Electrical Power Supply to a Campus Health Çenter: FUTA - A Case Study.

By

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(EE/95/7503)

A Thesis Submitted to The School of Post Graduate Studies in Partial Fulfillment of The Requirements for The Award of Master of Engineering Degree in Electrical and Electronics Engineering (Power Option)

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November, 2007.

CERTIFICATION

This is to certify that this research work was carried out by Mr. J. O. Petinrin of the department of Electrical and Electronics Engineering and is accepted in partial fulfillment of the requirements for the award of Master of Engineering (M.Eng.) degree in Electrical/Electronics Engineering (Power option).

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DEDICATION

This work is dedicated to my caring father, late Chief Matthew Oluwafemi Petinrin.

ACKNOWLEGEMENT

My special thanks and gratefulness go to my supervisor, Dr, V.S.A. Adeloye, I sincerely appreciate his concerted efforts towards the successful completion of this research. His discussions and criticisms during the time of consultations really made the work interesting. May the Lord God lift you up. Amen.

I heartily express my gratitude to all lecturers and entire staff in the Department of Electrical and Electronics Engineering who at various capacities contributed towards the success of my studies.

My special thanks go to Prof. B. J. Olufeagba, Dr. J. O. Oni, Dr. M. T. Babalola, Dr. E. O Ogolo, Engr. S. A. Oyetunji, Mr. T. O. Ale, the Director of Academic Planning in person of Mrs A. O. Adebayo, and FUTA Heath Centre staff for their valuable assistance. May the Almighty God replenish their efforts in Jesus name.

I am sincerely grateful to my dear Wife Mrs. E. K. Peti nrin for her prayer, love, support, commitment and encouragement; my children – Yemi, Tomi and Wole Petinrin. I thank you all. May the Lord preserve you from all evil works and make you to be the head and not the tail. Amen.

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ABSTRACT

Frequent power failure, burning of protective devices and equipment at the FUTA Health Center can be attributed to the ad-hoc electrical installation at the Health Center.

It is characterized by poor planning, inappropriate ratings and in some cases unanticipated loading of the circuits.

In this thesis, the power needs at the Health Center are identified and transformed into the electric power requirements. Then an appropriate designed supply network using adequate protective devices, suitable cable ratings to replace the existing ones as well as an alternative supply (generator) in case of power failure is proposed for the Health Center

A clear guideline for the design of electrical services for Health Centers in tertiary institutions was highlighted and procedure for upgrading the electrical installation was produced. The results offered in this thesis will be useful when putting up FUTA Health Center physical structure in the 'Master plan' location of the University.

CHAPTER ONE

INTRODUCTION

1.1 Preamble

Regular uninterrupted electric power is essential for the smooth functioning of a modern society. This is because modern society require stable energy supply to drive motors, run industries / manufacturing plants, commercial centers and for domestic usage like buildings and street light in order to maintain the modern quality of life. The development and application of electric power have improved the quality of life in the history of the world. Its uses have facilitated great technological advancement in many professional areas. It enables engineers to promote integrated mechanization and automation of production processes among others.

One of the area that has received considerable boost as a result of the availability and use of electrical energy is health. Many sophisticated processes are now possible but require electrical energy. The University Health Center is one place where the 'best' ought to be available. Also the often hurried nature of the start of tertiary institution in Nigeria has often led to the conversion of some other facility to the Health Center. The conversion often times addresses the physical aspects while neglecting the electrical services. This results in electrical services that may and is often unsuitable for the purpose of the Center.

It is not unusual to feed lighting circuits being for heating and other high demand equipment. It is in the light of this that this project was undertaken. The experience at FUTA Health Center had been one of frequent failure in some part of the Center due to burnt protective devices, cabling, fuse and breaker trips.

The site of this project is Federal University of Technology, Akure (FUTA). It is situated along Akure Ilesa road, Akure with a land area of about 576.128 hectares closely bounded by thick forests. The present campus site was inherited from The Federal Polytechnic, Akure (now in Ado-Ekiti) in the year 1982. The Institution occupies two major land areas referred to as Obanla and Obakekere.

The Health Center, in the case study is located at Obakekere. It is sandwiched between The Postgraduate School by the West, Chemistry Laboratory by the East, Students' hostel in the North and FUTA main road at the South.

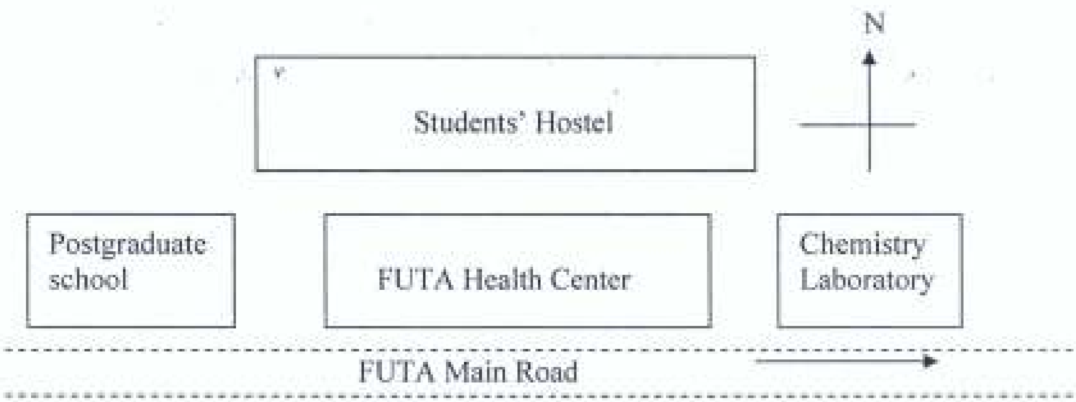


Fig.1.1 FUTA Health Center Location.

Since 1982, the electricity supply network development to FUTA has been piece- meal rather than from a consolidated plan. This has had an indirect effect on the Health Center. There is no means of determining the precise load consumed at a particular period. The Institution merely receives an estimated consumption value from The Power Holdings Company of Nigeria Plc (PHCN), which is subject to error and often referred to as the 'crazy bill'. The Health Center is temporarily made of converted lecture rooms and offices, therefore there is yet to be a permanent (building) plan and electrical design with the actual energy demand by the Health Center.

