DESIGN OF ELECTRICAL POWER NETWORK TO A MAIN HALL.

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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DESIGN OF ELECTRICAL POWER NETWORK TO A MAIN HALL

By

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A THESIS SUBMITTED TO THE DEPARTMENT FOR THE AWARD OF BARCHELOR IN ELECTRICAL/COMPUTER ENGINEERING IN PARTIAL FULFILMENT OF ENGINEERING (B.ENG) DEGREE IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA.

NOVEMBER 2010.

ATTESTATION

I, ABUBAKAR ABDULLAHI hereby declare that this project titled " Design of Electrical Power Network to a Main Hall of 100ft×80ft, consisting of 5A lights, 15A Switch socket outlets, 13A Switch socket outlets and 5A Fans hung on the ceiling." was carried out by me in the department of electrical and computer engineering under the supervision of Prof. Oria Usifo. All the information utilized and their sources have been duly acknowledged.

....
Abubakar Abdullahi

15/11/2010
....
Date

CERTIFICATION

I hereby certify that this work has been supervised and meets part of the requirement for the award of bachelors of engineering (B.Eng) Degree in the department of electrical and computer engineering, federal university of technology Minna, Niger state.

………………… 28/10/10 …………………

Prof. Oria Usifo — Date
Project supervisor

………………… Jan. 11, 2011 …………………

Engr. A G. Raji — Date
Head of Department

………………… 1/12/10 …………………

External examiner — Date
Engr. Dr. G. I. Igbeka

DEDICATION

This work is dedicated first and foremost to God almighty, to my mum Mrs. Fatima Abubakar, Dad Mr. Baba Abubakar, and my siblings and all who have been of great support.

ACKNOWLEDGMENT

My foremost thanks and gratitude goes to God almighty for his divine guidance and protection all through the course of my study.

My special thanks go to my mum Mrs. Fatima Abubakar for all the love, sacrifice and support. Also to my dad Mr. Baba Abubakar, my siblings Muhammad, Ibrahim, Salihu, Habibat, my uncles and aunts, my friends I say a big "thank you".

Many thanks to my supervisor Prof. Oria Usifo for his guidance and insightful support and contributions during the course of this project work.

ABSTRACT

The purpose of this project is to design electrical power network to a main hal. It treated the calculations of illumination in the hall and around its perimeter, the power loads for 13A and 15A socket outlets, the associated supply cables and finally the calculation of sub-main cable.

The minimum value of earthing rod resistance was also determined. The ratings of fuses were also specified for the Distribution Board.This project shall be very useful for students aspiring to become consultants in power installation engineering.

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CHAPTER ONE

1.0 INTRODUCTION

Electrical services design practically refers to the production of a standard electrical format and clear view of equipment and facilities provided in a scheme, on paper prior to the actual construction work

Building services engineering is practically concerned with the provision of utility and environment comfort services for the occupant of the built environment.

In order to protect the building and its content from electric shock and burnt certain regulations have been formulated to control the design of the electrical services.

Most of these regulations must be complied with [9].

1) Electrical supply regulation 1937
2) Coal and mines (electricity regulation 1956)
3) Electricity regulation 1971-1980
4) Electricity (factory act) special regulation 1908 and 1944

Designing a layout is the first step in providing electrical services for a building regardless of the wiring method adapted[3]. Some parameters common to all electrical designs are thoroughly taken in to consideration. Such factors include:

a) The type of supply and the earthing arrangement available.
b) Supply continuity and the provision of emergency supply in case of outage or for special use.
c) **Safety:** Electricity if not controlled can be dangerous, hence the provision of appropriate equipment and use of quality workmanship goes a long way to minimize danger.
d) **Maintenance:** The ease of carrying out maintenance of facilities provided should be maintainable at minimum cost.

c) **Future Expansion:** In view of the ever changing nature of man and our continuous quest for growth and development, adequate allowances must be provided in specifying the capacity of cables and distribution equipment without incurring undue cost.

The scope of building services engineering include all aspect of design, installation, maintenance associated with communication in building, energy management system, electrical services, facilities management, heating and ventilating, security and fire prevention, intelligent buildings, lifts, lighting, refrigeration, water supply[3].

This project will be mainly concerned with electrical design services. The electrical design service includes design and installation of power distribution system. The electrical design also has to do with visual comfort i.e. lighting design and installation. Lighting is necessary for task illumination, display, ambience, safety and security. (Pritchard D. C 1986)

This study is necessary in the provision of lighting to meet the various requirements and also to provide understanding of the various lighting tools available at one's disposal, which is capable for effective and efficient visual environment. The design of electrical power network to the main hall is targeting a comfort to the end users in most cost (capital and running cost) effective and also to minimize wastage and unnecessary unwanted contrast in the built environment. (Bovey H.E 1981)

As touching this particular project, owing to the peculiar properties of electricity, an attempt is being made to ensure satisfactory results from the risk of time and to also safeguard the user from electric shock. (as covered by the regulation for the electrical equipment of building known as IEE wiring regulation).

In a long run, a good electrical design in all building should be able to provide for efficient, safe and convenient living and working conditions

1.1 AIMS AND OBJECTIVES

The aim and objective of this project work is an attempt to design an electrical power network for the main hall based on the standard prescribed by various codes of practice and regulation with views to:

1. Determine the illumination in the hall.
2. Determine power of 13A socket outlets.
3. Determine power of 15A socket outlets.
4. Determine power of the distribution board.
5. Determine size of cables to lamps.
6. Determine size of cable to socket outlets.
7. Determine size of cables to the distribution board.
8. Provide protection for all the cables in terms of fusing.
9. Provide earthing for the total installation work.

1.2 SCOPE AND LIMITATION

This project work will be limited to the complete electrical installation design; the design will incorporate power, lighting, cabling e.t.c.

1.3 PROBLEM DEFINITION AND METHODOLOGY

This project work is an attempt at the design of electrical power network to a main hall.

The process of designing involves the following:-

i. The development of the working drawing/ site layout.

ii. The power design.

iii. The lighting design.

iv. Calculation of the entire load from (ii) and (iii) above.

v. The cable design.

CHAPTER TWO

2.1 LITERATURE REVIEW

Long before the spread of modern civilization, the blessing of fire, heat and light can never be over emphases. The use of fire was the human utilization of energy in a form other than sunlight. It provided protection against climatic changes and thus improved the chances for survival [3].

Electrical lighting had its real beginning in about 1870 with the development of commercially usable lamps and was given greater impetus nine (9yrs) years later by Edison's first practical incandescent lamp. Today's electric light sources fall in to three generic classifications: The incandescent lamp, the gaseous discharge lamp, and the electroluminescent sources.

Electrical power as described by Britannica (1987) is the energy generated through the conversion of other forms of energy such as mechanical, chemical or thermal energy [5]. The institution of electrical regulation for the electrical equipment of building published in 1981 with amendment in January 1983 covers prevention of fire risk arising from industrial electrical installation work of a building.

