International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

Electrical Load Analysis of Some Selected Buildings in Ramat Polytechnic, Maiduguri, Borno State: A Case for Mitigating Fire Outbreaks

Y.A.Mshelia [1], John Adam[1]
Department of Electrical and Electronics Engineering
Ramat Polytechnic, Maiduguri Borno State Nigeria

Date of Submission: 25-03-2024 Date of Acceptance: 05-04-2024

ABSTRACT: Most architectural drawings are not usually accompanied with their detailed electrical plan. The main aim of the research is to design the building electrical services of an office complex. In achieving this, lighting point circuit, power point circuit (sockets and air conditioning units) were designed. In the attempt to achieve the above stated objectives previous related works were reviewed such as journals, electrical design textbooks of several editions and various electrical regulatory bodies standard were consulted and adhered to in the design. In designing the distribution board, calculation of the load of each circuit were carried out which ensured proper allocation of load on the distribution board, as well as the assigning of proper cable sizes to the various units that make up the building. Addressable fire alarm system was used for the proper design of the fire alarm system due to the numerous advantages it has over other types of fire alarm and detection systems. The designed load of the entire building was 125.962KW which is the summation of the Red phase load (41.003KW), Yellow phase (41.593KW) and Blue phase load (42.466KW). Hence a 250A 10-way Medium voltage switchgear panel (MV panel) were used in the final circuits of the office complex. The results showed that fire occurrence can only be stopped using fire rated doors and windows, compartmentalizing buildingspaces and treating them with materials resistant to fire. The paper concluded that through design and constructionmanagement the impact of fire disaster could be minimized.

KEYWORDS: Electrical fire, buildings

I. INTRODUCTION

Every electrical installation is residential, commercial or an industrial building and is preceded by a careful plan or design. Designs for building installations involves various calculations based on several factors which includes; type of building, purpose of building, physical building parameters. (Olatomiwa, et al. 2012). There are several Standards and regulatory bodies such as the IEEE (Institute of Electrical and Electronics Engineers), BSS (British Standard Specification), NEC (National Electrical Code), NERC (Nigerian Electricity Regulatory Commission), SON (Standard Organization of Nigeria) and NESIS (Nigerian Electricity Supply and Installation Standards) and many more that regulate the electrical service design.

Electrical design is the process that involves planning, creating, testing, and installation of electrical equipment in accordance with the approved regulations. The design includes lighting layout, power layout, power distribution layout, fire prevention layout systems, public address system and close circuit TV layout, and voice and data communications layout design. Though electricity is for comfort and also exists in a form that is convenient to harness, however, it will also be important that electrical design is as economical as possible whereby design of the power distribution system should be convenient so as to minimize power losses.

This Research focuses on the electrical design of an office complex which will cover the lightning point, power point layout, Air conditioning circuit, fire alarm circuit and design of the sizing of transformer. The Research will also present a better approach to electrical design of an office complex based on the provision of the Institute of Electrical

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

and Electronics Engineers (IEEE) Regulation, which consists lighting, power, distribution board, cable sizing. AUTOCAD shall be used in the design of the various layouts. Safety, flexibility of installation, durability and cost of installation will be considered in the electrical process design of the office complex.

1.1 AIM AND OBJECTIVES

The project is aimed at electrical load analysis and specifications for some office complex. In order to achieve the main aim, the project would strive to achieve the following specific objectives;

i. To show lighting point circuit design, air conditioning and distribution board development.

ii. To calculate the load analyses of the power and the load balancing.

iii. Fire alarm and detection specification (protection circuit)

iv. To determine fire safety measures for security of people and property against fire

1.2 AUTOCAD APPLICATION

AutoCAD is a commercial computer aided design and drafting software application used for a large number of different design processes. Its usage centers on drawing with electronic equivalent of real life drafting tools. AutoCAD has numerous applications in a wide range such as interior designs, aeronautical designs, architectural designs, engineering designs etc. AutoCAD electrical is an Autodesk specially made for electrical design layout, schematic diagram, line diagram, instrumentation and control system. It main purpose is to create and modify electrical design system. Advantages are preprogrammed tasks and comprehensive symbol libraries; promote design automation, better productivity, reduced error and more accurate information for the project design.

