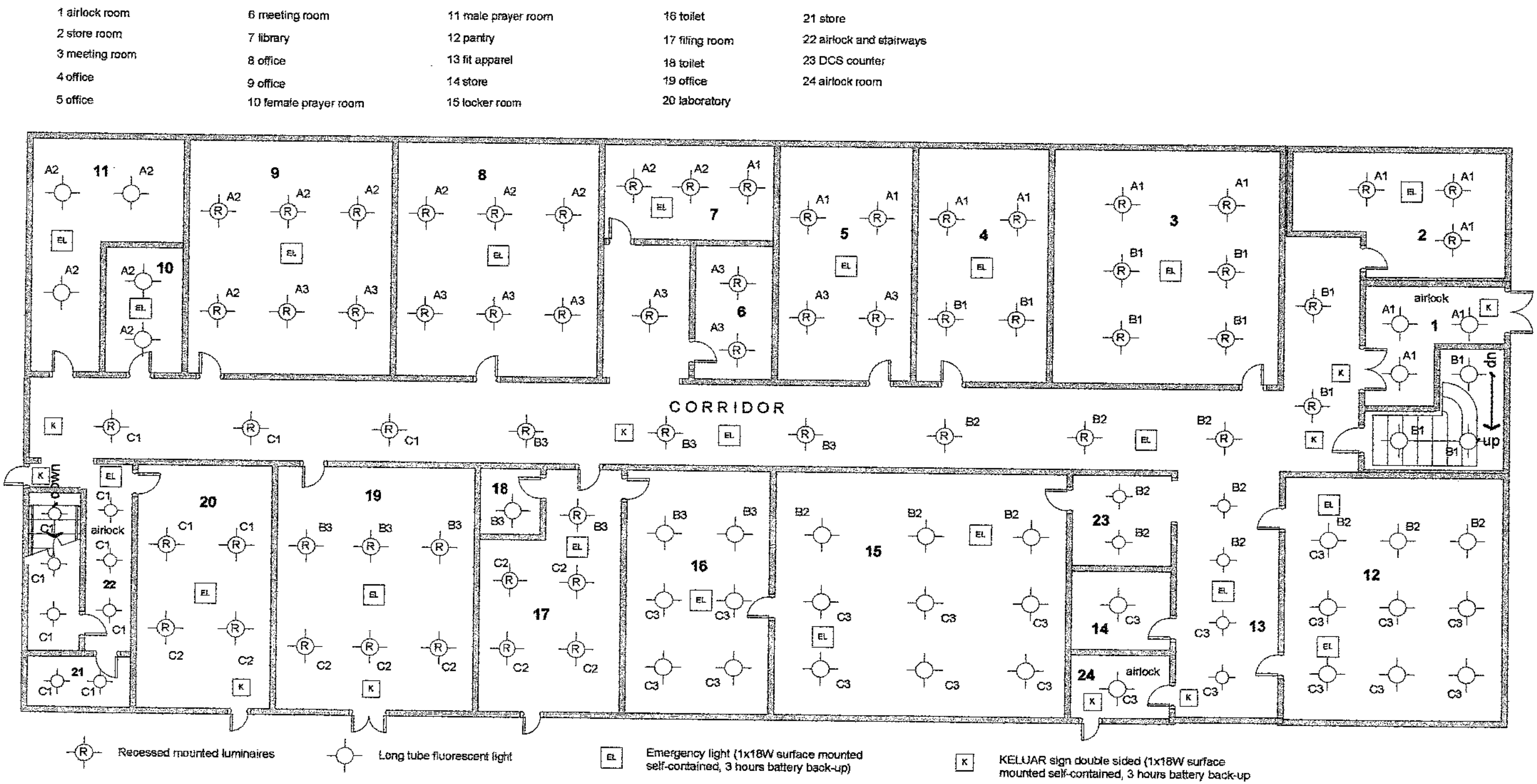


Figure 7 Ground floor of the building with normal lighting and emergency lighting fixtures arrangement.

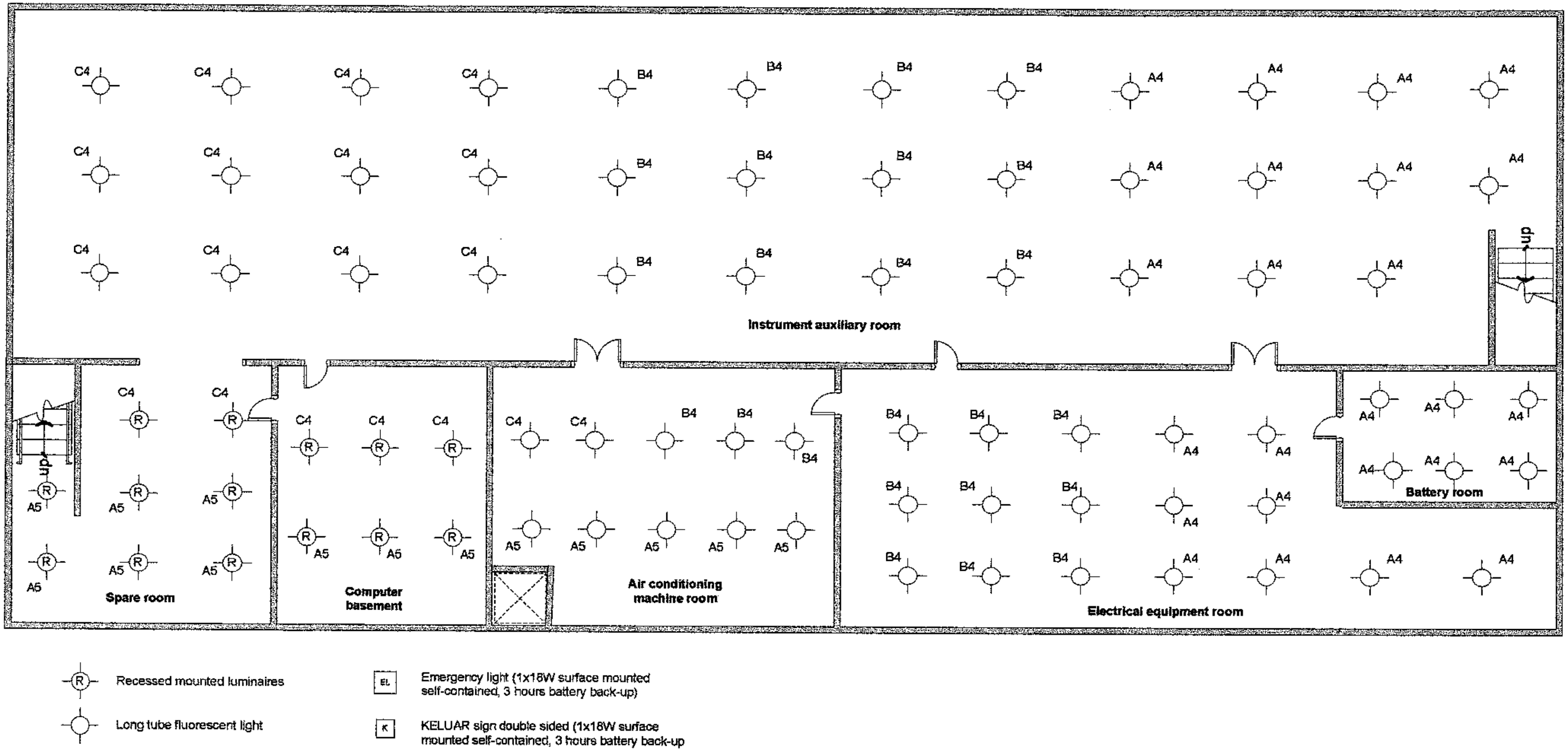


Figure 8 Basement of the building with normal lighting and emergency lighting fixtures arrangement