The study of the existing power supply system in FUTA shows that power obtained from this source, viz. PHCN and the generating sets owned by the Institution. The 11kV supply from PHCN is fed to the High-Tension (H.T) panel through the input bus - bar. The H.T. panel is interconnected via the output bus - bar ring main unit (RMU) which in turn feeds the various sections of the institution through a number of 11kV/415V transformers with accessories as shown in the schematic in fig.1.2.

There are two feeder pillars, one for Obanla and the other for Obakekere. The one for Obakekere as shown in fig 1.3 supplies electricity to staff quarters, the staff schools, the library, auditorium, the sport complex, Obakekere hostels, Senate building and FUTA Health Center. Obanla feeder supplies electricity to Obanla staff Quarters, Schools, Laboratories and Workshops. In the event of power failure from PHCN, four generating sets with ratings 1MVA, 700kVA 630kVA and 250kVA are available for use. The 1MVA and 250 kVA generators are connected in parallel redundancy to supply RMU_1 through a 1.25MVA transformer while the 700kVA and 630kVA generators are connected in parallel redundancy to supply RMU_2 through 1MVA transformer.

The generators are in parallel redundancy, in the event of loss of the smaller generator, the larger capacity generator will be put to use during and after peak loads, in which case that generator will not be economically operated. However, in the event of loss of larger capacity generator, the smaller one will be incapable of meeting the peak load demand hence some section will experience load shedding.

For economic operation, the entire generator fleet has to be synchronized. Then the generators will share load based on their capacity and will experience less load mismatch since one, two or more generators can be used simultaneously.

The Health Center is fed from two sub-stations. Viz: 500kVA substation at Works Department which supply electricity to Works department, Hostel, Staff secondary school, Wema Bank, Postgraduate school, part of Library and part of Health Center; and 300kVA substation at Obakekere staff quarters, which supply Staff quarters, Great hall, Staff primary school, Physics block, Chemistry block, part of Library, part of Health center and Industry design studios.