Explanatory note on the electrical distribution regulation 1937 indicates the requirement of long distribution cable to a usable point inside the building, from which point of installation commenced, also designed to provide safety especially from fire, shocks and burns. The institute of electrical engineering prepares and issues standard for electrical equipment of the building. The aim of the set standard is summarized as follow.

- As a measure to prevent outbreak of fire which can destroy lives and property.

Ensuring proper earthling and thereby eliminating shocks to occupants.

The standard issued is also geared toward avoiding current leakage.

Electrical supply capacity depends on the power requirement within the building, which is normally assessed in terms of the maximum demand for electricity and its annual consumption by all equipment installed. Knowledge of plant load together with the detail of its characteristics is necessary in order to establish the likely maximum demand and the annual consumption of electricity ideally [8].

The installation load should be assessed as accurately as possible by adding together the load requirement of all lighting and power points and suitable diversity factor applied as it is unlikely that all items of plant will simultaneously demand maximum power at the same time. The maximum demand is usually less than the aggregate of the individual maximum demand and the ratio of the two is defined as the diversity factor. The assessment should take in to account of the diversity between point loads, both from a seasonal and a short term point of view. The IEE regulation gives suitable value of diversity factor for most equipment installed in large building.

(IEE WIRING REGULATION 1981)

2.2 THEORY OF DESIGN

2.3 DESIGN FACTORS

These are factors that are taken in consideration for a good installation work to be carried out. Some factors are of a standard values. Others are assumptions which other are worked for. And they are discussed below.

2.3.1 MAINTENANCE FACTOR (M.F)

Lighting output from lamps could be reduced reasonably by dust and dirt or fittings. The ageing of lamps contributes to poor output illumination. In fact, maintenance factor is the ratio of the average illumination on the working plane after a specified period of use of a lighting installation to the average illumination obtained under the same conditions for a new installation. The figure could be between 0.7 – 0.8. The depreciation factor is the reciprocal of maintenance factor [1] i.e.

$$\text{Depreciation factor} = \frac{1}{\text{Maintenance Factor}}$$

$$\text{Maintenance factor (M.F)} = \frac{\text{Illumination under working}}{\text{Illumination under perfectly clean place}}$$

2.3.2 COEFFICIENT OF UTILISATION

This is a factor in illumination engineering taking care of the utilized flux reaching the working plane, since sources of the emitted flux cannot get to the working plane. The effect of the above is to reduce the illumination on a working plane or contrarily, to increase the power of the light source in other to achieve a given illumination level. Therefore coefficient of utilization is the ratio of the utilized flux to the luminous flux emitted by the lamps [1].

The utilization factor depends on the following:

a. Light distribution of the luminaire.

b. Light output ratio of the luminaire.

In factories, lamps are fixed on root trusses or beam. The lamps used here, have high luminous output and thus increase in cost. The spacing – height ratio is a function of the type of lighting fitting and illumination needed on a working environment [1].

2.3.4 ROOM INDEX (K)

This is the ratio of the area of the room in particular to the product of the mounting height and the parameter of the room. The room index, K is a function of the room dimensions and determined with the formula [1]:

$$K = \frac{L.B}{HM\,(L+B)}$$

Where:

L = Room length

B = Room breadth

HM = Mounting height.

2.3.5 MOUNTING HEIGHT (HM)

This is the virtual distance between the luminance and the working plane and some lines the distance between the floor and the luminance. It can be calculated practically from the formula:

$$H.M = Hc - (Hs + Hw)$$

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LUMINOUS FLUX (Ø):

It is the energy radiated out per second from a body in the form of luminous light wave. It is a sort of power unit. The unit is lumen (lm). It is called flux contained per unit solid angle of a source of one candela or standard candela. Luminous flux, $Ø = 4\pi I$ lumen.

ILLUMINANCE (E):

This is the amount of light falling on an area A of a surface. It is denoted by E. It is called the intensity of illumination; the unit is "lux". Good light is important in all building for efficient, safe and convenient living and working conditions. The goals of lighting design are to create an efficient and pleasing interior.

These goals are elaborated below:

i Lighting must have the proper quality.

ii Lighting levels should be adequate for efficient seeing of the particular task involved i.e. general lighting should be provided in all spaces, sufficient for movement and casual seeing.

iii The entire lighting design must be accomplished efficiently in terms of capital and energy resource.

Illumination technology has become a highly specialized subject which is divided in to three broad areas namely:

i. Interior illumination of buildings for living and working.
ii. Exterior illumination for some special purpose.
iii. Illumination of streets and public highways.

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I = luminous intensity

d = distance of separation

Ø = Angle of incidence.

Both the inverse square law and cosine law are mostly used for outdoor lighting design.

2.6 CONDUIT

A conduit may be defined as a tube or channel. In electrical installation work, conduits refer to metal tubing of comparatively light gauge, or non- metallic tubing. The term conduit is also used in connection with the underground pick-up system for electric Trans. Before steel conduit was introduced and when an alternative to wood casing was being sought, cables were sometime drawn in to ordinary gas pipe [1].

2.7 ELECTRIC CABLES

Electric cable form an essential connecting link for conveyance of electric power to building installation, most power cable used for the distribution of electricity in building consist of three components – a conductor (or conductors), insulator and protection both mechanical (which may be either an integral part of the cable or provided by wiring system) and electrical[3].

2.7.1 CHOICE OF CABLES AND CONDUCTORS

The I.E.E Regulation stipulates that all cables carrying current must be so selected as to be able to carry their rated currents, without deterioration [1].

This is why in choosing cables; two factors have to be born in mind namely:

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According to the number of cores, the cable consist of, the cables may be divided in to two classes known as single core cables; twin core cables; three core cables; two core with ECC (earth continuity conductor) cables etc.

According to voltage grading the cables may be divided in two classes: (i) 250/440 volts cables and (ii) 650/1100 volts cables.

According to the type of insulation the cables are of the following types:

1.Polyvinyl chloride (PVC) cables.

2.Lead sheathed cables.

3.Tough rubber sheathed (TRS) or cab tyre sheathed (CTS) cables.

4.Vulcanized India-Rubber (VIR) insulated cables.

5. Flexible cord and cables.

6. Weather proof cables.

7. XLPE (cross-linked polyethene) cables.

2.8 ELECTRIC LIGHTING

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2.8.3 LIGHTING FITTING SCHEMES

The distribution of the light emitted by lamps is usually controlled to some extent by means of reflectors and translucent diffusing screens, or even lenses.

The interior lighting schemes may be classified as (i) direct lighting (ii) semi-direct lighting (iii) semi-indirect lighting (iv) indirect lighting and (v) general lighting [8].

1. Direct Lighting Distribution. It is the most commonly used type of lighting scheme. In this lighting scheme more than 90 percent of total light flux is made to fall directly on the working plane with the help of deep reflectors. Though it is more efficient but causes hard shadow and glare. It is mainly used for industrial and general outdoor lighting.

(i) 0 - 10% upward.

(ii) 90 - 100% downward.