1.3 SOURCES OF FIRE IN HOUSING

Sources of fire could be many and even innumerable. According to Issah and Aliyu (2012),"fire could originate from both external and or internal sources. External sources include therisk of bush burnings, and lightning strikes. Internal risks of fire are ever present with our widespread reliance on the use of electrical appliances such as desk lamps, heaters, computers,power boards and other equipment within the collection building". In general, the sources aresurmised under error of omission and commission that is human inherent tendency to evade hisresponsibility and the attempt at hiding his heinous activities through fragrant ignition of fires.For further enlightenment and understanding, some other potential ignition sources of fires areoutlined as follow:

- Smokers' materials such as cigarettes, matches and lighters.
- Naked flames such as gas open flame equipment.
- Electrical, gas, oil- fired heaters (could be fixed or portable)
- Cooking and lighting equipment
- Deliberate fire raising
- Faulty or unused electrical equipment
- Sparks and frictional heat such as from over heating
- Interaction of reactive chemicals

Table 1 Shows a brief review of some selected havocs of fires Disasters in Nigeria(Issah and Aliyu (2012)),

Table 1 Some selected fire havocs in Nigeria

S/N	Type Of Fire	Estimated Number Of Lives Lost	Value Of Property	State/Town	Year Occurrence
1	NECOM House fire outbreak	Un defined	Multi million naira	Lagos	1983
2	Pipe line fire explosion	1082	Un defined	Delta	1998
3	Multiple bomb explosion at Military cantonment	800	Un defined	Lagos	2002
4	Pipe line fire explosion	700	Un defined	Lagos	2006
5	Frequent fire accidents	69	765 million naira	Abuja	2012
6	Various fire accidents	230	Un defined	Rivers	2012
7	Numerous fire accidents	31	227 million naira	Osun	2012
8	Numerous fire accidents	60	790 million naira	Gombe	2012
9	Innumerable bombing	Thousands of lives	Un defined		Since 2009 till date

II. METHODOLGY

The implementation of the work will be based on the modular approach. In this approach the design shall focus on groups of electrical design layout of an office that perform specific tasks which would be integrated to give full detail design of an office complex. The entire project is sectioned into nine blocks as shown in the block diagram of figure 1

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

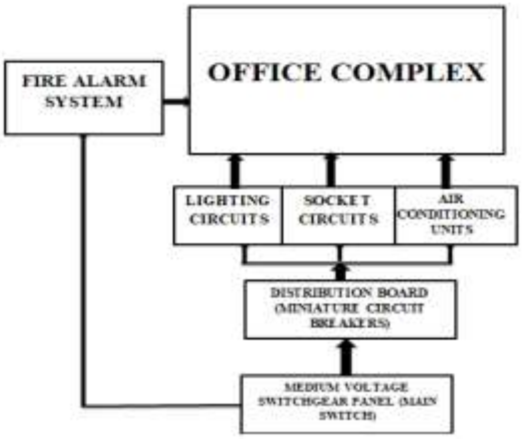

Fig 1. Block diagram of the entire research plan

2.1 REVIEW OF SIMILAR WORKS

In this chapter, attempt is made to review some past related projects from journals, online thesis and books. The focus shall be on looking at the methods used in implementing them so as to highlight their pros and limitation.Futhermore, explanation is given to general installation knowledge, some of the tools, formulas, electrical symbols used in this project to give an overview of the components on how they are used, operated, or applied as the case may be. The above statement is outlined below.

Olatomiwa et al (2012) presents the design and development of Calculator software for residential electrical services design. The software was developed using Java programming language and it serves as a valuable design tool for electrical engineers, students and technicians by providing a faster, easier and more accurate means of carrying out some basic calculations such as; determination of number of lighting fixtures required in a room, the design current and power required per final sub-circuit, the total connected load, voltage drop across chosen cables and load balancing across the three phases of a three-phase supplied building. The results of these calculations help the designer to make vital decisions such as types of luminaries, sizes of cables and nominal ratings of protective devices required by each circuit and by the entire installation in line with appropriate standards and regulations. It consists of four major modules controlled by main interface namely; lighting, final sub-circuit, voltage drop/cable sizing and load balancing module. The merit of the project compared to other design software for electrical service inclusion of a load balance module. It is flexible and easy to use and the module functions independently to give result. Its demerit is that it does not include the design of lightening arrestors. The software can only be used for design of residential building.

Erick (2010) University of Nairobi, building electrical services design for hostel along Nyere road , Nairobi Kenya. The project specify the size and number of backup generator to be employed, the final circuit consisting lighting design using lumen method, power point design by considering the needs of the final user. The final circuits were supplied by fifteen, (15) consumer units. These consumer units are then all distributed on one, (1) distribution board, ensuring that all the single phase loads are balanced almost equally on each phase with 341.389 amperes on red phase, 333.472 amperes on the yellow phase and 335.972 amperes on the blue phase. This guaranteed that cables and distribution equipment are utilized much more effectively due to small differences in current on each phase. The advantage of the project was commercial back up deisel generator was incoporated in the design. One of the challenge faced was the sizing of the generator cable which has a line current of 626,4amps which from IEEE table no cable size exists for such a line current.hence the use of two cable conductor connected in parallel and sized to accomodate 313.021Amps each to tackle the issue. It shows that the generator for the design is not efficient which lead to over load on the generator causing frequent break down of the generator.