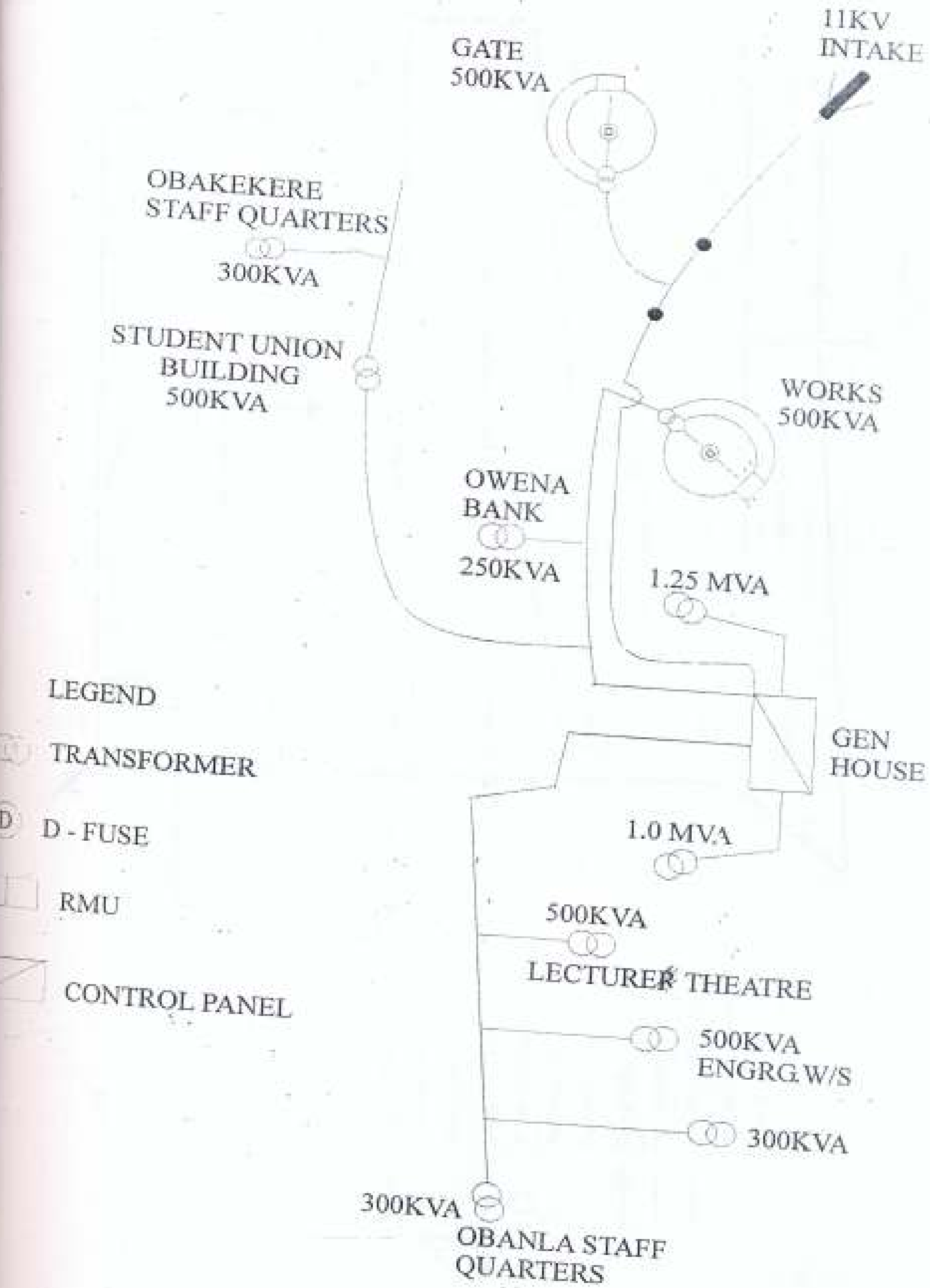


Fig. 1.2 Power Distribution Within FUTA

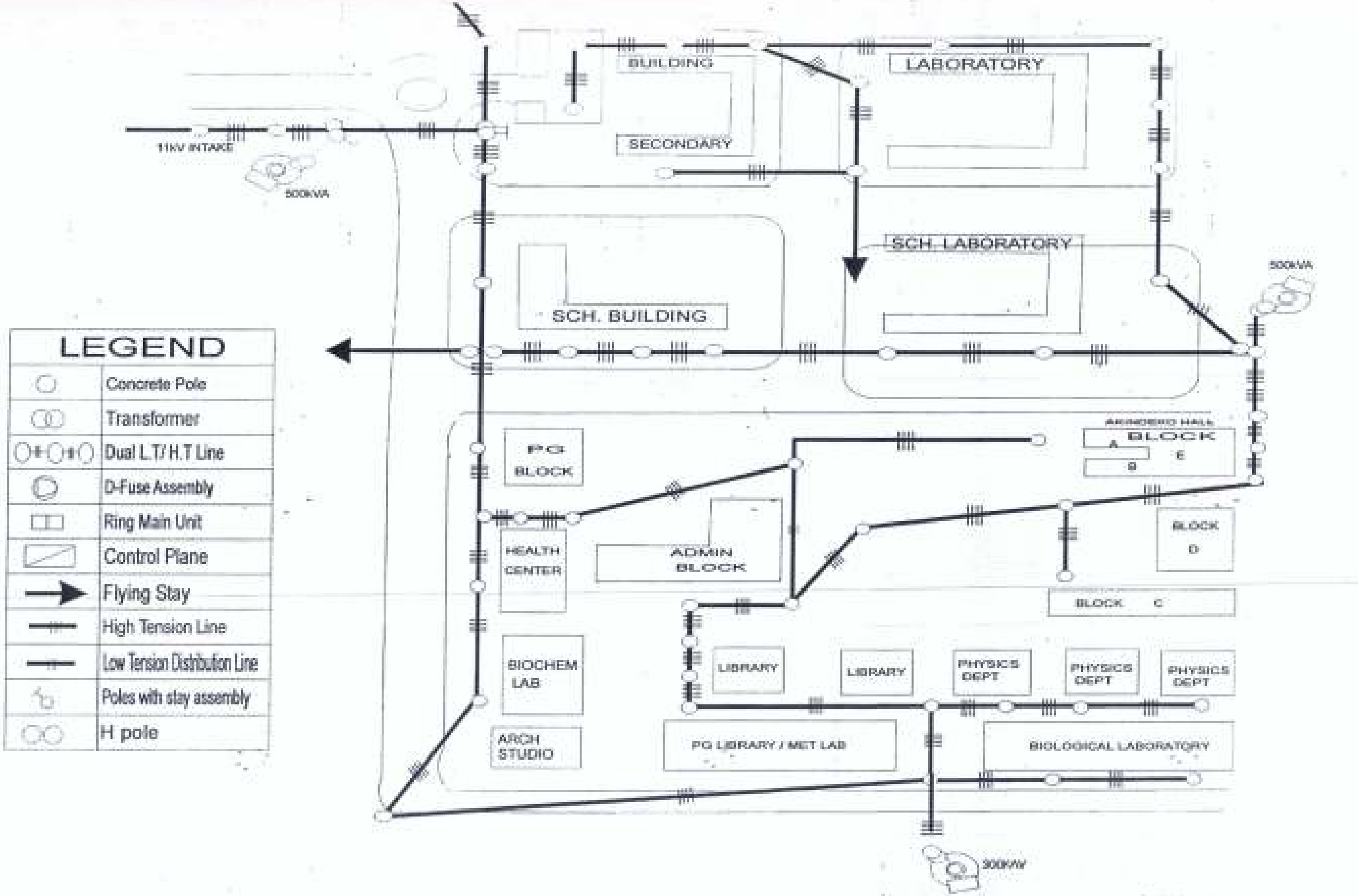


Fig. 1.3 Power Distribution Around The Health Center Area.

1.2 Purpose of Study

The purpose of electricity supply regulations is to guarantee the safety of the public while simultaneously ensuring a proper and sufficient supply of electricity. The present Health Center is a number of converted classrooms and offices, therefore, there is no initial physical (building) plan and electrical design to meet energy requirement by the Health Center.

This results in phase burn out and uneven distribution of load on phases. Therefore, there is the need to re-design the electrical installation system in order to overcome t he problem of insufficient power supply, burning of protective devices, and service cables due to under rated cable size, loosened terminals and burnt contacts.

Presently there is no back up power supply like a generator in case of public power utility failure. The generators available in the powerhouse serve mostly the senate building. In case of public power utility failure, activities requiring power supply are brought to an abrupt halt at the Health Center. Such activities include laboratory tests, integrity of constant temperature chambers, such as drugs kept inside the refrigerators for vaccination while the whole Health Center is left in darkness at night.

1.3 Aim and Objectives.

1.3.1 Aim

The aim of this research is to provide a clear guideline for the design of electrical services for FUTA Health Center.

1.3.2 Specific Objective

The specific objectives of this research are to:

(a) determine the suitability of the protective devices and cable of electrical power supply to FUTA Health Center;

(b) evaluate the optimum electrical power requirement of the Health Center;

(c) determine the possible causes of phase failure and insulation breakdown of the electrical system; and

(d) determine possible causes of power instability at the Health Center.

1.4 Expected Contribution to Knowledge

The result of this study will establish a clear guideline for the design of electrical services for Health Centers in tertiary institutions. It will also provide a procedure for upgrading the electrical installations at Health Centers. It will also provide maintenance culture on electrical installations, apparatus and equipment.

sCHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Electrical power is a little bit like the air you breathe: It can really be thought of until it is missing. Electricity is a form of energy. Basically mains wiring (110/120V or 230V) is relatively simple to wire and connect and does not require a lot of special equipment or handling. But the wiring has to be right, because wrong wiring can cause fire outbreak and loss of lives, money and materials. Most dangers can virtually be eliminated with a little knowledge and proper safety practices. Safety is of utmost importance when working with electricity. Electrical codes around the world require wire that is well insulated, right size for the application (generally thick enough that it does not heat too much), has enough physical protection for the application and has right wire colours in it, (Levy, 1977).

Many different wires are used in mains wiring for different applications. The size of the wire determines the current it can carry and the insulation at the maximum operating voltage. Electrical wiring system design is always a compromise between safety and cost. Practical systems are designed in such way that the wiring is "safe enough" in normal use, but are not overly expensive. The safety requirements on the new installations are stricter than on old systems, but there are many quite old electrical installations in use and will be in use for long time.