2. Semi-direct Lighting Distribution. In this lighting scheme 60 to 90 percent of the total light flux is made to fall downwards directly with the help of semi-direct reflectors, remaining light is used to illuminate the ceiling and halls. Such a lighting scheme is the best suited to rooms with high ceiling where a high level of uniformly distributed illumination is desirable. Glare in such units is avoided by employing diffusing globes which not improve the brightness towards the eye level but also improve the efficiency of the system with reference to the working

(i) 10 - 40% upward.

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3. Semi-indirect Lighting Distribution. In this lighting scheme 60 to 90 percent of total light flux is thrown upwards to the ceiling for diffuse reflection and the rest reaches the working plane

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3. **Semi-indirect Lighting Distribution.** In this lighting scheme 60 to 90 percent of total light flux is thrown upwards to the ceiling for diffuse reflection and the rest reaches the working plane

directly except for some absorption by the bowl. This lighting scheme is with soft shadows and glare free. It is mainly used for indoor light decoration purposes.

(i) 60 - 90% upward.

(ii) 10 - 40% downward

4. **Indirect Lighting Distribution.** In this lighting scheme more than 90 percent of light flux is thrown upwards to the ceiling for diffuse reflection by using inverted or bowl reflectors. In such a system the ceiling act as the light source and the glare is reduced to minimum. The resulting illumination is softer and more diffused, the shadows are less prominent and the appearance of the room is much improved over that which results from direct lighting. It is used for decoration purposes in cinemas, theatres and hotels etc. and in workshops where large machines and other obstructions would cause troublesome shadows if direct lighting is employed.

5. **General Lighting Distribution.** In this scheme lamps made of diffusing glass are used which give nearly equal illumination in all direction.

(i) 40 – 60 % upward.

(ii) 40 – 60% downward.

2.9 ILLUMINATION FORMULAE

The formula for obtaining the total number of lumens required for types of environment is as follows:

$$\text{Total lumens} = \frac{luminance \times Area\ of\ working\ plane}{MF \times CU} \quad \text{..........(2.1)}$$

From the above,

$$\text{Luminance, E} = \frac{Total\ lumens\ (lm) \times MF \times CU}{Area\ (\text{m2})} \text{ .... (2.2)}$$

Also the formula for obtaining the total number of lamps required for a given illumination level is as follows:

$$\text{Number of lamps, N} = \frac{Total\ lumen}{Luminous\ Flux} = \frac{F}{\emptyset} \text{ .... (2.3)}$$

Where:

MF = Maintenance factor

CU = Coefficient of utilization.

Ø = Luminous flux per lamp or lumens per lamp (lm)

2.10 CIRCUIT PROTECTION AND CONTROL

There are many ways of protecting both installation and the user from risk of electric shock or fire, which may occur under fault conditions. In general, a protective device is designed to disconnect the circuit whenever it detects a fault condition [3]. The two most common devices employed are:

i. **FUSE:** A fuse provides the simplest form of over current protection. The following terms are used in connection with fu

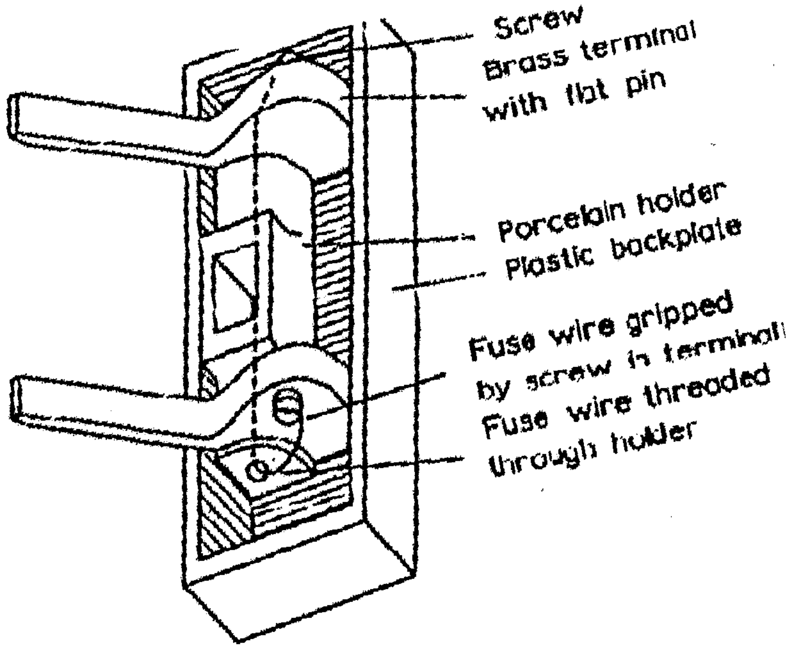

Figure: 2.0 Rewirable fuse

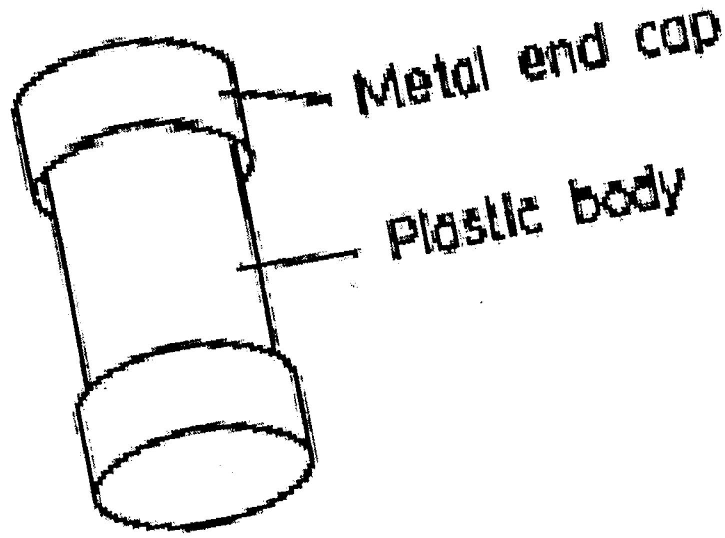

Figure: 2.1 Cartridge fuse.

FUSING CURRENT: This is the minimum current that will blow the fuse.

CURRENT RATING: This is the maximum current that a fuse will carry indefinitely without undue deterioration of the fuse element.

FUSING FACTOR: This is the ratio of the fusing current to the current rating.

i.e., fusing factor $= \dfrac{Fusing\ current}{Current\ rating}$ .... (2.4)

ii **Circuit Breakers:** This may be used to disconnect automatically a faulty circuit. Miniatures circuit – breakers (MCB) have been developed in recent years, as an alternative to fuse, as a means of protection for domestic installations and other small loads.

IEE regulation stipulates that, every electrical circuit and sub-circuit shall be protected against excess current by fuse, circuit breaker, or similar devices [4]. These are expected to perform the following function:

i Must be of adequate making and breaking capacity.

ii Operate automatically at current values suitable related to the safe current rating of the circuit.

iii Must be suitably located and of such construction as to prevent danger from overheating, scattering of hot metal when they come in to operation, and so as to permit ready renewal of fuse element without danger.