Nabeel et al (2013) Analysis and evaluation of electrical wiring safety of requirement in Jordanian residential building is a paper that provides an analysis of a field study of the status of electrical installation in residential homes and the apartment in the north of jordan. A questionnaire was designed to find out all possible shortcomings of electrical installation in those residential unit. The main outcome of the study indicate that most houses lack necessary safety measures due to poor implementation and

unprofessional electrical design and wiring and the

absence of necessary monitoring. The advantage was that the study shed light in the status of electrical design and safety that should be implemented in Jordan. It shows the importance of following electrical design standard to ensure protection of human lives and their property. The research was only limited to Jordanian residential buildings.

Najeem et al (2020) International Journal of Engineering Technology Research & Management published the design of an electrical installation of a storey building which analyses the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

electrical service design of a Storey building using the lumen method for the lighting calculations. The purpose of this work is to present a suitable approach to electrical services design based on the provision of the Institution of Electrical Engineers (lEE) Regulations, which includes lighting, power, and distribution board's schematics. The appropriate ratings of protective devices are put in place and there is adequate provision for future expansion. Limitation was that fire alarm system was excluded in design of the electrical installation.

Slanet et al (2018) faculty of engineering University of Muhammadiyah Yogyakarta in which they presented a journal on Electrical design and installation of a new building Aisyiyah University Yogyakarta, Indonesian. It consists of 10 floors in which lighting loads, power load (sockets) and power loads electric motors (air conditioners, elevators and others) were design based on standard specification of electrical design. The total load of the building calculated was 594.2kVA and the power supplied from the state electricity company was 800KVA and the backup generator capacity of 1000KVA. One of the merit of the design was improvement of the power factor. Limitation was high lighting strike effect and exclusion of fire alarm system.

Seely (1982), corroborates above stance on measures to mitigate fire spread. According to him "the spread of fire over a surface could be restricted by the provisions for such materials tohave low rates of surface spread of flame, and in some cases restrict the rate of heat produced". Substantiating above views,
Punmia and Jain (2008), said that "No building material isperfectly fire proof. Every building contains some materials such as furniture, clothing, eatableswhich can easily catch fires or which are vulnerable to fire. However, the endeavor of theArchitects and engineers should be to plan, design and construct the building in such a way that

III. MATEIALS AND METHODS

3.1 Lighting Point Design

Lighting points refers to light (number of fitting) and fans on a particular circuit for the design Fan are assigned 100W, lighting point 18 W, or 6 W in each case of rest room and corridors and diversity factor which means the probability of loads of a particular circuit being all ON or OFF or what percentage of the load is likely to be ON is 0.9 (Meaning that there is 90% chance that all the lighting point in that circuit is ON). The circuit AL1 means lighting point on circuit 1 of distribution board A. The peak load and load of lighting point of each circuit for both the ground floor and first floor are calculated using equation 1 and 2

$$Peakload = (6w*numberoflightingpoint) + (18w*numberoflighingpoint) + (100w*numberoffans) \quad 1$$

$$Load = peakload*diversityfactorforlightingpoint\ (0.9) \quad 2$$

For circuit AL1 (Ground floor) for Electrical Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

For circuit AL1 (Ground floor) for Computer Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

Table 2 Ground floor (Electrical Department) distribution board A lighting point

Are of building	Circuit label	No of fitting 6W	18W	Fan (100W)	Peak load	Diversity	Load
HOD Office	AL1	6.0	0.0	1.0	136	0.9	126
Secretary office	AL2	1.0	0.0	1.0	106	0.9	96
Exam office	AL3	1.0	0	1.0	106	0.9	96
Record Office	AL4	1.0	1.0	1.0	106	0.9	96
6 Staff offices	AL5	6.0	0	6.0	636	0.9	576
Hall walk way	AL6	0.0	7.0	0.0	700	0.9	630
Library Hall	AL7	3.0	6.0	7.0	826	0.9	756

For circuit BL1 (Ground floor) for Computer Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

ii) Load = (862 x 0.9) = 775 W

For circuit BL1 (Ground floor) for Computer Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

Table 3 Ground floor (Computer Department) distribution board B lighting point

Are of building	Circuit label	No of fitting		Fan	Peak load	Diversity	Load
		6W	18W	(100W)			
HODs Office	AL1	6.0	0.0	1.0	136	0.9	126
Secretary office	AL2	1.0	0.0	1.0	106	0.9	96
Exam office	AL3	1.0	0	1.0	106	0.9	96
Record Office	AL4	1.0	1.0	1.0	106	0.9	96
Six Staff offices	AL5	6.0	0	6.0	636	0.9	576
Hall walk way	AL6	0.0	7.0	0.0	700	0.9	630
Library Hall	AL7	3.0	6.0	7.0	826	0.9	756