The purpose of the electrical system in a house is to distribute the power safely to all of the different rooms and appliances. The mains wiring is generally built using insulated copper cables. The choice of conductor material is a compromise among electrical properties, mechanical properties, and price. From the start, copper has been the material of choice for household branch circuits. Aluminum is softer than copper and weaker, and a poorer electrical conductor than copper, so is not widely used in small sizes for home wiring. Aluminium cable material is sometimes used (for economical reasons) for thick mains feeder cables coming from electrical utility to the mains distribution panel.

Unless these buildings are properly adapted, maintained and renovated, their technical installations become progressively less suited to the higher standards of functionality, security and safety required by today's society.

Electric lighting provides illumination for every nook and cranny of a building most especially in the night. It makes a building a pleasant place to work and carry out other tasks. The power point is to make life easier for those living or working in the building. Three- phase power are used in the supply of power because using them saves copper more than one live wires, can share same neutral wire. Globally, several different voltages and methods are used to distribute the "low voltage" power to the homes and end users.

Installation standards require that electrical installations are designed to ensure that the users of the installation are not exposed to dangerous shocks. Designing for electrical safety is a technical issue for which regulations, standards and technical solutions exist.

2.2 Electricity – The Phenomenon

Electricity, according to Theraja and Theraja (2005), occurs as a result of orderly drifting or movement, flow or transfer of electron (i.e. the negative charges on the outer surface of an atom) in a given or specific direction. Electricity can be generated in a number of ways, each employing either of the fundamental principles .

2.3 Fundamentals of Electricity Generation

- **Electromagnetism** – When a soft iron is rotating within a magnetic field or flux, electric current would be induced in the soft iron. This arrangement is most employed in power generating stations, through the use of AC or DC generator.
- **Electrolysis** – the process of generating electricity by chemical reaction. DC batteries are used extensively in automobiles, low voltage installation or as backup in uninterrupted power supply (UPS).
- **Electrostatic** – Certain type of material (conductors) when subjected to friction, build up electric charges which can be stored until it is needed. The nuclear power stations and condensers or capacitors use this principle to generate electricity.
- **Photo – voltaic** – This is the direct conversion of solar energy from sun to electrical energy through a chemical reaction in a semi – conductor known as solar cell.

2.4 Electricity Generation and Transmission

Electricity is generated at the power plant and transmitted to different substations from where it involves stages of production, viz; generation, transmission, distribution, (Theraja and Theraja, 2005).

2.4.1 Electricity Generation.

The first process in delivery of electricity to consumers is referred to generation. At generating plants other form of energy is transform into electrical energy for providing heat, light, and power for human activities. Wikipedia (2006), says that "the first power plants were run on wood, while today we rely on petroleum, natural gas, coal, hydroelectric and nuclear power and a small amount from hydrogen, tidal harness, solar energy, wind generators, and geothermal sources". Figure 2.1 shows a picture of an Hydro Generating Station.

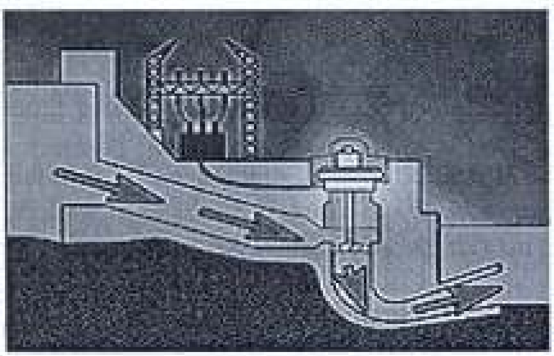


Fig 2.1 Hydro Generating Station
Source: http://demo.apogee.net/foe/graphics/go2.jpg

At the generating station, rotating turbines attached to electrical generator produced most commercial available electricity. The turbine may be driven by using steam, water, wind or other fluid as an intermediate energy carrier. The energy is produced at a relatively low voltage of up to 25kV.

2.4.2 Electrical Power Transmission

The term electrical power transmission refers to the bulk transfer of electrical power from place to place. Typically, power transmission is between the power plant and a substation near a populated area. This is distinct from electricity distribution which is concern with delivery from the substation to consumers, (Wikipedia, 2006). Transmission normally take place at high voltage (110kV and above).

AC power transmission is the conveyance of electric power (electricity) to consumers. Usually AC transmission lines carrying three-phase supply are used.

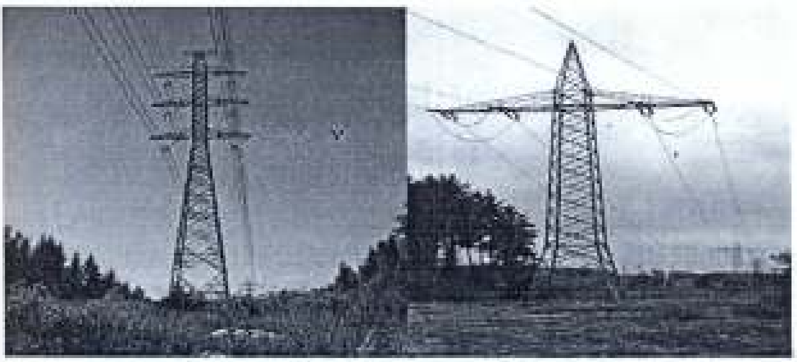


Fig 2.2 330KV and 132kV Electricity Transmission Tower
Source: http://en.wikipedia.org/ wiki/Electrical_Power_Grid

Today, voltage above 110kV are refers to as transmission voltage level. 330kV and 132kV Electricity Transmission Tower picture is shown in figure 2.2. Lower voltages such as 66kV and 33kV are usually considered sub – transmission voltages. Voltages lesser than 33kV are used for distribution.

2.5 Electricity Distribution

Electricity distribution is the final stage in the delivery of electricity. It is generally considered to include medium (less than 50kV) power lines, electrical substation, pole or ground mounted transformer, low voltage (less than 1000V) distribution wiring and electricity meters, (Wikipedia, 2006).