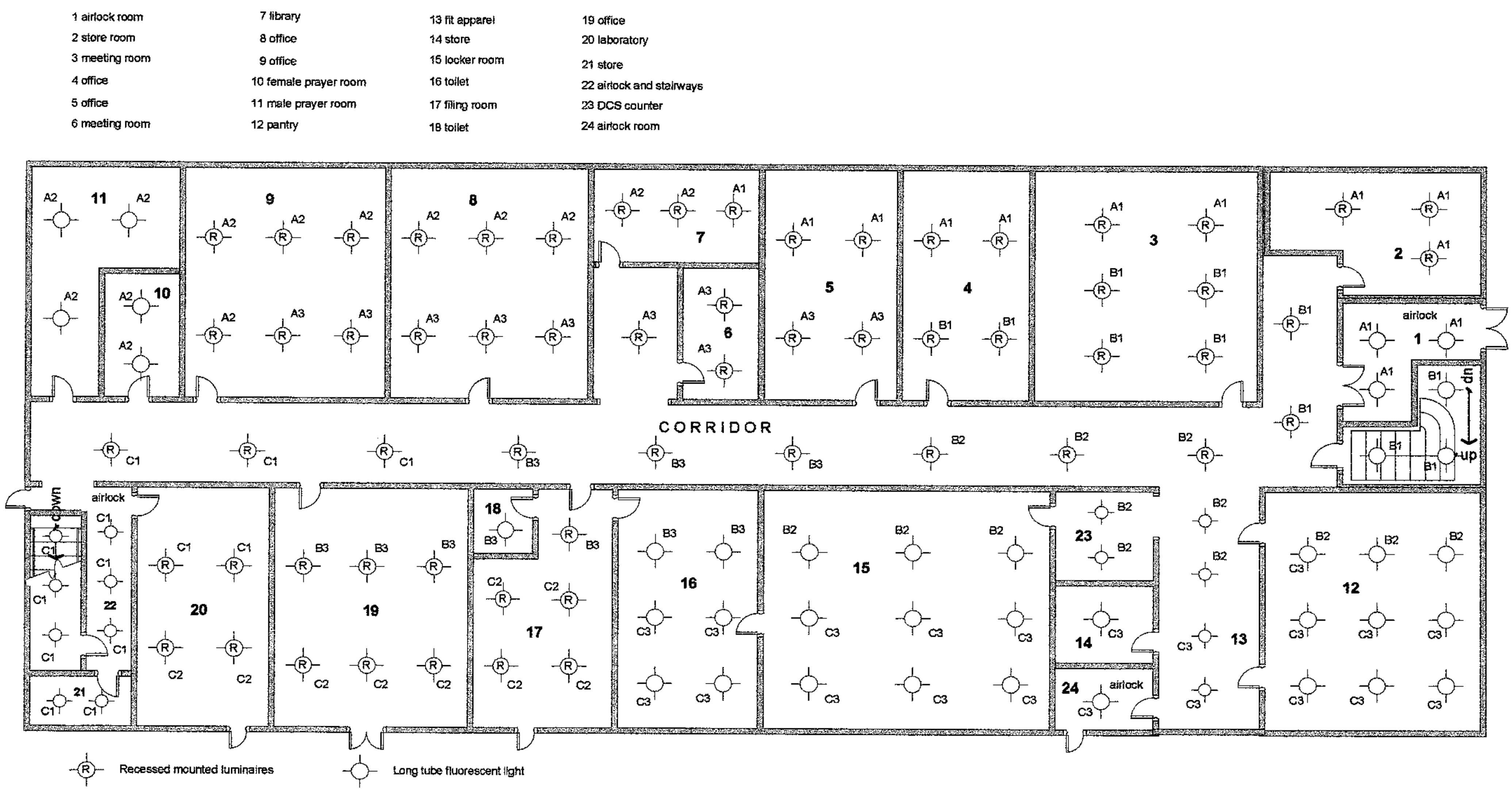


Figure 9 Ground floor of the building with normal lighting circuiting.

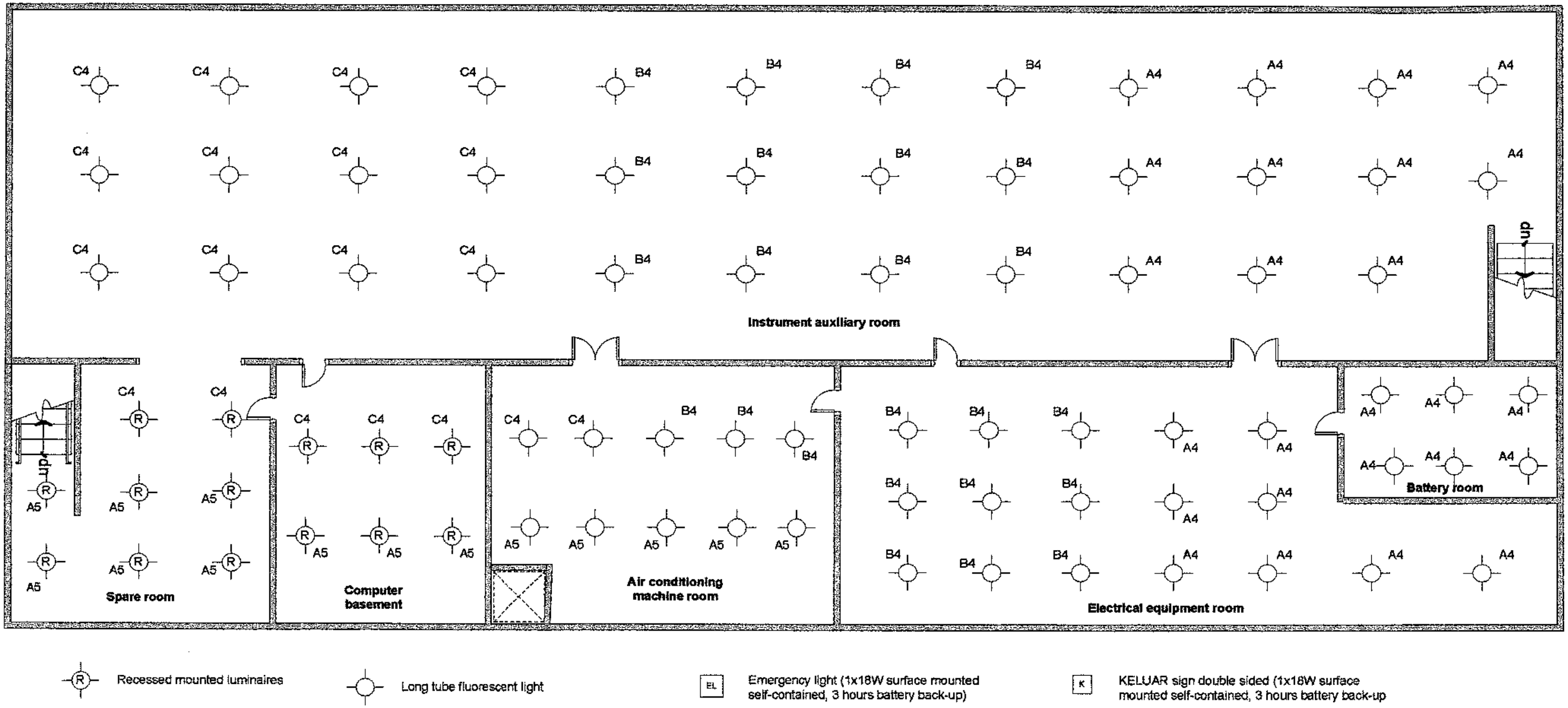


Figure 10 Basement of the building with normal lighting circuiting.