For circuit CL1 (First floor) for Agricultural Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

For circuit CL1 (First floor) for Agricultural Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

Table 4 First floor (Agricultural Department) distribution board C lighting point

Are of building	Circuit label	No of fitting		Fan	Peak load	Diversity	Load
		6W	18W	(100W)			
HOD Office	AL1	6.0	0.0	1.0	136	0.9	126
Secretary office	AL2	1.0	0.0	1.0	106	0.9	96
Exam office	AL3	1.0	0	1.0	106	0.9	96
Record Office	AL4	1.0	1.0	1.0	106	0.9	96
Six Staff offices	AL5	6.0	0	6.0	636	0.9	576
Hall walk way	AL6	0.0	7.0	0.0	700	0.9	630
Library Hall	AL7	3.0	6.0	7.0	826	0.9	756

For circuit DL1 (First floor) for Mechanical Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

For circuit DL1 (First floor) for Mechanical Engineering Department
Numbers of 6W lighting point = 6
Numbers of 18 W lighting points = 7
Numbers of Fans = 7
Therefore
i) Peak load = (6W x 6) + (18w x 7) + (100Wx 7) = 862 W
ii) Load = (862 x 0.9) = 775 W

Table 5 First floor (Mechanical Department) distribution board D lighting point

Are of building	Circuit label	No of fitting		Fan	Peak load	Diversity	Load
		6W	18W	(100W)			
HOD Office	AL1	6.0	0.0	1.0	136	0.9	126
Secretary office	AL2	1.0	0.0	1.0	106	0.9	96
Exam office	AL3	1.0	0	1.0	106	0.9	96
Record Office	AL4	1.0	1.0	1.0	106	0.9	96
Six Staff offices	AL5	6.0	0	6.0	636	0.9	576
Hall walk way	AL6	0.0	7.0	0.0	700	0.9	630
Library Hall	AL7	3.0	6.0	7.0	826	0.9	756

Generally standard for lighting points switch are place 1.5m to 2m from the ground level, wall

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

bracket are 2.4 m from ground. Different types of switch are used based on the area of the building.

3.2 Power Point Design

The power point refers to the socket and air condition point. In the design socket are assigned 250 W for double pole, 100W for single pole and air-condition system are assigned 2000W per unit. The diversity factor for power point (socket) is 0.6 (60%) and diversity factor for air condition circuit is 1.0 that means each air condition circuit carries only that unit on tithe circuit Ap1 means power point 1 circuit on distribution board A (DB-A) and A/AC1 means air condition circuit on DB-A and so on. The peak load and load of the power point (socket unit) are calculated using equation 3 and 4

Peak load = (Power for double pole x Number of double pole) 3

Load = Peak load x diversity factor for socket point (0.6) .4

Circuit AP1 (Ground floor) Electrical Department

Number of double pole = 6

Assigned power = 250W

i) Peak load = (250x6) = 15000W

ii) Load = 1500 x 0.6 = 900 W

Circuit AP2 (Ground floor) Electrical Department

Number of double pole = 6

Assigned power = 250W

i) Peak load = (250x6) = 15000W

ii) Load = 1500 x 0.6 = 900 W

Table 6 Ground floor (Electrical Engineering) distribution Board A power point circuit

Circuit Label	No of Socket (13 amps)		Peak load	Diversity factor	Load
	SP(100W)	DP(250W)			
AP1	-	6.0	1500.0	0.6	900.0
AP2	-	6.0	1500.0	0.6	900.0
AP3	-	6.0	1500.0	0.6	900.0
AP4	-	6.0	1500.0	0.6	900.0
AP5	-	5.0	1250.0	0.6	750.0
AP6	-	4.0	1000.0	0.6	600.0

Circuit BP1 (Ground floor) Computer Department

Number of double pole = 6

Assigned power = 250W

i) Peak load = (250x5) = 1250W

ii) Load = 1250 x 0.6 = 750 W

Circuit BP2 (Ground floor) Computer Department

Number of double pole = 5

Assigned power = 250W

I) Peak load = (250x5) = 1250W

II) Load = 1250 x 0.6 = 750 W

Table 7 Ground floor (Computer Engineering) distribution Board B power point circuit

Circuit Label	No of Socket (13 amps)		Peak load	Diversity factor	Load
	SP(100W)	DP(250W)			
AP1	-	5.0	1250.0	0.6	750.0
AP2	-	6.0	1500.0	0.6	900.0
AP3	-	6.0	1500.0	0.6	900.0
AP4	-	6.0	1500.0	0.6	900.0
AP5	-	4.0	1000.0	0.6	600.0
AP6	-	6.0	1500.0	0.6	900.0