In the early days of generation, DC generators were connected to loads at the same voltage because at that time there was no known way of doing DC voltage conversion. This reason and others like losses, efficiency etc. brought about adoption of AC voltage distribution. Voltage distribution occurs within and outside the installation area. Figure, 2.3 shows 11kV/415V – 240V Distribution Pole, showing pole mount transformer, HV/LV lines, and connection to residential consumers.

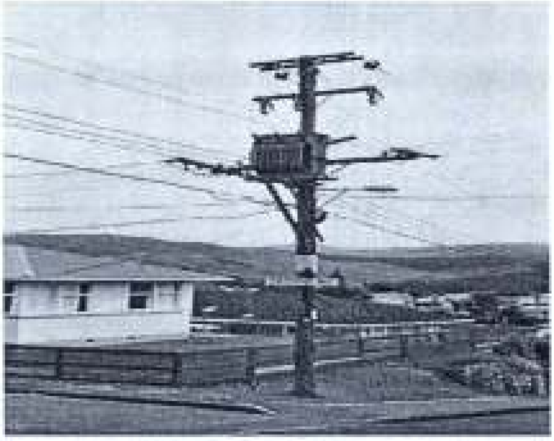


Fig 2.3: 11kV/415V-240V Ddistribution Pole.
Source: http://en.wikipedia.org/wiki/Electrical_distribution

2.5.1 Supply Distribution

Power sub-station houses transformer and other switchgears. Power transformer could be used to raise AC voltage from the generators and reduces it to supply load. Increasing the voltage reduces the current in the transmission and distribution lines and hence the size of conductors required and distribution losses incurred. This made it more economical to distribute power over a long distance.

PHCN, only authorized in power sector, employs the European system of supply distribution. Supply (Voltage) is distributed at the range of 33/11kV to transformer stations (Sub-Station).33/11kV is further step down at the sub-station to three-phase and neutral 415/240V,50Hz which is supply to the residential and commercial customers or point of utilization.

The single-phase, 240V, 50Hz system is the normal supply for small end – users such as dwellings, and other single-occupier premises where the load is relatively small. The Electricity Supply Regulation 28a, 1937, says that energy for use at low voltage must not be introduced by more than one pair of conductors of a three-phase or multi-phase system unless the connected loads exceeds 12kW and it is necessary to do so in order to avoid voltage drop or variation on the distribution system in the area, (Thompson, 1983).

Fig 2.4 shows part of a typical 3-phase 4-wire distribution system of a sub-station. The transformer sub-station is built at the load center of the area. The sub-station contains high voltage switchgear, a step down transformer, low voltage switchgear and bus - bars, and low voltage fuses or links.

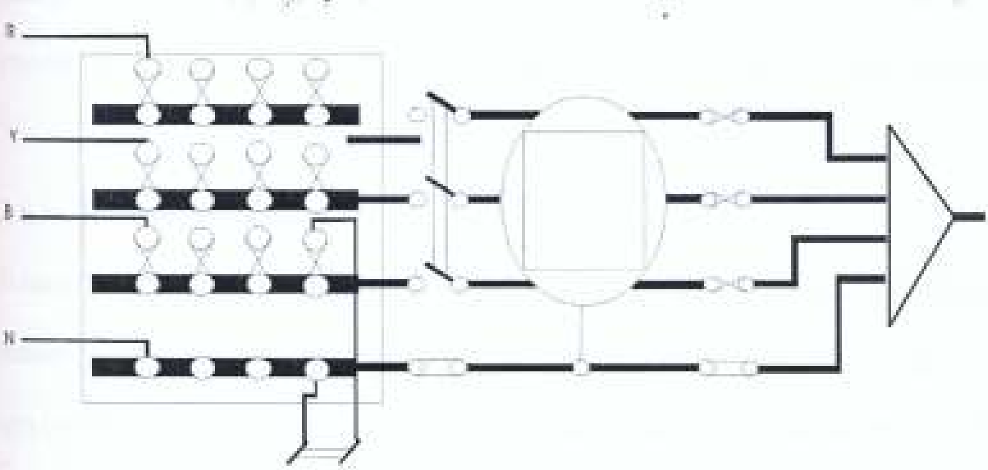


Fig.2.4. Four-wire, Three-phase Installation.

The supply to the primary is via a high voltage (11kV) feeder cable. The low voltage bus - bars are distinguished by colour marking. The local 4-wire distribution is connected in parallel to the bus - bars through the fuses or links, and the separate covers are also distinguished by similar colour markings. The Health Center like other larger non-domestic consumers is supplied with a 4-wire service, to give 240V single-phase for lighting and 415V, 3-phase for power.

2.5.2 Distribution Network Configuration

Distribution networks are typical of two types, radial or interconnected (ring). A radial network leaves the station and passes through the network area with no connection to any other supply. This is typically long rural lines with isolated load areas.

An interconnected network is generally found in more urban areas and will have multiple connections to other point of supply. These connections are normally open but allow various configurations by closing and opening switches (recently automatic). Interconnection model have advantages over radial model in the event or cases of a fault or required maintenance, a small area of network can be isolated and rest kept on supply.

2.5.3 Internal Distribution.

It may be taken as a general statement that all types of load in a 2-wire installation, lights, heaters, motors, etc., are connected in parallel at the same voltage, the energy used by any one load is the same whether the others are connected or not. The addition or subtraction of other loads in parallel has no effect upon the particular load under consideration, (Francis, 1982.).

If the resistance of the connecting leads are taken into consideration, as they must be in detailed calculation, these two statements must be modified; thus, the arrangement of loads is a mixture of parallel and series-parallel circuits, and the potential differences across the separate loads vary in some small degree.

An internal distribution system usually consists of the connection in parallel of a group of loads in a final sub-circuit, and the connection of this final sub-circuit to a local distributing bus bar located in a distribution board (D B). Other groups of loads are connected to same bus bars, so that the groups are effectively in parallel. In larger installations a number of these bus bars or fuse boards may themselves be connected in parallel to a main set of bus bars, or a main D B from which a pair of leads are connected to supply service cable through suitable switchgear, (Francis, 1982).

A switch in its own circuit must separately control each individual load. Fuses or circuit breakers control the separate groups. Similar control is repeated right back to the main supply terminals. Thus, circuit breaker, switch, or fuse controls any individual load, or any group, or the whole. The above general system applies to all types of installation, large or small.