Some other means of protecting circuits' structures and apparatus are Earthing, Switchgear.etc.

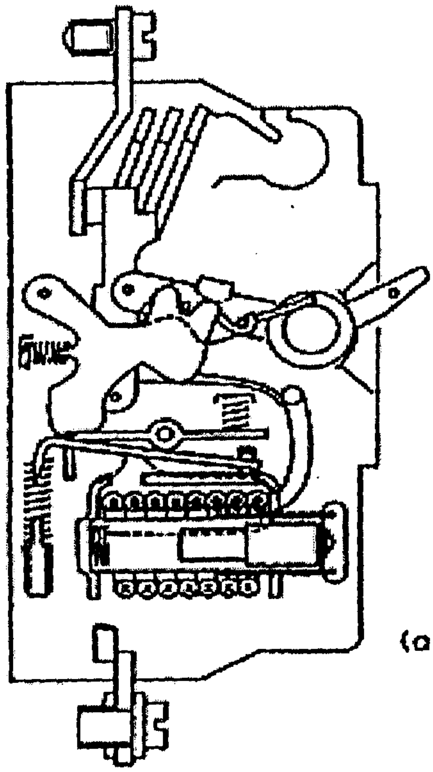

Figure: 2.2 Circuit Breaker

2.11 EARTHING

When insulation materials become damaged or if wire becomes displaced, any metal work directly in contact with the electrical wiring system could become live. If such metal work is touched there could be serious electric shock. Earthing of metal work prevents the risk of shock, so that a heavy current flows to earth [3].

The IEE regulations stipulates that every means of earthing and every protective conductor shall be selected and erected so as to satisfy the requirements of these regulations for the safety and proper functioning of the associated equipment of the installation[4].

The reason for earthing being among others is for:

i Equipment protection.

ii Personal protection.

iii Reliability of electrical services.

iv Correct functioning equipments.

A good connection to earth should have a low electrical resistance, ability to carry high current repeatedly, good corrosion resistance, and ability to perform above functions over a long period of time.

2.11.1 METHODS OF EARTHING

The IEE regulations states that every installation must have earth cables which are wires normally 2.5mm^2 (minimum) cross sectional area. The earthing wires must be so fixed to the installation such as lighting system, water, or gas. It recommends the following methods of earthing:

i Buried conductors.

ii Buried earth plates.

iii Deep driven earth rod electrodes.

iv Parallel driven earth rod.

2.12 POWER DITRIBUTION

2.12.1 INCOMING SERVICE

The incoming supply enters through the supply company (PHCN) equipment to the main switch of the "link type" (i.e. a switch which breaks both poles of the supply).

From the main switch, the supply is fed to a distribution board containing fuses or other suitable over load protective equipment.

2.12.2 CONSUMER CONTROL UNIT (DITRIBUTION BOARD)

These are usually small panels from which the final sub-circuit power supply points are taken. They are usually manufactured in standard size and the rating factors are usually indicated by the number of ways (outgoings), maximum current capacity, and the number of phases.

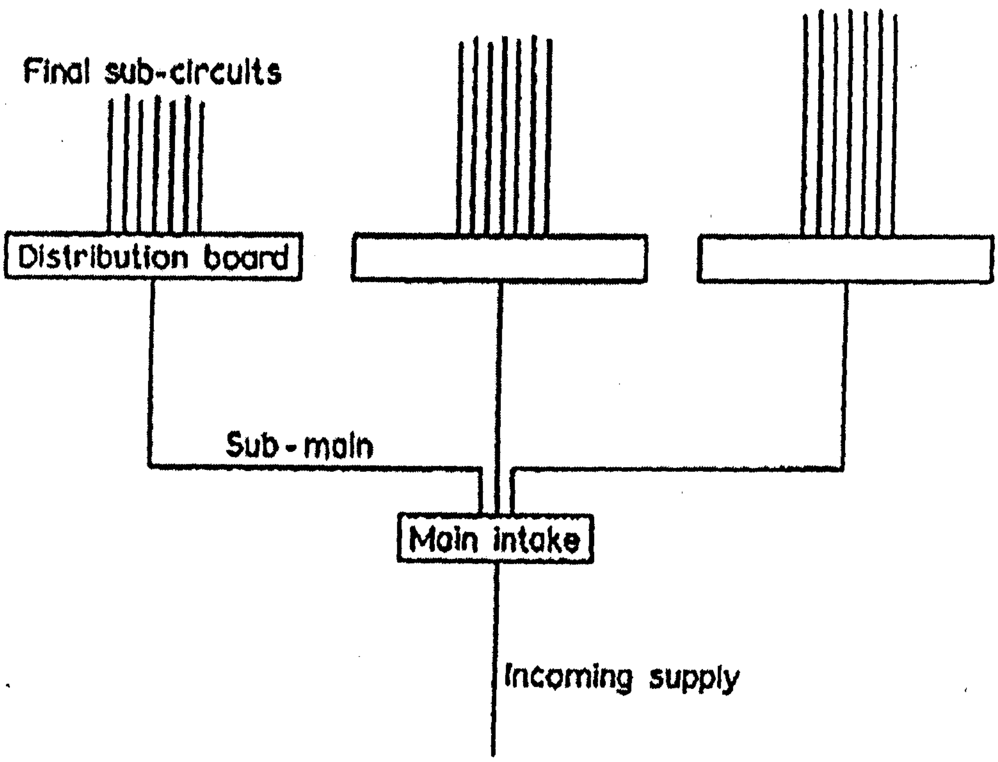

Figure: 2.3 Distributions

2.11.3 FINAL SUB-CIRCUITS

It is a circuit which is connected to any way of a distribution fuse board, or switch fuse feeding one or more points without the intervention of a further distribution fuse board.

It can therefore be seen that from the definition of a final sub-circuit, it mainly consists of a pair of 1.5mm^2 cables feeding a few lights or a very high 3-core cable feeding a large motor direct from a circuit breaker on the main switch board.

The IEE regulations have definite rules guiding final sub-circuits. The rules are necessary to ensure that wiring to sub-circuits and fuse protection is such that danger is prevented and satisfactory results are obtained [1].

2.12.4 TYPES OF FINAL SUB-CIRCUITS

Final sub-circuits are in the following categories:

1. A sub-circuit feeding 13A fuse plug.
2. A sub-circuit feeding a motor or rotating electrical machine.
3. A sub-circuit feeding fluorescent and other types of electric discharging lighting.
4. A sub-circuit with rated capacity not exceeding 15A.
5. A sub-circuit with rated capacity exceeding 15A [1].

2.12.5 POWER OUTLET CIRCUITS

Power outlets circuits are often used for fixed and moveable equipment. The main types are:

I Ring Circuit

A ring circuit is a final sub-circuit in which the conductors run from the distribution boards, through various socket outlets (load point) back to the same terminals of the distribution board. It thus forms a loop connection, otherwise known as a ring circuit [1].