Circuit CP1 (First floor) Agricultural Department

Number of double pole = 6

Assigned power = 250W

i) Peak load = (250x5) = 1250W

ii) Load = 1250 x 0.6 = 750 W

Circuit CP2 (First floor) Agricultural Department

Number of double pole = 5

Assigned power = 250W

i) Peak load = (250x5) = 1250W

ii) Load = 1250 x 0.6 = 750 W

Table 8 Ground floor (Agricultural Engineering) distribution Board C power point circuit

Circuit Label	No of Socket (13 amps)		Peak load	Diversity factor	Load
	SP(100W)	DP(250W)			
AP1	-	5.0	1250.0	0.6	750.0
AP2	-	6.0	1500.0	0.6	900.0
AP3	-	6.0	1500.0	0.6	900.0
AP4	-	6.0	1500.0	0.6	900.0
AP5	-	4.0	1000.0	0.6	600.0
AP6	-	6.0	1500.0	0.6	900.0

Circuit DP2 (First floor) Mechanical Department

Number of double pole = 6

Assigned power = 250W

i) Peak load = (250x6) = 15000W

ii) Load = 1500 x 0.6 = 900 W

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

Table 9 Ground floor (Mechanical Engineering) distribution Board D power point circuit

Circuit Label	No of Socket (13 amps)		Peak load	Diversity factor	Load
	SP(100W)	DP(250W)			
AP1	-	6.0	1500.0	0.6	900.0
AP2	-	6.0	1500.0	0.6	900.0
AP3	-	6.0	1500.0	0.6	900.0
AP4	-	6.0	1500.0	0.6	900.0
AP5	-	5.0	1250.0	0.6	750.0
AP6	-	4.0	1000.0	0.6	600.0

For Air condition (A.C) circuit where each circuit carries only one unit connected directly from the distribution board. The table3.3 showed the calculation of peak load and load of each A.C unit.

Table 10 Distribution board A and C power point circuit (A.C Unit)

Floor	Circuit Label	NO. of A.C(200W)	Peak load (W)	D.F	Load (W)
Ground floor	A/AC1	1.0	2000.0	1.0	2000.0
Ground floor	A/AC2	1.0	2000.0	1.0	2000.0
Ground floor	A/AC3	1.0	2000.0	1.0	2000.0
Ground floor	A/AC4	1.0	2000.0	1.0	2000.0
Ground floor	A/AC5	1.0	2000.0	1.0	2000.0
First floor	C/AC1	1.0	2000.0	1.0	2000.0
First floor	C/AC2	1.0	2000.0	1.0	2000.0
First floor	C/AC3	1.0	2000.0	1.0	2000.0
First floor	C/AC4	1.0	2000.0	1.0	2000.0

Generally, socket outlets are to be installed 1.3m above the floor level using 13 amps and 15 amps' socket in some cases while A.C units are to be installed 2m above the floor level using 20amps socket outlet. Table for distribution board B, D and E are attached in the Appendix 2

3.3 DISTRIBUTION BOARD DESIGN

3.3.1 Miniature Circuit Breaker

Miniature circuit breaker (MCB) rating calculation is important for the selection of MCB overcurrent on a particular MCB. The formula below was used to calculate the MCB rating for both lighting point and power point circuit.

$$\text{MCB Rating} = \frac{L}{V} \quad 5$$

Where
L = load of the circuit
V = Voltage of single phase (240V)
Therefore
AL1 circuit
Load = 686 W
Voltage = 240 V

$$\text{MCB Rating} = \frac{686}{240} = 2.85A$$

MCB Rating = 3 A
AP1 circuit
Load = 900W
Voltage = 240 V

$$\text{MCB Rating} = \frac{900}{240} = 3.75A$$

MCB Rating = 4 A

Table 11 Lighting Point MCB Rating for DB- A

Circuit Label	Load (W)	Voltage	MCB Rating(Amps)
AL1	866.0	240.0	3
AL2	1069.0	240.0	5
AL3	551.0	240.0	3
AL4	715.0	240.0	3
AL5	1084.0	240.0	3

Table 12 Power Point Circuit MCB Rating for DB-A

Circuit Label	Load (W)	Voltage	MCB Rating(Amps)
AP1	6.0	240.0	4
AP2	6.0	240.0	4
AP3	6.0	240.0	4
AP4	5.0	240.0	3
AP5	4.0	240.0	3