Within the point of utilization or electrical installation, voltages vary depending on the requirement of the equipments or apparatus assembly for such purpose. Internal distribution of an installation can be carried out using single phase or three-phase system. For any installation demanding electrical power in excess of 12kW, three-phase supply is more appropriate. Agreeing with this, Stetson (1996), gives that when electrical loads in a building exceed 400A or motor of 10Hp and larger will be used, the option of three-phase electrical services should be considered. He also says that with larger installation or proportionate increase in electrical load a single phase service may be inadequate or unsuited.

2.6 Electrical Supply Control

Schneider (2005) simply put "to control" is to make something (e.g. machine or system) work in the way that you want it. The operation of switchgear is an important part of electrical power control system. Supply control can be visualized as dual natured concepts, depending on whether the perspective is on supply authority (the Source) or the user (within the installation).

The present structure of the distribution feeder (supply authority) does not support quick fault detection, isolation of faulty region and restoration of supply to the maximum outage area, which is healthy, (Theraja and Theraja, 2005) That is, the control mechanism on ground is not up to task of resolving the riddle of unstable power supply. The control system employ by the supply authority in the substations to ensure safe and reliable supply includes transformer, circuit breaker, fuses, lighting arrestor, relays and switches for automation. This ensures that over-voltage, under- voltage; outage and frequency variation is controlled.

In the premises, switchgear control functions allow system operation or modification of loaded system at any moment, (Schneider 2005). IEE Regulation 530-1 and 3 enforce that switchgears employ for controlling loaded system must be capable of disconnecting both live and neutral the same time or phase(live) before neutral. Switchgear intended for such duty must be installed at least

a. At the origin of any installation.

b. At the final load circuit(s)

Good control switchgear ensures modification of load and emergency switching.

It is a requirement of wiring regulations that every consumer installation shall be adequately controlled by switchgear which is readily accessible to the consumer and which shall incorporate:

* Protection against electric shock;
* Protection against over current;
* Isolation and switching.

The size and type of main switchgear to be installed depend on the type of premises and anticipated load. It is advisable to install cables of sufficient capacity with .appropriate switchgear, to save additional installation expenses and outage time at a later date when extensions are projected. The switchgear, fuse gear, and circuit breaker should have adequate breaking capacity and should be related to the maximum short-circuit current obtainable from supply system.

Adequate means must also be provided for isolating the equipment to allow access for maintenance and other purposes. Where more than one phase is brought into a building as in the case of FUTA Health Center, special precautions must be taken to avoid the risk of shock. The regulations insist that all live terminals between which low voltage exist should be shrouded with an insulating material or be enclosed in earthed metal.. Single-phase D.B. that are connected to different phases must be more than two meters (2m) apart from each other, (IEE Regulation, 15^{th} Edition).

The position of D.B. is important, and should be near the electrical center of the load that it is intended to serve. This reduces the cost of service cable, though; the length between the supply-intake position and any particular distribution should be taken into consideration so that the volt drop does not exceed the permitted maximum of 2.5% of the nominal voltage of the supply.

2.7 Voltage Variation and Frequency

IEE Regulation 512 – 1 states that all equipment shall be suitable for the normal voltage (r.m.s.value for a.c) of the installation or the part of the installation concerned. 512 – 2 states that all equipment shall be suitable for design current and current likely to flow in abnormal condition for such periods of time as are determine by the characteristics of the protective device concerned. 512 – 3 states if frequency has an influence on the characteristics of the equipment, the rated frequency of the equipment shall correspond to the frequency of the current in the circuit concerned.

Supply authorities are permitted under the electricity regulations to allow consumer's voltage to vary not more than ± 6% of the nominal voltage. (Marrice, 1977). The permitted variation in frequency is ±1% the nominal frequency. In Nigeria most especially the Health Center, the voltage is very low. The voltage supply nowadays ranges between 100V and 180V which causes a lot of damages to equipment such as air conditioners, freezers, refrigerators and other motorized units.

2.8 Safety and Protection

The aim of safety and protection is to avoid or to limit the destruction of dangerous consequences of excessive (short – circuit) current, or those due to overloading and insulation breakdown, and to separate the defective circuit from the rest of the installation, (Schneider, 2005).

Electrical protection ensures:

- Protection of circuit elements against thermal and mechanical stress of short circuit currents;
- Protection of persons in the event of insulation breakdown;
- Protection of equipment and appliances (e.g. motor).

A distinction is made between the protections of,

- the element of the installation (cable, wire, switchgear),
- persons and animals and
- equipment and appliances supplied from the installation.

2.8.1 Safety

Safety is of utmost importance when working with electricity. Electricity may be invisible, but it can be dangerous if not understood and respected. The electrical installations should be properly designed, properly installed and use the necessary safety devices needed on this type of application. Fuses and circuit breaker are devices which protect wiring and equipment against short circuits and overloads. Circuit breaker is a protective device, which automatically cuts off power from the main circuit in the event of an overload or short circuit. Only a regulated amount of current can pass through the breaker before it will "trip." The fuses and circuit breakers generally connect to the live wires (the ungrounded phase conductor).

In case of an overload or a short on that circuit, the breaker trips and automatically shuts off power to that circuit.. Any house that has been properly wired by a qualified electrician will have a circuit breaker panel that is used to shut circuits off in the event that they draw too much current. It is the current capacity of circuit breaker (in amperes) that determines how much current a circuit can supply. The breaker size is chosen relative to the type of cabling and connector used for the circuit, as each have different capacities.

Safety is very important in any electrical design and installation stage. Safety must be guaranteed in electrical installation design and execution by complying with the provision of many electric codes, rules and regulations. Some of them are listed below

a) Institute of Electrical Engineers (IEE) for electrical installations,

b) British Standard specifications and

c) National Electric codes.

The following safety requirements must be taken into consideration during the design and should be adhered to during installation.