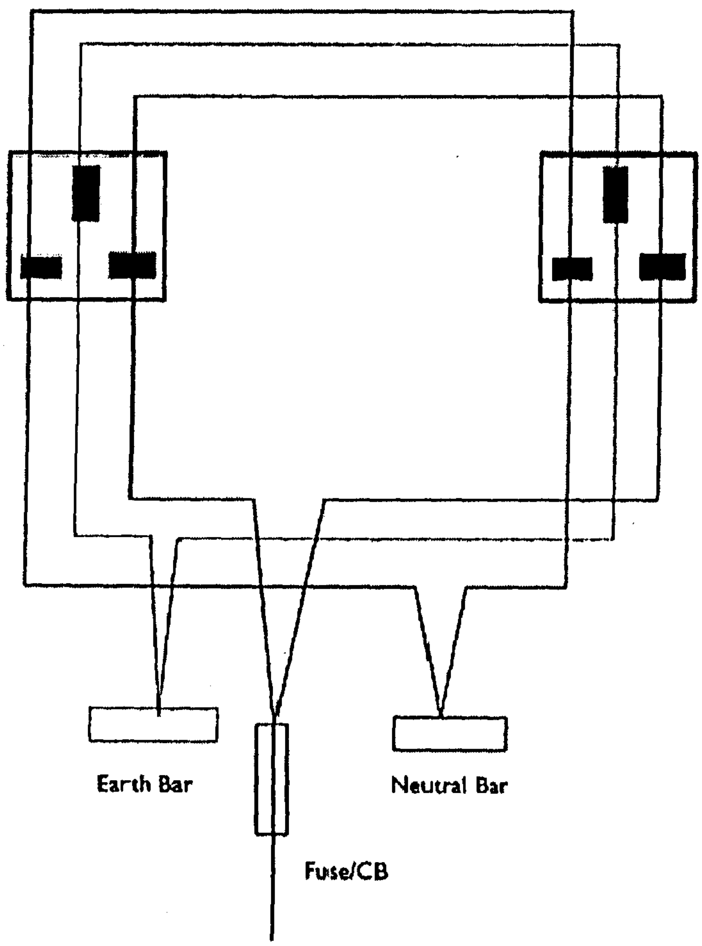

Figure: 2.4 Ring circuit

II Radial Circuit

Wiring for power supply to fixed appliance in accordance with the IEE regulations is often done as "radial" circuit, and each appliance must be protected by an appropriately rated fuse or breaker at the distribution board.

Radial circuit, as the term implies, means that three wires (live, neutral and earth) or five wires (3 No. Live, neutral and earth) are taken from the distribution board straight to the appliance or equipment being served [3].

III Spur Circuit

A spur circuit is a branch circuit from a ring circuit. It is a radial circuit taking it source from a socket outlet in a ring circuit [1].

For ring final sub-circuits complying with IEE regulations A.30-33, the total number of spurs shall not exceed the total number of socket-outlets and stationary appliances connected directly in the ring [4].

12.13 SWITCHS AND SOCKET OUTLETS.

A switch is used to make or interrupt a circuit. Normally when one talks of switches one has in mind light switches which turn lights on and off. A complete switch consists of three parts. There is the mechanism itself, a box containing it, and a front plate over it.

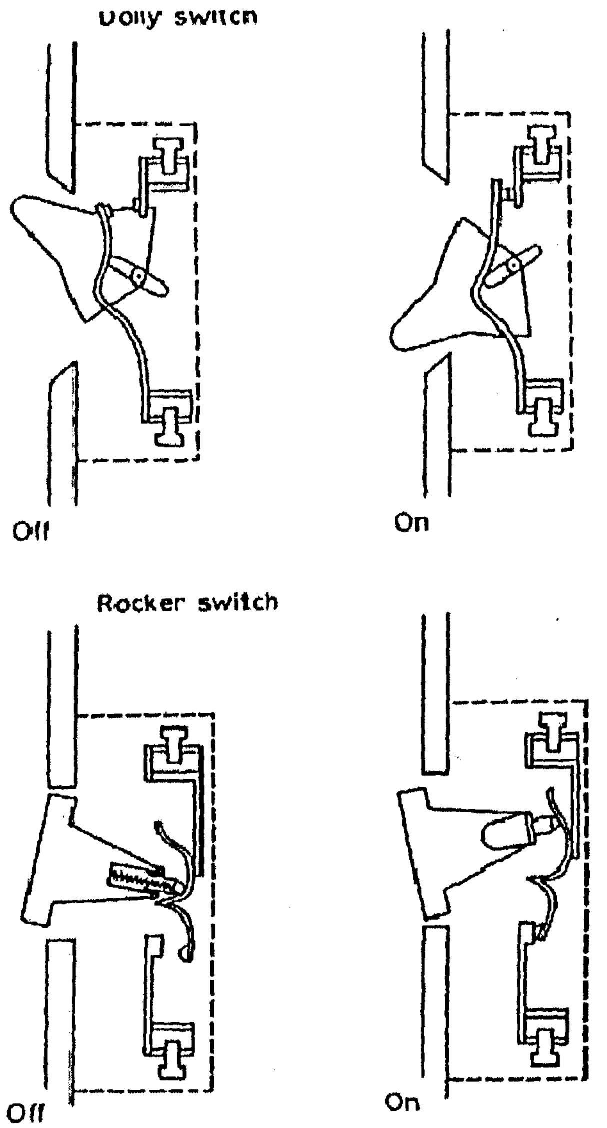

Figure: 2.5 Switch Mechanisms

A socket outlet is a female socket connected to the power wiring in the building and will accept the male plug attached at the end of the flexible cord of an appliance such as a vacuum cleaner, electric fire or electronic equipment [3].

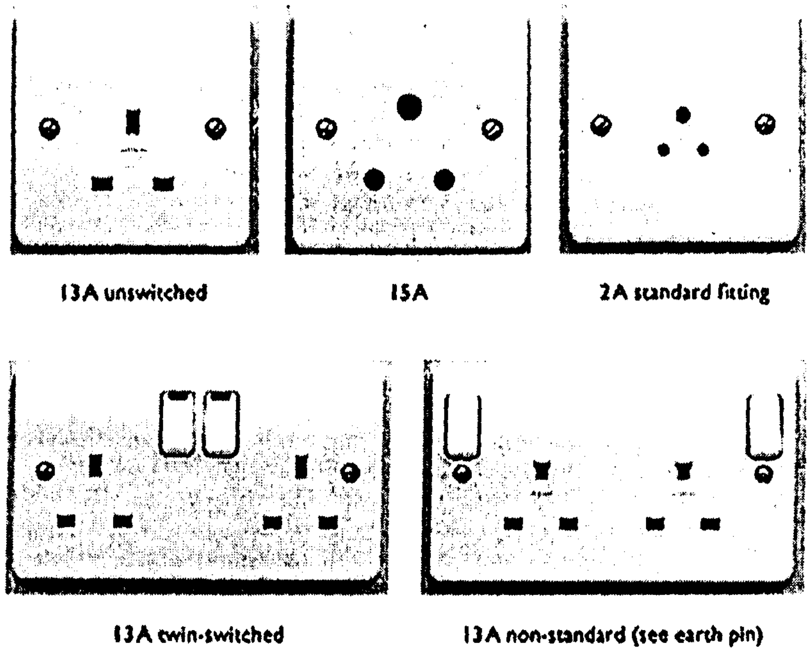

Figure: 2.6 Socket outlets

CHAPTER THREE

3.0 DESIGN PROCEDURE

LIGHTING

In the design of the main hall the following are assumed.