From the table 11 and 12. it shows that the MCB rating for lighting point circuit are below 5 amps and power points (socket unit) are below the range of 10 amps. Therefore, MCB rating of 10 amps, 30 amps and 20 amps was used for lighting points circuit, socket units and A.C units respectively. for future explanation and proper protection of the circuits during the installation process, other MCB rating table are attached in Appendix 2

3.3.2 Selection of distribution Board

The number of circuit determined the type of distribution board that will be selected. Three phase DBS comes in different configuration which are D4 by 3 phase (accommodate 12 circuits), D6 by 3 phase (accommodate 36 circuits), D8 by 3 phase (accommodate 24 circuits) D12 by 3 phase (accommodate 36 circuits) e,t c for the purpose of

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

the design which has minimum of 18 circuit per DSB. D8 by 3 phase (24 circuit) distribution board was used whereby leaving spare circuits just in case of future expansion or occurrence of fault in any circuits.

3.3.3 Allocation of circuit and load balancing on the distribution board

The D8 by 3 phase (red phase, yellow phase and blue phase) are allocated circuit whereby the load of each circuit across the red, yellow and blue phase are evenly distributed without much disparity. This is to ensure that some phases are not overloaded which can cause frequent breakdown and fault on that phase. The total load of each DB (A, B, C, D, and E) and the total current are calculated using equation 6 and 7

Total load of DB (P) -= RPL + YPL +BPL 6

Where

RPL = Red phase load

YPL = Yellow phase load

BPL = Blues phase load

Total current of DB = $\frac{P}{\sqrt{3} \times V \cos \vartheta}$

7

Where

P = Total load of each DB

V = Voltage of phase (415V)

$\cos \vartheta$= Power factor of 0.8

Therefore, the load and current are

Total load of DBA(P) = (7.195 + 7.318_+ 7,800) W = 22,313 W

Total current of DB = $\frac{22.313}{\sqrt{3} \times 415 \times 0.8} = 38.80A$

The maximum demand is 22,313 W and current is 13.80 A. Distribution board total load and current of B, D, and We are attached in the Appendix 3. The total load and current of the building is given by equation 8 and9

$TotalloadofDBS(P)$ = $(DBA + DBB + DBC + DBD + DBE) - - - - - - - equation8$

$TotalCurrentofDBS(P)$ = $(DBA + DBB + DBC + DBD + DBE) - - - - - equation9$

Therefore

$TotalloadofDBS(P)$ = (26,441 + 22,836 + 22,313 + 30,372 + 24,000)W = 125,962W

$TotalCurrentofDBS(P)$ = (45.98 + 39.71 + 38.80 + 52.81 + 41.73)A = 219.03A

3.4 CABLE SIZING

Cable sizing are determining by the maximum current of each circuit using standard cable sizing chart as attached to appendix 1. The appropriate cable selected in a single copper which are bunched and enclosed in conduit or trucking pipe at temperature of 15 ^{O}C the cable sizing selected as follow

i) Lighting circuit = 1.5 mm cable

ii) Power circuit = 2.5 mm cable

iii) Air conditioner = 4.0 mm cable

The size of the conductor that brings power to each DB is determine by the total current (3 phase) of that DB-A which has a total current of 44.42 A in accordance to the cable chart for 3 phase conductor,44 A fall under 10 mm cable but 16 mm (four core cable) was selected for future expansion

Table 13 Cable sizing used to supply the distribution board

Floor	Distribution Board	Cable size in mm (four core)
Ground floor	A	16
Ground floor	B	16
First floor	C	16
First floor	D	16

3..5 SIZING OF TRANSFORMER

Transformer are rated in KVA; hence the total load of the entire building was found from the simple addition of the loads of the DBs in watts. The total load of the building is 125.962W which is the same as 125,962 Kilo watts, it is converted to KVA using equation 10

Transformer rating = total load in KW/Power factor (0.8) 10

Transformer rating = 125,962/0.8 = 157,453 KVA

Applying 25% future load growth for the possibility of another floor within the office complex

157,453KVA x 0.25 = 39.363KVA

Adding the 25% to the total KVA = (157,453 + 39,363) KVA = 196,816 KVA Rounding up to the nearest hundreds we have 2000KVA

Therefore, the required transformer for the building is 200KVA transformer

IV. RESULT AND DISCUSSION

4.1 ANALYSIS OF DESIGN

In analyzing the design of the lighting point and power point which consists of socket and the A,C units which are design in different circuits. The table 14 shows the summary of load obtained during the design lighting point and power points.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 21-31 www.ijaem.net ISSN: 2395-5252

Table 14 Summary of load obtained for lighting point and power point

Distribution Board	Lighting Point Load (W)	Socket Units Load (W)	Air conditioner Unit load (W)
A	5491.0	4,950.0	16,000.0
B	3,886.0	4,950.0	14,000.0
C	3,663.0	4,650.0	14,000.0
D	4,872.0	5,400.0	20,000.0
Total load (W)	17,912	19,950	64,000