- Protection against over current and overload by using adequate protective devices.
- Protection and prevention against earth leakage and earth fault by using earth leakage circuit breaker (ELCB), providing effective earthing for the system by using copper earth rod.
- Accessibility of equipment – all equipment which requires operation and attention should be strategically located so that adequate and safe means of access working space afforded for such operations and attention.
- Switching and isolation – effective means of isolating and switching for ready operations should be provided so that all voltages can be cut off from every installation.
- Adequate spares should be provided to accommodate future extension.
- Inspections and testing should be carried out on completion of installation.

2.8.2 Protection

One of the greatest considerations in electrical installation design is system protection. Speedy elimination of a fault by the protective system requires correct operation of a number of sub-systems of the protective system, (William, 1982).

The essence of system protection is to prevent accident and if it occurs, its effects will be limited. The principle of protection is that a faulty circuit is disconnected as fast as possible from the supply to prevent system breakdown, and isolate it until repair is carried out. The faults to be protected against are short circuit, overload and earth fault. These fault if not protected can result to fire outbreak, shock, and damage to equipment. Many precautions are needed to make occurrence of short circuits unlikely, because the very high currents caused by short circuit situation can cause lots of damage to electrical installation. Protective devices are needed to break short-circuit and overload currents.

A ground fault circuit interrupter (GFCI), is an electronic device for protecting people from serious injury due to electric shock. GFCIs constantly monitor electricity flowing in a circuit. If the electricity flowing into the circuit differs by even a slight amount from that returning, the GFCI will quickly shut off the current flowing through that circuit. The advantage of using GFCIs is that they can detect even small variations in the amount of leakage current, even amounts too small to activate a fuse or circuit breaker. GFCIs work quickly, so they can help protect consumers from severe electric shocks and electrocution. Even if the GFCI is working properly, people can still be shocked. However, the GFCI can act quickly to prevent electrocution. All GFCIs work in the same manner to protect people against ground faults.

2.8.3 Cable Protection

Cables have to be protected, to guide against any excessive current that can damage it, resulting in insulation breakdown or fire outbreak. Cables are to be rated a little more than the load current since the protection provided depends on the current carrying capacity of the cable. Generally, the protective device must not have a rating greater than the rating of the smallest cable in the circuit.

2.8.4 Earth Fault Protection

Earthing is the connection of the central (star) point of the supply transformer and the metallic parts of an installation which are exposed to touch, to the general mass of earth. This is to prevent the potential of live conductors rising above the declared value, and to automatically cut off the supply when any appreciable leakage current flows due to installation fault, (Akintante, 1983).

Grounding of Nigeria wiring installations can vary somewhat since there exists a number of different earthing schemes in use. In almost all cases neutral and earth are run separately within an installation, with all accessible metalwork and earth terminals within the premises tied back to a common earthing point at the entrance to the property. There are three common earthing schemes, they are:

* TT: No direct earth feed to properties - an individual ground electrode must be provided at each property. This is most common with overhead supplies - mainly in rural areas.

* TN-S: Earth cable run from the transformer ground to each property - the earth forms the armour and sheath of underground cables.

* TN-C-S: Combined neutral and earth cable from substation to properties. This could potentially be very dangerous as a neutral break can lead to the combined neutral/earth on the load side of a break rising to phase potential so there are special regulations governing the system. In practice multiple earths are provided along the entire cable run in addition to the transformer star point (hence the usual name PME or 'protective multiple earth').

In addition there are a couple of special schemes not in general use:

* TN-C: Combined neutral and earth continues within the installation (generally using concentric conductors)

* IT: Either no earth at all or else via a current limiting impedance. Not allowed in public supplies but recommended for such cases as medical life- support equipment.

There must be a continuous low path between the fault and the earth connection of the transformer, for the earth fault protection to operate. It must be capable of carrying the fault current without the risk of damaging healthy equipment and cables, (Folarin and Petinrin, 2005).

Figure 2.5 is the explanatory schematic diagram of TT system and is not intended to represent actual installation.

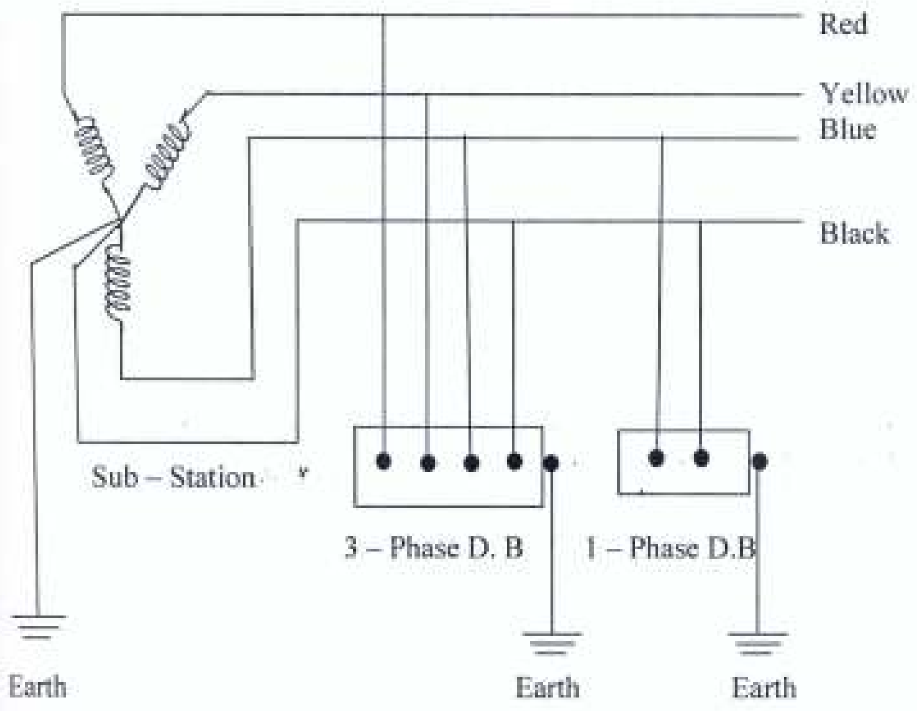


Fig. 2.5 T.T. System of Earthling

All earthing cable and electrode must be able to carry the system short circuit current without a dangerous temperature rise or voltage gradient along the earthing system

The method of earthing employed in FUTA Health Center is TT system of earthing, copper earth rod (England type) buried in the earth with the earthing lead connected with it. A non - ferrous cap is to hold the earthing lead tightly with the earth electrode. In addition, Earth Leakage Circuit Breaker (ELCB) voltage operated need to be provided for effective earthing protection.