4.6 Lighting Power Schedule

For the first floor, there are 24 rooms/separated area with each have different desired illumination level. The required illumination level is provided in PETRONAS Technical Standard (PTS 33.64.10.10). The numbers of light fittings are obtained from the previous lighting simulation. Therefore, the light fittings are arranged and labeled according to three phase circuit.

Lighting power schedule is used to determine the total wattage of lighting load and to ascertain the total amount of wattage and KVA are balance for phase. Since the light fittings are well arranged and already assigned to few phases, the lighting circuit is now encompasses to three phase circuit namely, red, yellow and blue. Basically, lighting power schedule consists of type of light fittings, the total wattage, and label of circuit.

The total wattage also converts to kilovolt-ampere (KVA) for each phase. The total KVA is then used to determine the size of miniature circuit breaker. These sums must be balanced so that each phase has nearly or exactly the same value. Otherwise, some lights may have to be reassigned to a new phase to maintain the balance.

The steps used in the preparation of the draft panel schedule were as follows:

i) Calculating the total kVA for the building

ii) Filling the necessary information about the total KVA rating of each phase

The first draft of lighting power schedule is included in **Appendix C**. The sums of total wattage of each phase are not balanced. The following table shows the summary of lighting power schedule:

	Wattage (W)		
	Red	Yellow	Blue
Total wattage	3924	3276	3150

Table 3 Summary of lighting power schedule

Due to this problem, the lighting circuiting is rearranged to balance the sum of wattage for each phase. Some amendment was done to the normal lighting circuiting and lighting power schedule at the first floor only (refer to **Figure 7**). The value of KVA is calculated by using the formula as shown below:

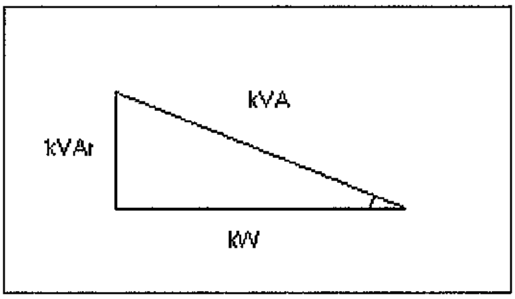


Figure 11 : Power triangle

To convert kilovolt-ampere (kVA) to kilowatts (kW):

$$P\ (kVA) = P\ (kW) / \cos\theta \qquad (1)$$

The value of power factor used is 0.9. This value is used according to the standard power factor value used by MLNG Sdn. Bhd. The amended lighting power schedule is included in **Appendix D.**

	Wattage (W)		
	Red	Yellow	Blue
Total wattage	3780	3456	3186

Table 4 Summary of lighting power schedule (amended)

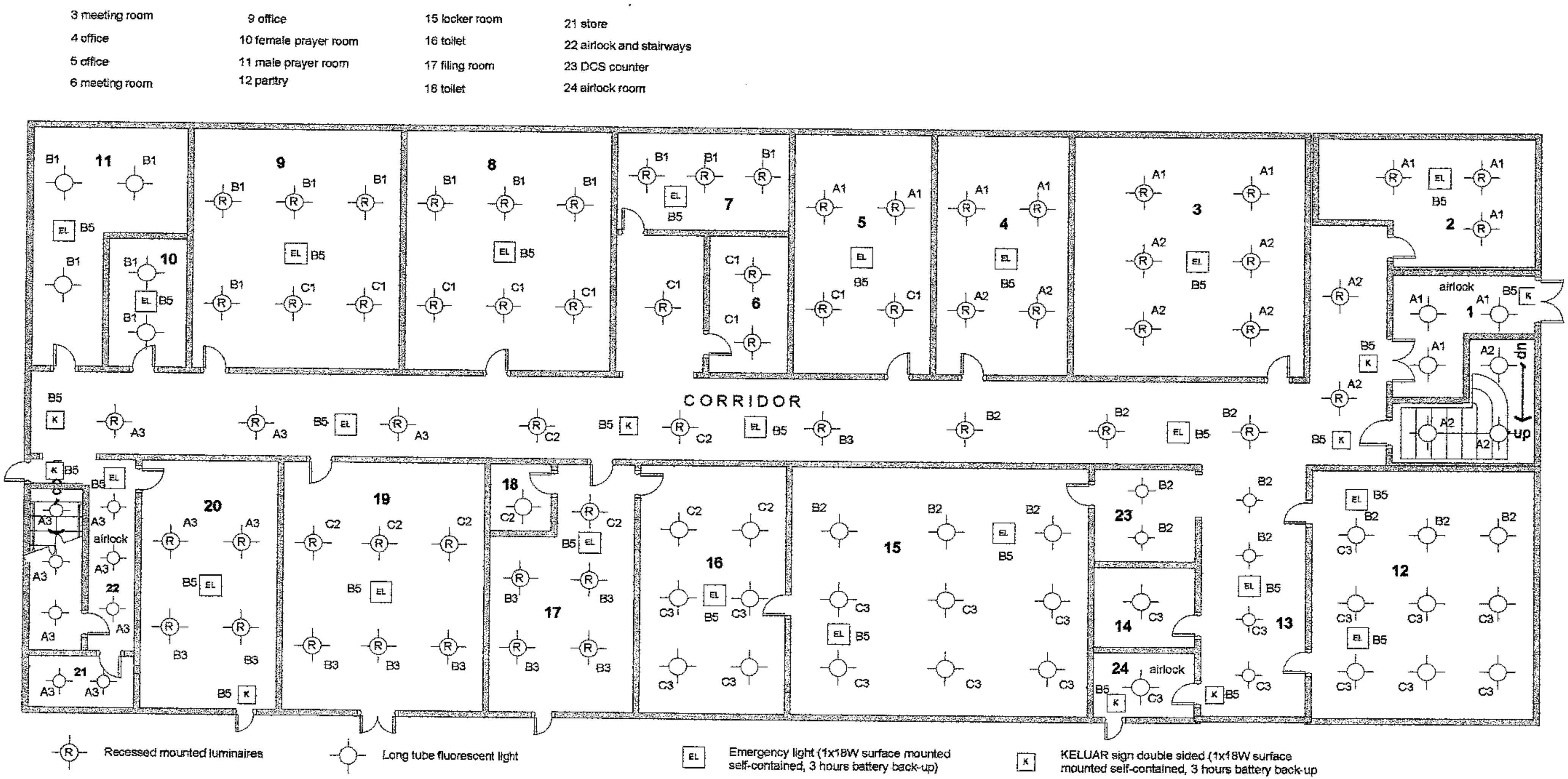


Figure 12 Ground floor of the building with normal lighting and emergency lighting circuiting (after the circuit rearranged)

4.7 MCB sizing calculation

There are three phases in the building wiring system, namely red, yellow, and blue. The lighting wiring schedule shows which lights assigned to which phase and room. It also shows the number of lights, their type, and wattage. For example, the lighting in one room may be assigned to red phase circuit while another room may have the blue phase. It is normal practice to have each room assigned to one phase circuit. However, for this project, each room assigned to two phase circuits for backup purposes in case one of the circuits gets disconnected or short-circuited.