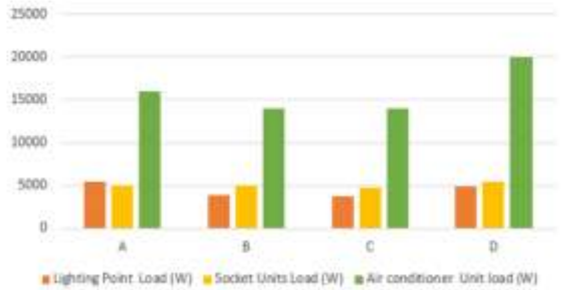

Figure 2**Bar chart of load obtained from lighting points and power points.**

From the table 14 the percentage of loads of each unit of the building is calculated using equation 11.

$$percentage = \frac{\text{given load in watss}}{\text{total load in watts}} \times 100\% \quad 11$$

Therefore

i) $\text{lighting points percentage} = \frac{18,012}{125,962} \times 100\%$

ii) $\text{socket units percentage} = \frac{19,950}{125,962} \times 100\%$

iii) $\text{A.C units percentage } \frac{88,000}{125,962} \times 100\%$

From the calculation, the table 4.1 shows that A.C unit's carries the highest percentage of load (70%) which is due that A.C unit has high power consumption and diversity factor of 1.0 and for such all AC units are design on single circuit (directly from the DB) socket unit loads takes a percentage of 16 % due to its power consumption which is higher than lighting point despise its diversity factor of 0.6 compared to the lighting point with diversity factor of 0.9, sockets carry much load such as laptop, photocopy machine, refrigerator etc. so it is expected that such appliances have high power consumption. Therefore, the socket unit was designed to accommodate such load to reduce the chance of fault in the power units. Lighting points has the lowest percentage of 14% in spite of diversity factor of 0.9. The result of load obtained is due to power consumption of lighting point which is low compared to other units despite the high number of lamp fitting and has fans in the design

Table 15: Total load of each distribution board per phase

Floor	Distribution board	Red phase (W)	Yellow phase (W)	Blue phase (W)	Total load (W)
Ground Floor	A	8,301	8,985	8,255	25,541
Ground Floor	B	8,020	7,443	7373	22,836
First Floor	C	7,195	7,318	7800	22,313
First Floor	D	9,487	9,847	11,038	30,372
Total		33,003	33655	34,466	80982

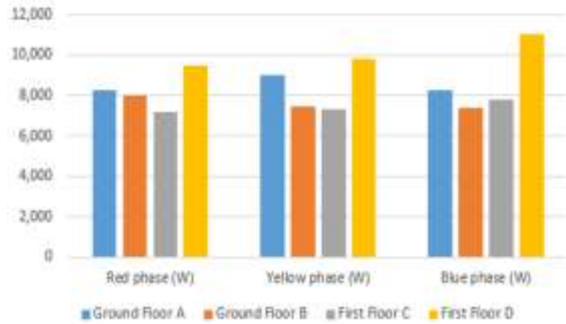

Figure 3 : Bart chart of loads on each phase

From the table 15 the distribution board with the highest load is distribution board D because it accommodates 22 circuits which are 6 lighting points, 6 socket units and 12 A.C units' circuit compared to the other distribution board of maximum circuit of 19 circuits. Also from the table it shown that the blue phase has a load of 34,466W hence the result obtained was influenced by high number of A.C unit circuit that were assigned to the blue phase when balancing the load on the distribution. The table also gives an insight when there is a future expansion of load. The loads will be assigned to other phases to avoid much load on the blue phase.

The summary in table 16 shows the cable sizing for lighting point, power point, distribution board, MV panel and fire alarm detection after analysis the various load of the design which determined the size of the transformer which is a step down 200KVA transformer

Table 16 Cable sizing of the building

S/N	AREA OF DESIGN/EQUIPMENT	CABLE SIZE(mm)
1	Lighting points	1.5
2	Socket unit design	2.5
3	Air conditioning unit design	4
4	Distribution board (A, B, C, and D)	16 (four core cable)
5	MV Panel	150 (four core cable)
6	Fire alarm design	FPLR Shielded
7	Transformer	armored cable (PVC/SWA)

From table 16 the cable size for lighting point 1.5 mm, socket units 2.5mm and A.C unit 4mm were used due to the power consumption of each design and were based on the cable size chart standard by NEC in electrical design service.

Distribution board A, B, C, and D, cable selected was 16mm four core (that is red, yellow, blue and earth) Cable which is due to calculated load of each distribution board.

