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A Paper on the Challenges of Electrical Installation Design for a Residential Building

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ABSTRACT

Load data was obtained from an existing building in the area for consideration. These data were keys in determining the distribution arrangement of the various loads in the distribution board. The capacities of the distribution boards used for the various blocks were calculated from the design. Cable sizing was also done in order to ensure an efficient connection of the different electrical accessories such as 13A and 15A sockets, lamp holders and even switches. The connecting cable to the distribution board for all blocks represented was calculated in the design. The information obtained from the design will ensure an efficient electrical installation for the building.

INTRODUCTION

An electric power distribution system is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV with the use of transformers **[1]**.

For small commercial buildings or residential customers, power companies lower the voltage with a transformer on a power pole or mounted on the ground. From there, the electricity is fed through a meter and into the building **[2].**

Small commercial or residential buildings have a very simple power distribution system. The utility will own the transformer, which will sit on a pad outside the building or will be attached to a utility pole. The transformer reduces the voltage from 33kV or 11kV down to 415V and then passes the electricity to a meter, which is owned by the utility and keeps a record of power consumption **[3].**

A protective earth (PE), known as an equipment grounding conductor in the US National Electrical Code, avoids this hazard by keeping the exposed conductive surfaces of a device at earth potential**[4].** To avoid possible voltage drop no current is allowed to flow in this conductor under normal circumstances. In the event of a fault, currents will flow that should trip or blow the fuse or circuit breaker protecting the circuit. A high impedance line-to-ground fault insufficient to trip the over current protection may still trip a residual-current device (ground fault circuit interrupter or GFCI in North America) if one is present **[5].** Regulations for earthing system vary considerably among countries and among different parts of electric systems. Most low voltage systems connect one supply conductor to the earth (ground).

One of the major challenges discovered during the course of this work include faulty connections to the distribution board. A pictorial view is seen in fig 1 and fig 2.

Fig 1: Faulty load distribution on the distribution board

Fig 2: By-passed distribution board

Aim

The aim of this paper is to study the challenges of electrical installation design of residential buildings.

Objectives

The objectives of this work will include the following;

- To identify the electrical installation problems of existing buildings as it relates to the various electrical loads available(lighting loads and power points)
- To design a good distribution of loads for residential buildings

Scope

This work will include the lighting and power point calculation design for a localized, residential area. Nevertheless, this analysis can also be done in larger areas or cities.

METHODOLOGY

The project will commence by first, capturing the various electrical installation design problem that exist currently in the localized area for consideration as it relates to the load distribution. The power point and lighting calculations are then made for the affected buildings. In carry out the power point design, an estimated calculation for the 13amp socket load as well as the 15amp air conditioner load is done. The lighting load calculation will include the lighting units and fan load is done. These calculations will aid in determining the size of the distribution board as well as cables to be used. At the end of the designs, every sub circuit is carefully arranged in the distribution board with their appropriate fuses or MCB (Miniature Circuit Breaker).

Conductor Size Calculations

The size of a cable to be used for an installation depends upon;

i. The current rating of the cable under defined installation conditions and the maximum permitted drop in voltage as defined by Regulation 525.**[7]**

The factors which influence the current rating are:

1. Design current: cable must carry the full load current.
2. Type of cable: PVC, copper conductors or aluminum conductors.
3. Installed conditions*:* clipped to a surface or installed with other cables in a truncking.
4. Surrounding temperature: cable resistance increases as temperature increases and insulation may melt if the temperature is too high.
5. Type of protection: for how long will the cable have to carry a fault current?

MCB and Fuse rating for Load Distribution

The protective fuse rating or miniature circuit breaker rating for each sub circuit is obtained thus;**[7]**

i. The total load in wattage for the sub circuit is obtained and the value is divided by the required number of sub circuit.
ii. The value obtained from the division is further divided by the recommended distribution voltage (240V).
iii. The recommended fuse rating is gotten from the final value obtained from i and ii respectively.

Regulation 525 states that the drop in voltage from the supply terminals to the fixed current-using equipment must not exceed 2.5% for lighting circuits and 5% for other uses of the mains voltage. That is a maximum of 6V for lighting and 11.5 V for other uses on a 230V installation. The volt drop for a particular cable may be found from:

Voltage drop = Factor x Design Current x Length of run 1

The localized building to be considered is a storey building with twelve rooms each on the ground and first floor. Table 1.0 shows facility (load) requirement for a localized building.

Table 1.0: Facility Requirement for the Localized Building

Ground Floor						
	RM 1	RM2	RM3	RM4	RM5	RM6
Lighting Points(W)(60W &40W)	140	140	140	140	140	140
Fans(W)	240	240	240	240	240	240
13Amps socket (4nos. each)(W)	2000	1800	1700	1950	1680	1600
15Amps Socket (1nos each)(W)	1200	1200	1200	1200	1200	1200

Table 1: Continued

Ground Floor						
	RM 7	RM8	RM9	RM10	RM11	RM12
Lighting Points(W)(60W &40W)	140	140	140	140	140	140
Fans(W)	240	240	240	240	240	240
13Amps socket (4nos. each)(W)	1850	1820	1660	1550	1700	1600
15Amps Socket (1nos each)(W)	1200	1200	1200	1200	1200	1200

For the fan load, a total of two ceiling fans were seen in each room. Each of the fans has a load of 120W. The 13A socket load includes majorly a 400W electric plate, 1200W pressing iron. Laptops, phone chargers, television, sound systems, standing fans and other electrical accessories constitute the remaining part of the load. The 15A socket had no air conditioning system connected. Nevertheless a provision was made in the connection and planning.