The sum of all the circuits in the room is then calculated to get the total current and kVA for each phase. These sums must be balanced so that each phase has nearly or exactly the same value. Otherwise, some lights may have to be reassigned to a new phase to maintain the balance. The following figure is power triangle that used in most of calculations in this project.

To obtain the current rating for each circuit:
Thus, I (A) = P (kVA) / 240 V since 240V is applied to each circuit

In normal practice, this current rating must be substantially less than the rating of the moulded circuit breaker (MCB). For example, if the MCB rating is 6 A, each circuit should then be rated in the region of 0-4 A.

All the calculation and results are tabulated in a table of lighting power schedule as shown in **Appendix E.**

4.7.1 Example of Design Calculation for MCB Sizing for circuit A1

P (kVA) = 0.828 kW / 0.9

= 0.92 kVA

I (A) = 0.828 kW / (0.9 x 240 V)

= 3.83 A

The current rating for MCB:

I (A) = 20% (3.83) + 3.83

= 4.6 A

The suitable MCB size is then one that rated 6 A.

4.7.2 Technical verification analysis of circuit breaker's sizing

The next part of the results is the verification analysis of the lighting distribution network. The scope of analysis will be focused on the building, which is a one storey block with basement. This building is a typical office building with basement. The basement encompasses of instrument auxiliary room, battery room, electrical equipment room, air conditioning machine room, computer basement and a spare room.

Miniature circuit-breaker (MCB) is used to protect the final circuit of Distribution Board (DB) of lighting and small power installations against overload current and short-circuit. MCB will trip on a small current sustained overcurrent but not on a harmless transient overcurrent such as switching surge. It is as an alternative to fuse which easily reset and re-closed when the fault in the circuit is cleared. The calculation for MCB sizing will be done after all the total load calculated.

The selection of MCB based on calculated appropriate current rating for circuit-breaker. Nominal current rating or rated trip rating circuit-breaker is the current which the circuit-breaker can carry continuously without causing the breaker to trip, overheat or deteriorate. Besides, it is identified as the nearest available current rating which equal or greater than the design (rated) current. On the other word, the nominal current is the normal operating current.

The rated short-circuit current breaking capacity (kA, R.M.S value) is the root mean square (R.M.S) value of the a.c component of current at which the circuit-breaker can break safely under the specified conditions of voltage. It is the maximum prospective fault current which shall not to be less than the maximum prospective short-circuit current at the point of installation. The maximum current that flows through the breaker and the breaker is capable to interrupt at the instant of ignition of arc during a breaking operation at a stated voltage under prescribed conditions. The breaking capacity is usually expressed in kA or MVA. The typical values range from 3kA to 43kA.

Some specifications and operations of circuit breakers are described here as an additional information regarding the verification analysis. Normally, the rated current (I_N) of a circuit breaker is the current that it can carry continuously, generally for duration of more than eight hours. The rated current shall not cause a temperature rise in excess of the specified values when the ambient temperature is between -5°C to 40°C. The temperature rise limits also specified for different parts of a circuits breaker. A circuit breaker will not operate (trip) if the current passing through it is 105% to 113% of its rated current. [8,9]

The first factor to be considered for the verification analysis is the design current in each circuit in the installation. Design current is important because its value will determine the correct current rating of the circuit breakers. The design current which is the expected load current in a circuit can be determined by the power demand (the rated wattage), power factor and efficiency of the connected load. Besides, the design principle is the design current of the DB shall be less than the summation of all the design currents in each outgoing circuit.

After all calculations performed, the final lighting panel schedule is prepared according to the correspondence format. The lighting panel schedule is as per in **Appendix F.** The diversity factor used in lighting power schedule is actually the percentage of power at one time used. On the other hands, the factor that used to find the actual load when all loads in normal operation.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Since the energy efficient and effective lighting system is the objective of this project, the simulation output will help to implement the strategy of energy efficient as stated theoretically. Simulation improves the quality of routine design and allows the engineer to assess the performance of the power system not only during the design stages, but also when the system is already operating. The applicable codes and standard used in this project is according to PTS 33.64.10.10. Although the cost of lighting design and technology is a lot of matter, the impact of lighting shall be considered. Besides, the major concern should be put on the quality and energy efficiency. The whole project workflow is actually in line with the objective of this project that is to have an effective and efficient lighting system.

5.2 Recommendation

Improvements can be made for the future continuation of this final year project by analyzing a more complex lighting design. As an example, UTP can be a good location for lighting design case study since power blackout occurred frequently. The lighting system shall be improved in order to provide an intelligent lighting system that able to control number of light depend on power available during power failure occurrence.

CHAPTER 6

REFERENCES

1) www.energyusernews.com/CDA/Article_Information/Fundamentals_Item/0,2637,8219,00.html
2) http://www.sirim.my/techinfo/catalogueonline/Subject/91.140.50.html
3) http://doityourself.com/electric/buildingssavemoneywithefficientlight.htm
4) http://www.lighting.philips.com
5) http://www.schorsch.com/kbase/glossary/luminance.html
6) http://www.merlin-gerin.com.tr/html/en/products/bt/elp/id.htm
7) www.ecbcs.org/Annexes/annex36.htm
8) Lighting, D. C. Pritchard, Fifth Edition, 1995, page 15-16, 21-157, 169
9) BS EN 60947-2: 1992, "Low voltage switchgear and controlgear, Part 2. Circuit Breaker", The British Standard
10) BS EN 60898: 1991, "Circuit breakers for overcurrent protection for household and similar installations", The British Standard.
11) PETRONAS Technical Standards (PTS 33.64.10.10) – Illumination Level

APPENDIX A
PETRONAS TECHNICAL STANDARDS (PTS 33.64.10.10) – ILLUMINATION LEVEL

APPENDIX 4 ILLUMINATION LEVELS

The required illumination levels, measured at the working plane or 1 m above the floor level in a horizontal plane, are shown in the table below.

These values are mean values and the uniformity ratio (E_{min}/E_{mean}) is ¼ for normal installations.

These values shall be used as a basis for the design of new installations unless higher illumination levels are required by national or local regulations in the country of installation. The tabulated illumination levels apply when the luminaires are dirty, i.e., after taking account of the following fouling factors:

Location	fouling factor
Plant areas (both indoor and outdoor):	0.80
Non-plant areas (outdoor):	0.80
Non-plant areas (indoors):	0.85

REQUIRED ILLUMINATION LEVELS

Location		E_{mean} (Lux)	Notes
CONTROL ROOMS			
General, including front of panel		300/500	1, 7
Rear of panels		150	
Auxiliary rooms		150/300	2
Outside, near entrances		150	
PLANT AREAS			
Operating areas requiring regular operator intervention	pumps, compressors, generators, drivers, valves, manifolds, loading arms, etc.	150	3
Local control and monitoring points	indicating instruments, gauges and control devices	75	
Level gauges (see-through) to be lit from behind by single tube fluorescent luminaries			
Access ways:	walkways, platforms, stairways, ladders, module roofs (offshore)	25	
Plant and jetty approaches and road intersections		5	
Non-operational areas with limited attendance, e.g., tank farms without equipment requiring regular operator intervention.		0.5	
Loading gantries:	top loading, walkways and top of tankers	150	
	bottom loading (coupling handling area)	150	
Road tanker parking area		25	