MV panel cable size of 120mm (4 four core) was selected based on the total current of the building (219A) whereby on the chart 219A falls under 120mm cable but 150mm was chosen for the purpose of additional current'

Fire alarm design cable size selected was 1.5 mm power limited, fire Alarm riser cable shielded (FPLR) which is in standard recognized by National Electric Code (NEC) but include an aluminum polyester foil shield and drain wire to protect against inference which gives a single advantage over other types of fire alarm cable.

Transformer cable size selected was PVC/SWA (PVC Insulated steel wire armored) cable size of 150mm (4 core) suitable for underground installation where mechanical protection of the cable is required

V. CONCLUSION

In this research, the designs are all in line with the main objectives, hence the laid down objectives at the start of the research was successfully met during the entire process which was based on the provision of the Institute of Electrical and Electronics Engineers (IEEE) Regulation.

An attempt was made to come up with an appropriate lighting scheme, power point circuit, and distribution board development for an office complex. Thus it can be concluded that the first objectives of this work has been achieved.

This study equally set out to execute proper calculations that will ensure proper load balancing on the distribution board for the office complex which was stated in the second objective. The result obtained at the end of the work confirmed that the study was able to accomplish its task.

Finally, a 200KVA transformer was successfully design for the office building complexrating.

5.1 RECOMMENDATION

Based on the design and specification of the office complex the following recommendation can further be made

1) A study on the bill of quantities can be prepared to give an estimate of the financial cost of electrical services design of the office complex, the bill of quantities will help in contract administration procedure as part of Engineering practice in the real practical world
2) Additional work can be done on the design of surveillance system, and telephone for security and emergency purposes
3) Research can be done on the calculation of voltage drop and the earth fault possibility which can be used to improve the protection of any building in general

REFERENCES

[1]. ERICK, O. O. (2010). Building Electrical Services Design For Hostel. University Of Nairobi , Department Of Electrical And Information. Nairobi : Researchgate.

[2]. NABEEL TAWALBEH AND REYAD EL-KHAZALI. (2013). Analysis and Evaluation of Electrical Wiring Safety. IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies , DOI: 10.1109/AEECT.2013.6716464.

[3]. NAJEEM O. ADELAKUN BANJI A.OLANIPEKUN SAMUEL O. ASOGBA. (2020). Design Of An Electrical Installation Of A Storey, International Journal of Engineering Technology Research & Management , Vol (04) Issue (01).

[4]. OLATOMIWA, LANRE. J AND ALABI, AKINYEMI C. (2012). Design and Development of Calculator Software for Residential Electrical Services Design. International Journal of Engineering and Technology Volume 2 No. 3, , ISSN: 2049-3444 © 2012.

[5]. SALMET.S. AGUS.J. KUNNU.P. WAHYU N.W AND YESSI J. (2018) Electrical System Design nd Installation of a New Building, Aissiyal University of Yogyakarta. Journal of Electrical Technology UMY, Vol (4).
[6]. MOHAMMED M. K. (2009) Project Report in Electrical Services Design for Three Bedroom Flat, B. Sc Thesis, Faculty of Engineering, Federal University of Technology, Minna Niger state, Nigeria.
[7]. OKOYE, C. U. & ADELAKUN, N. O. (2019), Design and Evaluation of Electrical Services for an Energy Efficient Home, Paper presented at 4th National Conference ASIF, O. HOSSAIN, M. RAHMAN, M, AND CHOWDHURY, M (2014) Fire Detectors Review and Design of an Automated, Quick Responsive Fire Alarm System Based on SMS. International Journal of Communications Network and System Science.
[8]. ZHANG, L. AND WANG, G. (2009) Design and Implementation of an Automatic Fire Alarm System, Based on Wireless Sensor Network.
[9]. WANG RUOHUI (2007) the VBA Based Secondary Development of AUTOCAD Computer Application.
[10]. DEBORAH, A.M. AND PATRICIA, L.F. (20012) User Productivity as a Function of AUTOCAD Interface.
[11]. HACKER (2011) Merrian-Webster: Electricity in Merriam-Webster.com Retrieved May 8, 2018, https://www.merriam webster.com/dictionary/electricity
[12]. ESNA (2000) IESNA Lighting Handbook, Ninth Edition, the Illuminating Engineering Society of North America
[13]. JOHN HAUCK (2009) Jones and Bartlett Publishers, LLC. Electrical Design of commercial and Industrial buildings
[14]. PADDOCK, J. O AND GALVIN, R. A. W. (1982). Electrical Installation Technology and Practice 13th Impression, London
[15]. LAWRENCE M (1993) Book of Wiring and Lighting, Consumer Association LoadIntroduction to Electrical Design lecture slide (EEE411) by Dr. Haruna, Y.S University of Technology, Bauchi