(i) Minimum lighting levels for Store and Toilet = 60lux.

(ii) Minimum lighting levels for Hall and stage = 150lux.

(iii) The utilization factor and maintenance factor is as shown in the table below:

Table 3.1: Dimensions of the properties of the building.

	LENGTH (m)	WITDTH (m)	AREA (m^2)	U.F	M.F
Toilet	3	2	6	0.80	0.70
Store	3	4	12	0.80	0.70
Stage	18.384	3	55.152	0.85	0.8
Hall	27.48	24.384	670.07	0.85	0.8

3.1 DESIGN SPECIFICATIONS

1. Supply phases = 3 phases

2. Voltage = 400/230V

3. Type of wiring = PVC/PVC conduit.

3.2 CALCULATION OF ILLUMINATION AND LAMPS PER FLOOR SPACE.

HALL

Given:

1. Area $A = (27.48 \times 24.384) = 670.1m^2$
2. Lamp fitting: 1.2m, 40watts fluorescent lamp.
3. Lamp efficiency; $\gamma = 36$ lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilisation factor, U.F = 0.85
6. Illumination level, E = 150 lux

Applying the formula.

$$E = \frac{\emptyset_t \times U.F \times M.F}{A}, \text{ lux (lumen/ } m^2) \text{ -------------------3.1}$$

Where E, - Illumination in the hall.

$\emptyset_t$,- Total luminous flux given to the hall.

From eqn. 3.1 we can find $\emptyset_t$

$$\emptyset_t = \frac{E \times A}{U.F \times M.F} \text{ ------------------------------------ 3.2}$$

$$= \frac{150 \times 670.1}{0.85 \times 0.8} = 147816.18 \text{ lumens.}$$

P_t = Total power of lamps in watts.

$\emptyset_t$ = 36 lumen/watt.

$$P_t = \emptyset_t / \gamma = \frac{147816.18\ lumens}{36 lumens/watt}$$

= 4106.005 watts

$n = P_t / P_L$ ------------------------------------ 3.3

Where, n = number of lamps

P_t = Total power of lamps in watts.

P_L = Individual lamp power output, in watts.

$$n = \frac{Pt}{PL} = \frac{4106.005}{40} = 102.65 \approx 103 \text{ lamps}$$

103 lamps of 40 watts each shall be chosen.

<u>**STAGE**</u>

Given:

1. Area , A = (3 × 18.384) = $55.15m^2$
2. Lamp fitting; = 1.2m, 40 watts fluorescent lamp.
3. Lamp efficiency; γ = 36 lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilisation factor, U.F = 0.85
6. Illumination level; E = 150 lux

Using the formula in eqn 3.1

$$E = \frac{\emptyset_t \times U.F \times M.F}{A}, \text{ lux (lumen/ } m^2)$$

$$\emptyset_t = \frac{E \times A}{U.F \times M.F}$$

$$= \frac{150 \times 55.15}{0.85 \times 0.8} = 12165.4 \text{ lumens.}$$

γ = 36lumens/watt

$$P_t = \emptyset_t / \gamma = \frac{12165.4}{36} \text{ watts}$$

= 337.93 watts

$n = P_t / P_L$, where P_L = 40watts.

= 337.93 / 40 = 8.44 ≈ 8 lamps

8 lamps of 40 watts each shall be chosen.

STORE

Given:

1. Area A = (3 × 4) = 12m^2.
2. Lamp fitting = 60watts incandescent lamp.
3. Lamp efficiency, γ = 13 lumens/watt.
4. Maintenance factor, M.F = 0.7

5. Utilisation factor, U.F = 0.8
6. Level of illumination, E = 60 lux.

Using the formula.

$$E = \frac{\emptyset_t \times U.F \times M.F}{A}, \text{ lux (lumen/ } m^2 \text{)}$$

$$\emptyset_t = \frac{E \times A}{U.F \times M.F}$$

$$= \frac{60 \times 12}{0.8 \times 0.7} = 1285.71 \text{ lumens.}$$

γ = 13 lumens/watt

$$P_t = \emptyset_t / \gamma = \frac{1285.71}{13} \text{ watts}$$

= 98.90watts.

$n = P_t / P_L$, where P_L = 60watts.

= 98.90 / 60 = 1.6 ≈ 2 lamps

2 lamps of 60watts each shall be chosen.

TOILET

Given:

1. Area A = (2 ×3) = 6m^2.

2. Lamp fitting = 60watts incandescent lamp.
3. Lamp efficiency, $\gamma = 13$ lumens/watt.
4. Maintenance factor, M.F= 0.7
5. Utilisation factor, U.F = 0.8
6. Illumination level, E = 60lux.

Applying the formula

$$E = \frac{\emptyset_t \times U.F \times M.F}{A}, \text{ lux (lumen/ } m^2)$$

$$\emptyset_t = \frac{E \times A}{U.F \times M.F}$$

$$= \frac{60 \times 6}{0.8 \times 0.7} = 642.86 \text{ lumens.}$$

$\gamma = 13$ lumens/watt.

$P_t = \emptyset_t / \gamma = \frac{642.86}{13}$ watts

$= 49.45$ watts

$n = P_t / P_L$, where $P_L = 60$watts.

$= 49.45/ 60 = 0.82 \approx 1$lamp

1 lamp of 60 watts shall be chosen.

3.3 SECURITY LIGHTING AROUND THE BUILDING PERIMETER.

Given:

1. Total distance round the building (perimeter) = 109.73m
2. Hanging height of the lamp = 2.5m from floor level.
3. Distance from lamp for Emin = 2.5 lux is 3m.

Using point to point lumen computation, the formula below can be employed

$$E = \frac{I \cos \theta}{d^2}, \text{ lux}$$

$$I = \frac{E d^2}{Cos\ \theta}$$

Where $I = {}^{\emptyset}/_{4\pi}$ Candela.

$$d = \sqrt{2.5^2 + 3^2} = 3.9\text{m}$$

$$Cos\theta = \frac{2.5}{3.9} = 0.641$$

$$I = \frac{Ed^2}{Cos\theta} = \frac{2.5 \times 3.9^2}{0.641} = 59.32 \text{ Candela.}$$

To find $\emptyset = I \times 4\pi = 59.32 \times 4 \times 3.142 = 745.53$ lm.