Location		E_{mean} (Lux)	Notes
NON-PLANT AREAS			
Switchrooms, including relay and auxiliary rooms		150	
Workshops and garages	indoor general	250	3
	local on workbenches and machine tools	400	4
	outdoor storage and handling areas	50	
Warehouses and stores	indoor between storage racks	150	
	bulk storage	50	
	outdoor storage areas	5	
Laboratories and analyser rooms		400	
Street lighting and fence lighting	lit by twin 40 W fluorescent or single 70 W HP sodium (SON) luminaires on standard 8 m poles at, typically, 50 m spacing		5, 6
NON-INDUSTRIAL AREAS			
Canteens (dining areas)		100	
Car parks		1	
Catering areas (food preparation and serving)		300	
Communications rooms		400	
Computer rooms		400	7
Conference rooms		400	
Corridors and stairways		100	
Drawing offices		400	7, 8
First aid rooms		400	
Libraries and reading rooms		400	
Lifts		100	
Offices		400	
Plant rooms		150	
Print rooms		250	
Reception areas		150-400	
Recreation rooms and lounges		300	
Store rooms		150	
Toilets and locker rooms		100	

NOTES:

1. 300 lux applies at night and 500 lux during the daytime. Control of the illumination level down to 100 lux should be possible either by switching off rows/groups of luminaires, or by use of electronic dimmers, or both.
2. 150 lux applies for normal access and 300 lux for maintenance activities. The illumination level should be controlled by switching each lamp in a twin fitting from separately controlled circuits or by switching alternative fittings.
3. Where overhead travelling cranes are installed, floodlights should be fitted under the crane beam to provide an illumination level of 400 lux for better illumination during maintenance.
4. In areas where very fine work is carried out, local lighting with higher illumination levels may be required, e.g., 750 - 1000 lux on an instrument workshop bench.
5. Higher illumination levels apply where security fence lighting is required, e.g., for use with video camera surveillance. These shall be specified to be compatible with the video system utilised.
6. At the security barrier and check point in front of site entrance gatehouses, higher illumination levels may be required.

7. In rooms where VDUs are permanently installed, the lighting shall be designed to avoid reflections and glare from the screens.

8. Local lighting shall be provided to give an illumination level of 700 lux on drawing boards.

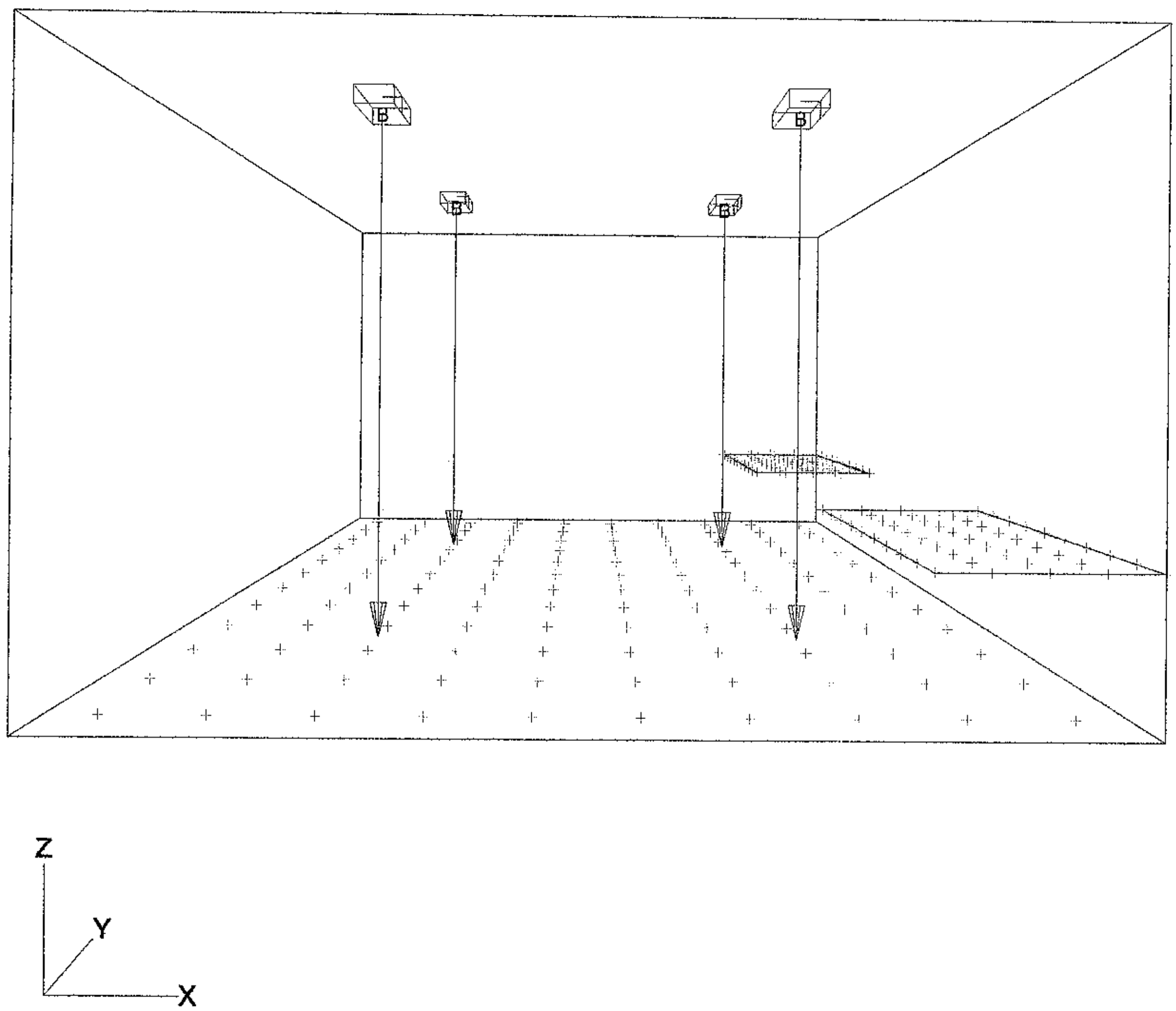
APPENDIX B
LIGHTING SIMULATION

Date:	18-09-2004
Description:	Room 16 Toilet Lamp: 2x18W fluorescent

The nominal values shown in this report are the result of precision calculations, based upon precisely positioned luminaires in a fixed relationship to each other and to the area under examination. In practice the values may vary due to tolerances on luminaires, luminaire positioning, reflection properties and electrical supply.

Project Description

3-D Project Overview



B ⟶ TMS011/218 GKH218

Width	Length	Height	Working Plane Height
5.00 m	8.00 m	3.00 m	0.00 m

Summary

Room Summary

m Dimensions			Surface	Reflectance
th	5.00	m	Ceiling	0.70
ɡth	8.00	m	Left Wall	0.50
ɡht	3.00	m	Right Wall	0.50
king Plane Height	0.00	m	Front Wall	0.50
			Back Wall	0.50
			Floor	0.20

m Position (Front Bottom Left)

	0.00	m
	0.00	m

l Average Room Surface Luminance (cd/m2):

eiling	Left	Right	Front	Back	Floor
7.9	13.9	13.9	12.7	12.7	8.6

ed Glare Rating (CIE): 20

ɔverall maintenance factor used for this project is 1.00.