Table 2: Facility Requirement for the same Building (First Floor)

First Floor						
	RM 1	RM2	RM3	RM4	RM5	RM6
Lighting Points(W)(60W &40W)	140	140	140	140	140	140
Fans(W)	240	240	240	240	240	240
13Amps socket (4nos. each)(W)	1780	1680	1900	1500	1210	1770
15Amps Socket (1nos each)(W)	1200	1200	1200	1200	1200	1200

Table 2: Continued

First Floor						
	RM 7	RM8	RM9	RM10	RM11	RM12
Lighting Points(W)(60W &40W)	140	140	140	140	140	140
Fans(W)	240	240	240	240	240	240
13Amps socket (4nos. each)(W)	1800	1860	1700	1450	1330	1220
15Amps Socket (1nos each)(W)	1200	1200	1200	1200	1200	1200

DESIGN CALCULATIONS

A. Ground floor calculation

i. Lighting Load

For RM1 to RM6, the total lighting load is (140 x 6) =840W.

The current requirement is calculated thus;

840W/240V =3.5A

Hence, **one sub-circuit** will suffice with a fuse rating of **5A**.

For RM7 to RM12, the total lighting load is (140 x 6) =840W.

The current requirement is calculated thus;

840W/240V =3.5A

Hence, **one sub-circuit** will suffice with a fuse rating of **5A** also.

ii. Ceiling Fan Load

For RM1 to RM6, the total fan load is (240 x 6) =1440W.

The current requirement is calculated thus;

1440W/240V =6A

Hence, **one circuit** will suffice with a fuse rating of **10A**.

For RM7 to RM12, the total fan load is (240 x 6) =1440W.

The current requirement is calculated thus;

1440W/240V =6A

Hence, **one sub-circuit** will suffice with a fuse rating of **10A** also.

iii. 13A Socket Load

According to the BS 7671:2008 on-site guide, a **30A** fuse will be used to protect the 13A sockets for two rooms. This is because the floor area of two adjoining rooms is less than **100m²**.Hence, **six sub-circuits** will suffice. Each of the sub-circuits will be ring connected.

iv. 15A Socket

According to the BS 7671:2008 on-site guide, a **20A** fuse will be used to protect the 15A sockets. Each 15A socket has a dedicated 20A fuse linked with a radial circuit. Hence, **twelve sub-circuits** will suffice.

The ground floor has a total of twenty-two sub circuits hence an eight way, three poles plus a neutral distribution board should be used.

v. Current rating of the distribution board

This is calculated thus;

The overall load on the ground floor =Sum of the Lighting Load+ Fan Load+13A Load+15A Load

=(1680+2880+20910+14400)W

=39870W

$$\text{Current} = \frac{Power}{Voltage * \cos\phi * \sqrt{3}}$$

2

Three phase voltage =415V, Power Factor =0.85

$$\text{Current} = \frac{39870}{415 * 0.85 * \sqrt{3}} = 65.3\text{A}$$

Hence, an **80A** switch gear and distribution board should be used.

B. First floor calculation

i. Lighting Load.

For RM1 to RM6, the total lighting load is (140 x 6) =840W.

The current requirement is calculated thus;

840W/240V =3.5A

Hence, **one sub-circuit** will suffice with a fuse rating of **5A**.

For RM7 to RM12, the total lighting load is (140 x 6) =840W.

The current requirement is calculated thus;

840W/240V =3.5A

Hence, **one sub-circuit** will suffice with a fuse rating of **5A** also.

ii. Ceiling Fan Load

For RM1 to RM6, the total fan load is (240 x 6) =1440W.

The current requirement is calculated thus;

1440W/240V =6A

Hence, **one circuit** will suffice with a fuse rating of **10A**.

For RM7 to RM12, the total fan load is (240 x 6) =1440W.

The current requirement is calculated thus;

1440W/240V =6A

Hence, **one sub-circuit** will suffice with a fuse rating of **10A** also.

iii. 13A Socket Load.

According to the BS 7671:2008 on-site guide, a **30A** fuse will be used to protect the 13A sockets for two rooms. This is because the floor area of two adjoining rooms is less than **100m²**.Hence, **six sub-circuits** will suffice. Each of the sub-circuits will be ring connected.

iv. 15A Socket

According to the BS 7671:2008 on-site guide, a **20A** fuse will be used to protect the 15A sockets. Each 15A socket has a dedicated 20A fuse linked with a radial circuit. Hence, **twelve sub-circuits** will suffice.

The first floor has a total of twenty-two sub circuits hence an eight way, three poles plus a neutral distribution board should be used.

v. Current rating of the distribution board

This is calculated thus;

The overall load on the first floor =Sum of the Lighting Load+ Fan Load+13A Load+15A Load

= (1680+2880+19200+14400)W

=39870W

Recall equation 2

Three phase voltage =415V, Power Factor =0.85

$$\text{Current} = \frac{38160}{415 * 0.85 * \sqrt{3}} = 62.5\text{A}$$

Hence, an **80A** switch gear and distribution board should also be used.

CONCLUSION

Load data was obtained from the localized residential building. These data were keys in determining the distribution arrangement of the various loads in the distribution board. The capacities of the distribution boards used for the various blocks were calculated from the design. Cable sizing was also done in order to ensure an efficient connection of the different electrical accessories such as 13A and 15A sockets, lamp holders and even switches. The connecting cable to the distribution board for all blocks represented was calculated in the design. The information obtained from the design will ensure an efficient utilization of power if implemented.

RECOMMENDATIONS

One notable flaw in the electrical installation of the blocks sited in this work is the lack of a distribution board. In most cases where they are present, they are not properly connected. Hence, appropriate distribution board should be installed. Also, the utilization proper cable sizes are keys to a good installation. Hence the right sizes of cables should be used for the different types of loads to be connected.

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