Efficiency, γ of incandescent lamp = 13lm/w

Lamp to be used = $745.53/_{13}$ = 57.3 watts

Incandescent lamp of 60watts shall be chosen and hung 8m apart round the building. Number of lamps round the building = $\frac{109.73}{8}$ = 13.72 ≈ 14lamps of 60watts each.

3.4 CALCULATING THE SIZE OF CABLES

3.4.1 Final sub-circuit cables:

The cables from final sub-circuits power outlets (13A and 15A) are usually standard cables and are given in Table 4A and 5A, I.E.E wiring regulation of 15th Edition.

Lighting and fan circuits

Each of the lighting circuit is assumed to carry 10 numbers of 100watts lamps

= 1000watts as maximum power.

Taking phase voltage = 230V

Power/phase = 10 × 100 = 1000watts

Current/phase = $\frac{1000}{230}$ = 4.35A.

Fuse rating = 5A

From Table 9D2 of IEE 15th edition

1.5 mm^2 PVC twin core cable can carry 14A.

Voltage drop /A/ m= 42mV

Total length of cable = 22m

Ambient temperature = 40° C

Temperature correction factor = 0.94

Load per phase / circuit, $I = \frac{1000}{230} = 4.35A$

Voltage per phase V= 230V.

Applying the correction factor = $I = \frac{4.35}{0.94} = 4.63A$ of 0.94 in Appendix 9.

Fuse rating = 5A

Voltage drop = $I \times L \times$ mV/A/m.

$= 4.63 \times 22 \times 42mV/A/m$

$\Delta V = 4.28V$

Permitted voltage drop = 2.5% of 230V = 5.75V.

4.28 < 5.75V

Hence 1.5 mm^2 size cable is chosen for each lighting and fan circuit.

3.4.2 13A, SWITCH SOCKET OUTLET POWER CIRCUITS

Assumed 1, 13A switch socket outlet = 500watts load.

1, 13A switch socket outlet circuit has 6 numbers of 13A S.S.O

Total load = $500 \times 6 = 3000 watts.$

Voltage / phase / circuit = 230V

Current / phase/ circuit = $\frac{3000}{230} = 13.04A$

Length of cable/ circuit = 20m

Ambient temperature = 40^{o} C

Temperature correction factor = 0.94

Applying correction factor, I = 13.04/0.94 = 13.87A

Fuse rating 20A.

Let's choose $2.5mm^2$ cable with 17mV/A/ M in Tab. 9D2 and current carrying capacity of 24A.

Then voltage drop = $I \times L \times$ mV/A/m

= $13.87 \times 20 \times 17m$V/A/M

ΔV = 4.72V

Permitted voltage drop = 2.5% $\times 230V = 5.75V$

ΔV = 4.72 < 5.75V.

Hence, $2.5mm^2$ cable is chosen for the 13A SSO circuit each.

3.4.3 15A, SOCKET OUTLET POWER CIRCUITS

Assumed 1, 15A switch socket outlet = 2.5KW (3.571KVA) load.

1, 15A, circuit has a total load = 3571VA with power factor of 0.7.

Voltage / phase / circuit = 230V

Current / phase / circuit = $\frac{3571}{230}$ 15.53A

Length of cable = 25m.

Ambient temperature = 40^{o} C

Temperature correction factor = 0.94

pplying this correction factor to the value of current, I = $\frac{15.53}{0.94}$ = 16.52A

ting 16.52 $\times 1.5 = 24.78 = 30A$

D2, 15th Edition of I.E.E regulation I choose a cable of $4mm^2$ with voltage drop of 11mV/A/M with current carrying capacity of 32A

Voltage drop on cable = I $\times L \times mV/A/m$

= 16.52 $\times 25 \times$ 11mV/A/M

ΔV = 4.543V

Permitted voltage drop = 2.5% × 230 = 5.75V

ΔV = 4.543 < 5.75V

Hence, $4mm^2$ cable is chosen for each 15A socket outlet circuit.

For the 15A, socket outlet, it is assumed that an air conditioner of P_{max} = 2.5hp is connected. It has an efficiency of 74.5% a power factor of 0.7.

$$\text{Total input power} = \frac{2.5 \times 745}{0.7 \times 0.745}$$

= 3571.4VA

= 2500W

3.4.4 TABLE 3.2 LOAD SCHEDULE FOR DISTRIBUTION BOARD

Code number	Cable size mm^2	Fuse rating	Description of fitting	Number of fitting	Watt per point	Power factor	R	Y	B
A1	4	30	15A socket outlet	1	2500	0.7	3571		
A2	4	30	15A socket outlet	1	2500	0.7		3571	
A3	4	30	15A socket outlet	1	2500	0.7			3571

A4	4	30	15A socket outlet	1	2500	0.7	3571		
A5	4	30	15A socket outlet	1	2500	0.7		3571	
A6	4	30	15A socket outlet	1	2500	0.7			3571
B1	2.5	20	13A socket	4	500	0.8	2500		
B2	2.5	20	13A socket	4	500	0.8		2500	
B3	2.5	20	13A socket	4	500	0.8			2500
B4	2.5	20	13A socket	4	500	0.8	2500		
L1	1.5	5	2 × 40W fluorescent fitting	10	40	0.7		1143	
L2	1.5	5	2 × 40W fluorescent fitting	10	40	0.7			1143
L3	1.5	5	2 × 40W fluorescent fitting	10	40	0.7	1143		
L4	1.5	5	2 × 40W fluorescent	10	40	0.7		1143	

			fitting						
L5	1.5	5	2 × 40W fluorescent fitting	10	40	0.7			1143
L6	1.5	5	2 × 40W fluorescent fitting	4	40	0.7	457		
L7	1.5	5	1 × 100W ceiling fan	5	100	0.8		625	
L8	1.5	5	1× 100W ceiling fan	5	100	0.8			625
L9	1.5	5	1 × 100W ceiling fan	5	100	0.8	625		
L10	1.5	5	1× 100W ceiling fan	5	100	0.8		625	
L11	1.5	5	1 × 100W ceiling fan	5	100	0.8			625
L12	1.5	5	60W incandescent lamp	10	60	1	600		

L13	1.5	5	60W incandescent lamp	7	60	1		420	
L14	1.5	5	1 × 100W ceiling fan	3	100	0.8			375
							14,967	13,598	13,553
Total phase load = (42118) Overall diversity factor = 0.5 Maximum demand = 21059VA									

3.5 SELECTION OF SUB-MAIN CABLE FEEDING THE DISTRIBUTION BOARD

Assumed length of cable 30m

Ambient temperature = 40°c

Temperature correction factor = 0.94

Maximum Demand Load (3 phase) P_T = 21059VA

Nominal Voltage = 400V

Current per phase = $I = \frac{PT}{\sqrt{3}V} = \frac{21059}{1.732 \times 400} = 30.40A$

Applying correction factor = I = $^{30.40}/_{0.94}$ = 32.34A

Fuse rating of 60A is recommended

Cable $1 \times 4 \times 25mm^2$ with 95A and 1.6 mV/A/ m

Voltage drop = $95 \times 30 \times (1.6 \times 10^{-3})$

$\Delta V = 4.56$

Permitted voltage drop = $2.5\% \times 230V$

= 5.75V

$\Delta V = 4.56 < 5.75V$

Hence $1 \times 4 \times 25mm^2$ cable will be chosen according to Appendix 9, tab. 9D2 15th Edition of I.E.E. regulations

3.6 RESISTANCE OF THE EARTH ELECTRODE

The highest Distribution Board Circuit Breaker = 30A

Expected Excess current = 1.5× 30 = 45A

Phase Voltage = 230A

Earth Electrode Resistance = R = $\frac{V}{1.5 \times 30} = \frac{230}{45} = 5\Omega$

CHAPTER FOUR

4.0 COSTING AND ANALYSIS OF THE DESIGN.

TABLE4.1: Cost table for power and lighting.