ᑭroject Luminaires

:	Qty	Luminaire Type	Lamp Type	Power (W)	Flux (lm)
	4	TMS011/218 GKH218	2 * TL-D18W	38.0	2 * 1400

:	Maintenance factor	
	Luminaire	Lamp
	0.95	0.95

ɔtal installed power: 0.15 (kWatt)

ɔer of Luminaires Per Arrangement:

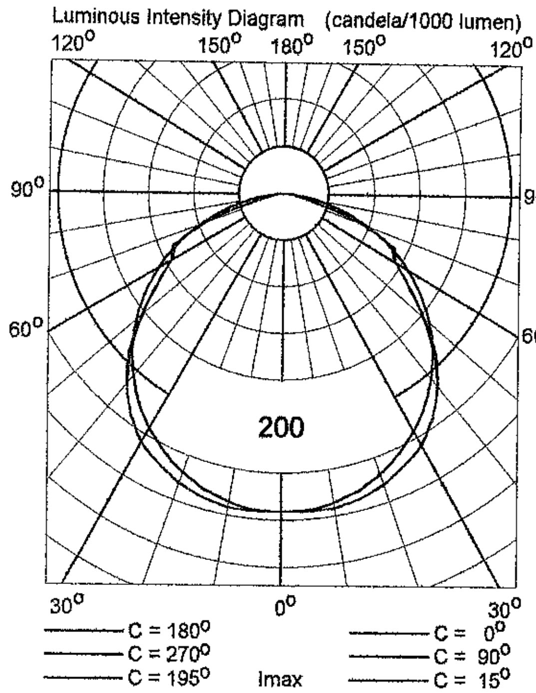
gement	Luminaire Code	Power (kWatt)
	B	
ı Block	4	0.15

Luminaire Details

Project Luminaires

011/218 GKH218 2xTL-D18W/840

t output ratios	
DLOR	: 0.80
ULOR	: 0.00
TLOR	: 0.80
ist	: Electronic
o flux	: 1400 lm
naire wattage	: 38.0 W
surement code	: LVT4534500
naire maintenance factor	: 0.95
o maintenance factor	: 0.95



Date: 18-09-2004

nstallation Data

Legends

ect Luminaires:

e	Qty	Luminaire Type	Lamp Type	Flux (lm)
	4	TMS011/218 GKH218	2 * TL-D18W	2 * 1400

Luminaire Positioning and Orientation

and e	Position			Aiming Angles		
	X (m)	Y (m)	Z (m)	Rot.	Tilt90	Tilt0
;	1.25	2.00	3.00	90.00	0.00	0.00
;	1.25	6.00	3.00	90.00	0.00	0.00
;	3.75	2.00	3.00	90.00	0.00	0.00
;	3.75	6.00	3.00	90.00	0.00	0.00

Date:	20-09-2004
Description:	Room 11 Male Prayer Room Lamp: 2x18W fluorescent

The nominal values shown in this report are the result of precision calculations, based upon precisely positioned luminaires in a fixed relationship to each other and to the area under examination. In practice the values may vary due to tolerances on luminaires, luminaire positioning, reflection properties and electrical supply.

;ummary

Room Summary

n Dimensions		
)	4.00	m
th	7.00	m
ıt	3.00	m
:ing Plane Height	0.00	m

Surface	Reflectance
Ceiling	0.70
Left Wall	0.50
Right Wall	0.50
Front Wall	0.50
Back Wall	0.50
Floor	0.20

n Position (Front Bottom Left)		
	0.00	m
	0.00	m

Average Room Surface Luminance (cd/m2):

ɜiling	Left	Right	Front	Back	Floor
9.3	17.5	14.4	11.5	17.5	9.2

ed Glare Rating (CIE): 20

ıverall maintenance factor used for this project is 1.00.

?roject Luminaires

Qty	Luminaire Type	Lamp Type	Power (W)	Flux (lm)
3	TMS011/218 GKH218	2 * TL-D18W	38.0	2 * 1400

ɔtal installed power: 0.11 (kWatt)

ɔer of Luminaires Per Arrangement:

gement	Luminaire Code A	Power (kWatt)
ı Block1	1	0.04
duals	2	0.08

;alculation Results

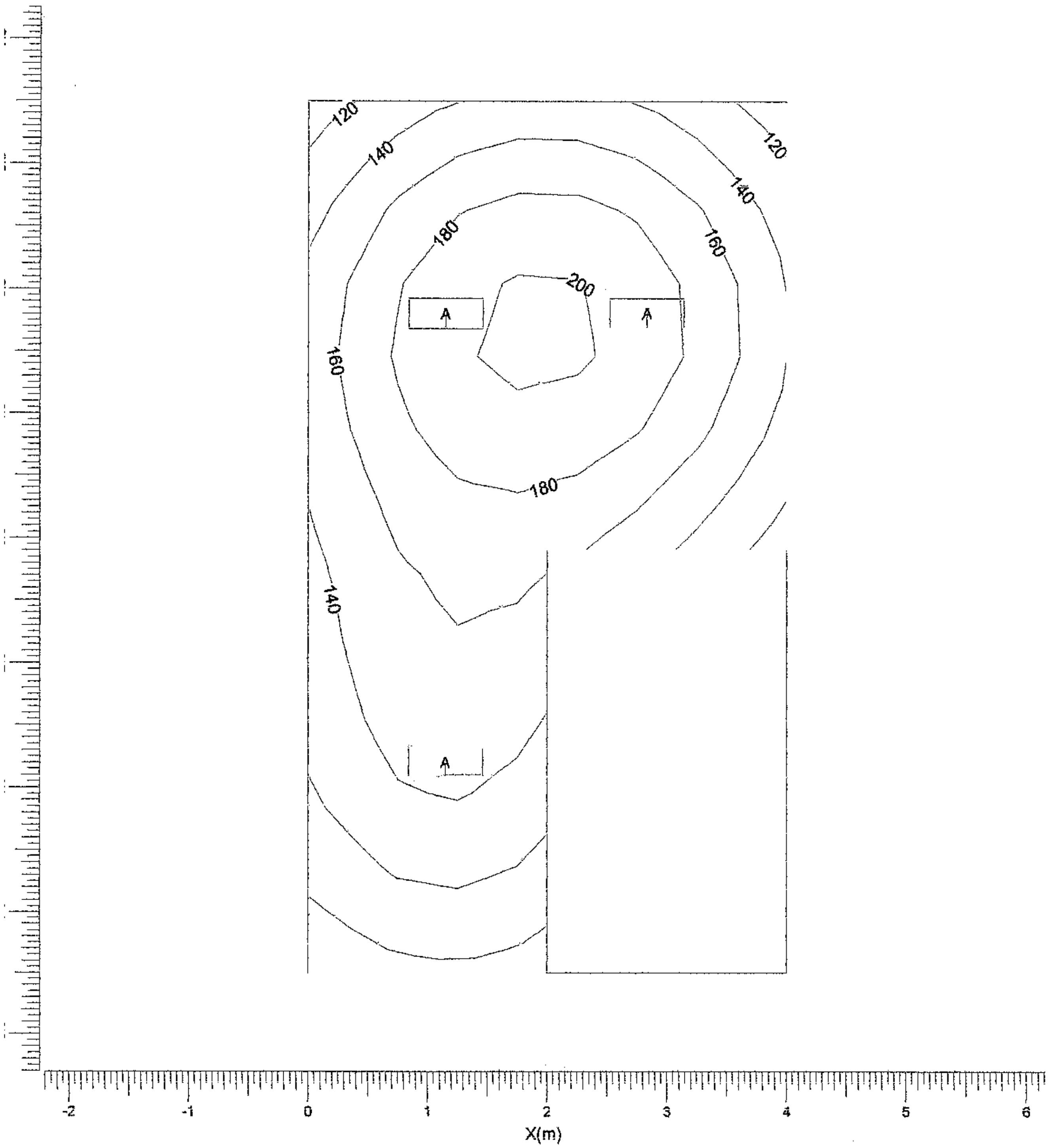
ıinance Calculations:

lation	Type	Unit	Ave	Min/Ave	Min/Max	Result
	Surface Illuminance	lux	157	0.61	0.47	Total

;alculation Results

3rid: Iso Contour

	:	Grid at Z = 0.00 m
ılation	:	Surface Illuminance (lux)
lt Type	:	Total



A ——▷ TMS011/218 GKH218

Average	Min/Ave	Min/Max	Project maintenance factor	Scale
157	0.61	0.47	1.00	1:50

.uminaire Details

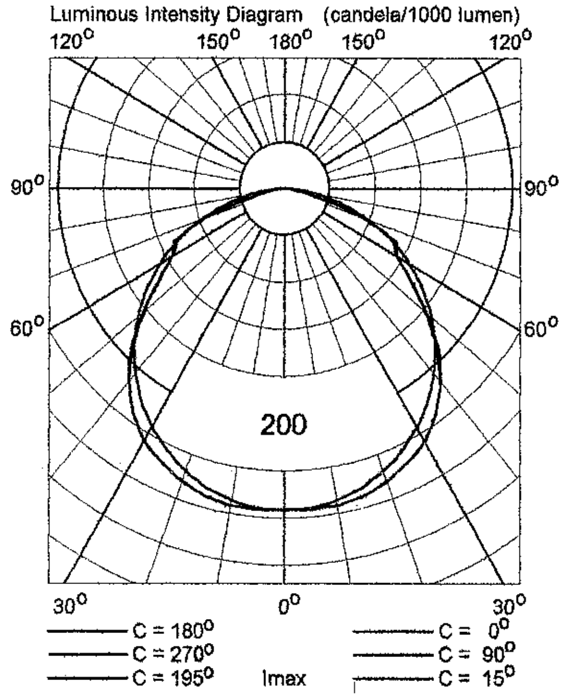
?roject Luminaires

)11/218 GKH218 2xTL-D18W/840

output ratios

)LOR	: 0.80
JLOR	: 0.00
'LOR	: 0.80
st	: Electronic
) flux	: 1400 lm
ıaire wattage	: 38.0 W
ırement code	: LVT4534500

Luminous Intensity Diagram (candela/1000 lumen)



nstallation Data

Legends

ıct Luminaires:

ı	Qty	Luminaire Type	Lamp Type	Flux (lm)
	3	TMS011/218 GKH218	2 * TL-D18W	2 * 1400

.uminaire Positioning and Orientation

ınd	Position			Aiming Angles		
ı	X (m)	Y (m)	Z (m)	Rot.	Tilt90	Tilt0
	1.15	1.70	3.00	0.00	0.00	0.00
	1.15	5.30	3.00	0.00	0.00	0.00
	2.83	5.31	3.00	0.00	0.00	0.00

APPENDIX C
LIGHTING PANEL SCHEDULE (1ST DRAFT)

Service Location	Light Fittings				Wattage (W)			Circuit no.	Label of circuit
	Mounted recessed light (4x18W)	Long tube fluorescent light (2x18W)	Emergency light (1x18W)	KELUAR sign (1x18W)	Red	Blue	Yellow		
First floor									
Room 1,2,3,4,5,7	10	3			828			1	A1
Room 1,3,4,corridor	8	3				684		2	B1
Room 20,21,22,corridor	5	8					648	3	C1
Room 7,8,9,10,11	9	5			828			4	A2
Room 12,13,15,23,corridor	3	10				648		5	B2
Room 17,19,20	9	-					648	6	C2
Room 5,6,8,9	10	-			720			7	A3
Room 16,17,19,corridor	7	3				612		8	B3
Room 12,13,14,24,15,16	-	20					720	9	C3
Basement									
Instrument auxiliary room, battery room, electrical equipment room	-	20			720			10	A4
Instrument auxiliary room, electrical equipment room, air conditioning machine room	-	21				756		11	B4
Instrument auxiliary room, spare room, computer basement, air conditioning machine room	5	14					864	12	C4

Computer basement, spare room	9	5			828				A5
Emergency									
1st floor			23	9		576			B5
Basement			11	4			270		C5
Total wattage (W)					3924	3276	3150		

LIGHTING POWER SCHEDULE

To calculate the kilovolt-ampere of the load:

$$KVA = \frac{\text{Power (kilowatt)}}{\text{Power factor}}$$

$$\text{Current (A)} = \frac{\text{Power (kilowatt)}}{\text{Power factor} \times 240\text{ V}}$$

APPENDIX D
LIGHTING PANEL SCHEDULE (2^{ND} DRAFT)

Service Location	Light Fittings				Wattage (W)			Circuit no.	Label of circuit
	Mounted recessed light (4x18W)	Long tube fluorescent light (2x18W)	Emergency light (1x18W)	KELUAR sign (1x18W)	Red	Blue	Yellow		
First floor									
Room 1,2,3,4,5,7	10	3			828			1	A1
Room 1,3,4,corridor	8	3				828		2	B1
Room 20,21,22,corridor	5	8					720	3	C1
Room 7,8,9,10,11	9	5			684			4	A2
Room 12,13,15,23,corridor	3	10				648		5	B2
Room 17,19,20	9	-					612	6	C2
Room 5,6,8,9	10	-			720			7	A3
Room 16,17,19,corridor	7	3				648		8	B3
Room 12,13,14,24,15,16	-	20					720	9	C3
Basement									
Instrument auxiliary room, battery room, electrical equipment room		20			720			10	A4
Instrument auxiliary room, electrical equipment room, air conditioning machine room		21				756		11	B4
Instrument auxiliary room, spare room, computer basement, air	5	14					864	12	C4

conditioning machine room									
29162916Computer basement, spare room	9	5			828				A5
Emergency									
1st floor			23	9		576			B5
Basement			11	4			270		C5
Total wattage (W)					3780	3456	3186		

TOTAL LOAD CURRENT & KVA			
R-N	**Y-N**	**B-N**	**TOTAL**
3.780 (KW)	3.456 (KW)	3.186 (KW)	10.422 (KW)
4.2 (KVA)	3.84 (KVA)	3.54 (KVA)	11.56 (KVA)

APPENDIX E
MCB SIZING CALCULATION

MCB Calculation

Circuit no.	Circuit label	Light Fittings			Total power (watt)	KVA	Current (Ampere)	MCB rating size [20%total load + total load] (Ampere)
		Mounted recessed luminaries (4x18W)	Long tube fluorescent lamp (2x18W)	Emergency lamp and 'KELUAR' sign (1x18W each light fixtures)				
1	A1	10	3		828	0.92	3.83	4.6
2	B1	8	3		828	0.92	3.83	4.6
3	C1	5	8		720	0.80	3.33	4.0
4	A2	9	5		684	0.76	3.17	3.8
5	B2	3	10		648	0.72	3.0	3.6
6	C2	9	-		612	0.68	2.83	3.4
7	A3	10	-		720	0.80	2.25	2.7
8	B3	7	3		648	0.72	2.25	2.7
9	C3	-	20		720	0.80	3.33	4.0
10	A4	-	20		720	0.80	3.33	4.0
11	B4	-	21		756	0.84	3.5	4.2
12	C4	5	14		864	0.96	4.0	4.8
13	A5	9	5		828	0.92	3.83	4.6
14	B5			32	576	0.64	2.67	3.2
15	C5			15	270	0.30	1.25	1.5

CALCULATIONS

A. Normal lighting

1. For circuit A1:

P (kVA) = 0.828 kW / 0.9
= 0.92 kVA

I (A) = 0.828 kW / (0.9 x 240 V)
= 3.83 A

The current rating for MCB:
I (A) = 20% (3.83) + 3.83
= 4.6 A

The suitable MCB size is then one that rated 6 A.