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	1.5mm^2 cable	50	22	1,100
2	2.5mm^2 cable	80	20	1,600
3	4mm^2 cable	200	25	5,000
4	25mm^2 cable	600	30	18,000
5	60A 8-ways TPN DB	8,000	1	8,000
6	13A socket outlets	150	16	2,400
7	15A socket outlets	200	6	1,200
8	60A E.L.C.B	2,500	3	7,500
9	1-gang switch point	100	14	1,400
10	Ceiling fan	3,500	28	98,000
11	Incandescent lamp holder	30	17	510

12	Fluorescent lamp holder	300	111	33,300
Total cost				178,010

TABLE4. 2: Cost table for lamps.

DESCRIPTION	RATING(WATTS)	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
Incandescent lamp	60	50	17	850
Fluorescent lamp	40	150	111	16,650
TOTAL COST				17,500

The total cost from table 4.1 and 4.2 above is ₦ 195,510

4.1 NUMBERING OF FINAL SUB-CIRCUIT

It is very important in any electrical installation design. This is because it creates room for easy identification of circuit during installation and during maintenance work. For this design circuits are numbered according to the type of load supply. "A" is for 15A socket outlets, "B" is for 13A socket outlets and "L" is for lighting and fan

4.2 ANALYSIS OF LIGHTING POINTS

From the lighting point layout,

L1 to L2 represent twin 40W fluorescent lamp

Power factor = 0.7

L1 = $80\times 10 = 800W$

$= {}^{800}/_{0.7}$ = 1143VA

L2 = $80 \times 10 = 800W$

$= {}^{800}/_{0.7}$ = 1143VA

L3 = 1143VA

L4 = 1143VA

L5 = 1143VA

L6 = $80\times 4 = 320W$

$= {}^{320}/_{0.7}$ = 457VA

L7 to L11 and L14 represent ceiling fan which has wattages of 100W

Power factor = 0.8

$L7 = 5 \times 100 = 500\text{W}$

$= {}^{500}/_{0.8}$ = 625VA

$L8 = 5 \times 100 = 500\text{W}$

$= {}^{500}/_{0.8}$ = 625VA

$L9 = 5 \times 100 = 500W$

$= {}^{500}/_{0.8} = 625VA$

$L10 = 5 \times 100 = 500W$

$= {}^{500}/_{0.8} = 625VA$

$L11 = 5 \times 100 = 500W$

$= {}^{500}/_{0.8} = 625VA$

$L14 = 3 \times 100 = 300W$

$= {}^{300}/_{0.8} = 457VA$

L12 and L13 represent 60W incandescent lamp

Power factor = 1

$L12 = 60 \times 10 = {}^{600}/_{1} = 600\ VA$

$L13 = 60 \times 7 = {}^{420}/_{1} = 420VA$

4.3 LOAD SUMMARY

From the load schedule table:

RED PHASE = 14967W

CURRENT DEMAND = ${}^{14967}/_{230} = 65.07A$

YELLOW PHASE = 13598W

CURRENT DEMAND = $^{13598}/_{230}$ = 59.12A

BLUE PHASE = 13553W

CURRENT DEMAND= $^{13553}/_{230}$ = 58.93A

4.4 POWER CIRCUIT

13A power socket outlets

Assuming the socket might be subjected for used for up to 500W capacity.

P = IV

Design current I= $^{P}/_{V} = ^{500}/_{230} = 2.174$A

Maximum number of socket per circuit= $^{13A}/_{2.174A} = 5.98 \approx 6$ socket outlets.

15A power socket outlets

Assuming the socket might be subjected for used for up to 2500W capacity

P = IV

Design current I= $^{P}/_{V} = ^{2500}/_{230} = 10.87$A

Maximum number of socket per circuit= $^{15A}/_{10.87A} = 1.34 \approx 1$ socket outlet.

CHAPTER FIVE

5.1 CONCLUSION

The design of electrical power network to a main hall involves a high degree of technology, research and experience. The electrical design of the building in view, it is discovered that the building required 1.5mm^2 cable size for the lighting and fan. Final sub-circuit 2.5mm^2 cable size for 13A socket outlet, 4mm^2 cable size for 15A socket outlet unit final sub-circuit.

5.2 RECOMMENDATION

To obtain the best performance from electrical services design in the building in terms of lighting there should be enough textures of lighting to provide the required illuminance for an easy task performance.

Lamp illuminance and room surface should be maintained periodically to reduce dirt on the lamp fittings and the room surfaces. In order also to obtain a very good electrical services performance in terms of safety, proper size of sub-main cable should be used in the distribution board of building to avoid short circuit in the cable. The user should also take precautionary measure such as putting off appliances when not in use or when there is power failure and avoid over loading of sockets, they should also report any abnormalities immediately they are noticed to the person concerned.

REFERENCES

[1] Oria Usifo, "Electrical Networks Design and Installation in building" 2nd Edition, Fredorus Ltd., Benin City, 1998. Pp 41-125

[2] Oria Usifo "Research project implementation made easy in electrical electronics engineering" Vol one, 1st Edition. Pp 250-264

[3] Barrie Rigby, "Design of Electrical Services for Buildings", 4th Edition, Spon Press London and New York. Pp.1-20

[4] I.E.E, "Regulations for the Electrical Equipment of Buildings", 15th Editions I.E.E Savoy Place, London, 1981.

[5] The New Encyclopedia Britannica, Macromedia Ready Reference, volume 4, 15th Edition, 1998.

[6] T. G. Francis, "Electrical Installation Work" 5th Edition, Longman Group Ltd, England, 1971.pp.55-100

[7] J. B. GUPTA "Electrical Installation Estimating and Costing" 1st edition, S.K. KATARIA and Sons.1968.pp34-36.

[8] B. R. GUPTA "Principles of Electrical Engineering". S. CHAND and Company LTD.2001.pp 840-870.

[9] J.O. PADDOCK and R. A. W. GALVIN "Electrical Installation Technology and Practices" Holder and Stoughton London. Pp 3-4.