2. For circuit B1:

P (kVA) = 0.828 kW / 0.9
= 0.92 kVA

I (A) = 0.828 kW / (0.9 x 240 V)
= 3.83 A

The current rating for MCB:
I (A) = 20% (3.83) + 3.83
= 4.6 A

The suitable MCB size is then one that rated 6 A.

3. For circuit C1:

P (kVA) = 0.720 kW / 0.9
= 0.80 kVA

I (A) = 0.720 kW / (0.9 x 240 V)
= 3.33 A

The current rating for MCB:
I (A) = 20% (3.33) + 3.33
= 3.996 A = 4.0 A

The suitable MCB size is then one that rated 6 A.

4. ***For circuit A2:***

P (kVA) = 0.684 kW / 0.9
= 0.76 kVA

I (A) = 0.684 kW / (0.9 x 240 V)
= 3.17 A

The current rating for MCB:
I (A) = 20% (3.17) + 3.17
= 3.8 A

The suitable MCB size is then one that rated 6 A.

5. ***For circuit B2:***

P (kVA) = 0.648 kW / 0.9
= 0.72 kVA

I (A) = 0.648 kW / (0.9 x 240 V)
= 3.0 A

The current rating for MCB:
I (A) = 20% (3.0) + 3.0
= 3.6 A

The suitable MCB size is then one that rated 6 A.

6. ***For circuit C2:***

P (kVA) = 0.612 kW / 0.9
= 0.68 kVA

I (A) = 0.612 kW / (0.9 x240 V)
= 2.83 A

The current rating for MCB:
I (A) = 20% (2.83) + 2.83
= 3.4 A

The suitable MCB size is then one that rated 6 A.

7. ***For circuit A3:***

P (kVA) = 0.540 kW / 0.9
= 0.6 kVA

I (A) = 0.540 kW / 240 V
= 2.25 A

The current rating for MCB:
I (A) = 20% (2.25) + 2.25
= 2.7 A

The suitable MCB size is then one that rated 6 A.

8. ***For circuit B3:***

P (kVA) = 0.612 kW / 0.9
= 0.68 kVA

I (A) = 0.612 kW / 240 V
= 2.55 A

The current rating for MCB:
I (A) = 20% (2.55) + 2.55
= 3.06 A

The suitable MCB size is then one that rated 6 A.

9. ***For circuit C3:***

P (kVA) = 0.720 kW / 0.9
= 0.80 kVA

I (A) = 0.720 kW / (0.9 x 240 V)
= 3.33 A

The current rating for MCB:
I (A) = 20% (3.33) + 3.33
= 4.0 A

The suitable MCB size is then one that rated 6 A.

10. For circuit A4:

P (kVA) = 0.720 kW / 0.9
= 0.80 kVA

I (A) = 0.720 kW / (0.9 x 240 V)
= 3.33 A

The current rating for MCB:
I (A) = 20% (3.33) + 3.33
= 4.0 A

The suitable MCB size is then one that rated 6 A.

11. For circuit B4:

P (kVA) = 0.756 kW / 0.9
= 0.84 kVA

I (A) = 0.756 kW / (0.9 x 240 V)
= 3.5 A

The current rating for MCB:
I (A) = 20% (3.5) + 3.5
= 4.2 A

The suitable MCB size is then one that rated 6 A.

12. For circuit C4:

P (kVA) = 0.864 kW / 0.9
= 0.96 kVA

I (A) = 0.864 kW / (0.9 x 240 V)
= 4.0 A

The current rating for MCB:
I (A) = 20% (4.0) + 4.0
= 4.8 A

The suitable MCB size is then one that rated 6 A.

13. For circuit A5:

P (kVA) = 0.828 kW / 0.9
= 0.92 kVA

I (A) = 0.828 kW / (0.9 x 240 V)
= 3.83 A

The current rating for MCB:
I (A) = 20% (3.83) + 3.83
= 4.6 A

The suitable MCB size is then one that rated 6 A.

B. Emergency Lighting

14. For circuit B5:

P (kVA) = 0.576 kW / 0.9
= 0.64 kVA

I (A) = 0.576 kW / (0.9 x 240 V)
= 2.67 A

The current rating for MCB:
I (A) = 20% (2.67) + 2.67
= 3.2 A

The suitable MCB size is then one that rated 6 A.

15. For circuit C5:

P (kVA) = 0.270 kW / 0.9
= 0.30 kVA

I (A) = 0.270 kW / (0.9 x 240 V)
= 1.25 A

The current rating for MCB:
I (A) = 20% (1.25) + 1.25
= 1.5 A

The suitable MCB size is then one that rated 6 A.

APPENDIX F
LIGHTING POWER SCHEDULE (FINAL DRAFT)

Service Location	Fittings: Mounted recessed light (4 x 18W)	Long tube fluorescent light (2 x 18W)	Emergency light and "KELUAR" sign (each 1 x 18W)	13A socket outlet	Total wattage (W)	Wattage (KVA): Red	Yellow	Blue	Circuit no.
HTING GROUP									
und Floor									
m 1,2,3,4,5,7	10	3			828	0.92			A1
m 1,3,4,corridor	8	3			828		0.92		B1
m 20,21,22,corridor	5	8			720			0.8	C1
m 7,8,9,10,11	9	5			684	0.76			A2
m 12,13,15,23,corridor	3	10			648		0.72		B2
m 17,19,20	9	-			612			0.68	C2
m 5,6,8,9	10	-			720	0.8			A3
m 16,17,19,corridor	7	3			648		0.72		B3
m 12,13,14,24,15,16	-	20			720			0.8	C3
ement									
ument auxiliary room, battery room, rical equipment room		20			720	0.8			A4
ument auxiliary room, electrical pment room, air conditioning machine 1 electrical equipment room, air litioning machine room		21			756		0.84		B4
ument auxiliary room, spare room, puter basement, air conditioning hine room	5	14			864			0.96	C4
puter basement, spare room	9	5			828	0.92			A5
rgency									
oor			32		576		0.64		B5
ement			15		270			0.3	C5
VER GROUP									
und Floor									
e (room 2), corridor				8	2400	2.67			A6
e (room 3)				8	2400		2.67		B6
e (room 4)				8	2400			2.67	C6
e (room 5)				8	2400	2.67			A7
ting room (room 6), library (room 7)				6	2400		2		B7
e (room 8)				8	2400			2.67	C7
e (room 9)				8	2400	2.67			A7
ry, fit apparel				4	1200		1.33		B7
counter, store (room 14), locker room m 15)				8	2400			2.67	C7
g room (room 17)				6	1800	2			A8
e (room 19)				8	2400		2.67		B8
ratory, male prayer room, female prayer 1				8	2400			2.67	C8
ement									
condition machine room				4	1200	1.33			A9
puter basement				8	2400		2.67		B9
trical equipment room				6	1800			2	C9
ument auxiliary room				4	1200	2			A10
ument auxiliary room				6	2400		2		B10
re room				6	2400			1.33	C10
total					**48822**	**17.54**	**17.18**	**17.56**	
AL							**52.27**		KVA
rsity factor = 40%							**20.91 KVA**		
TUAL LOAD									