2.8.5 Testing and Inspection of Installations

Electrical installation safety testing includes many different tests:

- Visual check: Examine visually that the connections are properly made and system components are not damaged.
- Continuity check: This applies a voltage to each pin in turn and checks the response of all other pins. This is checked against the required response. This test will detect missing connections (opens), extra connections (shorts) and miss wired connections ("wrong pins"). Test voltage is usually around 3-10 volts. This test can be made with normal multimeter.
- Resistance measurement: This test measures the resistance between every point in the cable and checks that the value is below the required value. This will detect poor connections, wrong wire lengths and bad crimps. Some basic tests can be done with a multimeter, but to measure low resistance values accurately, megger tester is most appropriate.
- Earth continuity test: This test checks the continuity and resistance of the grounding wires. This test is usually made by applying a current (10-30A) to the ground wire to check its resistance and make sure that it can withstand current going through it.

The electrical testing of mains outlet wiring with the modern testing instruments includes typically the following tests to make sure that the installation is safe:

- Measuring of ground wire resistance: ground wire resistance from outlet to mains distribution panel grounding bar (should be below 2 Ω).
- Insulation testing: Insulation resistance from live/neutral to ground at suitable voltage, (usually 500V).
- Line resistance measurement: The wire loop resistance from the mains panel to the outlet should be less than 2Ω.

Insulation resistance tests should be made on a dead circuit and any equipment which might be damaged by application of the test voltage must be disconnected or isolated. The insulation resistance should be measured between each live conductor and earth and should not be less than 0.5MΩ. Where practicable the tests are applied to the whole of the installation with all fuse links in place and all switches closed. Alternatively, the installation may be tested in parts. The resistance of the phase-neutral loop or phase-phase loop is needed to ensure that adequate over-current protection has been provided in the case of a short circuit developing between the two live conductors or live to neutral.

Generally, circuits protected by fuses need to have very low loop resistances. The phase-ground loop resistance is also needed to ensure adequate over-current protection, but also to ensure that, in the case of a ground fault, an adequately large current will flow to activate any protective devices. Depending on the situation the resistances are measured with resistance measurement device that supplies suitable measurement current to the wire loop or by using a short circuit current measuring meters (enough short circuit current guarantees low resistance). Where protection is provided by a residual current device (RCD), the effective operation of each RCD shall be verified by a test simulating an appropriate fault condition independent of any test facility incorporated in the device, followed by operation of the integral test device.

The testing and inspection of these installations must be in compliance with Part 6 of IEE regulations. It states that every installation, shall on completion and before being energized, be inspected and tested in accordance with the requirements of the section to verify, as far as practicable, compliance with installation regulation, (IEE Regulation 15th Edition). The method is such that no danger to person or property or damage to equipment can occur.

The information required by Regulation 514-3 shall be made available to the person carrying out the inspection and testing. A visual inspection shall be made to verify that the installed electrical equipment is

- in accordance with the British Standards, and
- correctly selected and erected in accordance with this Regulations, and
- not visibly damaged so as to impact safety.

The following items, where relevant, shall be tested in the sequence indicated.

- Continuity of ring circuit conductors,
- Continuity of protective conductors, including main supplementary equipment bonding.
- Earth electrode resistance,
- Insulation resistance,
- Insulation of site- built assemblies,
- Protection by electrical separation,
- Protection by barriers or enclosure provided during erection,
- Insulation of non conducting floors and walls,
- Polarity,
- Earth fault loop impedance ,

- Operation of RCD and fault voltage operated protective devices.

In the event of any test indicating failure to comply, that test and preceding, the result of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified, (IEE Regulation 15th Edition).

2.8.6 Test Certificate

Following the inspection and test listed above, a Completion Certificate shall be given by the contractor or by an authorized person acting on his behalf, to the person ordering the work. Any defect or omission revealed by inspection or test shall be made good before a Completion Certificate is issued unless there is alteration in installation as applicable to FUTA Health Center.

For an alteration to an existing installation, it shall be verified that the alteration complies with the Regulations and does not impair the safety of the existing installation. Periodic inspection and test must be conducted, the results of which shall be recorded accordingly (IEE Regulation 15th Ediyion). All the above test and inspection must be carried out in the presence of PHCN technical men, and the installation certified okay.

2.9 Interior Lighting Design and Energy Conservation

Artificial lighting is a major and conspicuous consumer of electrical energy. Energy consumption is measured as the product of power input (kilowatts) and the period of use (hours). To reduce it, both input and hours of use must be controlled.

Power input may be reduced by lowering general illumination levels, adopting selective lighting standards, and replacing inefficient sources. Hours of use can be reduced through sensible switching arrangements and automatic light control that takes advantage of available daylight and space occupancy.

One of the most effective means of decreasing power input is to choose efficient lamps. The efficacies of common lamps are described in units of lumens per watt. Efficacy alone, however, does not determine the best and most economic lamp choice. For example, High Intensity Discharge (HID) lamps can require a "warm-up" period of several minutes before they reach full light output, and this may be a disadvantage if frequent switching is required.

Lamp life, lumen depreciation, colour rendering, glare, and the total light distribution from the luminaries must also be considered. There is some evidence that improved visual clarity with the better colour-rendering lamps can compensate for their lower intensity output. Reduction in the connected load can be achieved by choosing luminaries that direct most of their light below the horizontal plane in the direction of the work plane. Limiting values of Visual Comfort Probability (VCP), as given in the IES Lighting Handbook, should be followed to avoid problems of discomfort glare.

Efficient manual switching of artificial lighting is extremely important for energy conservation. Although, repetitive switching of fluorescent lamps reduce their service life.

2.10 Power Supply Assessment

Before load assessment came into existence, consumers had been experiencing insufficient power supply, burning of protective devices, generator, transmitting and distributing equipment, because of failure to use the correct rating of the equipment. The purpose of the Electricity supply Regulations is to guarantee safety of the public and for ensuring a proper and sufficient supply of electrical energy, (Donnelly, 1980).

So it is essential that the consumer supply should be effectively controlled and also that all switchgear should be accessible. Therefore, the main switchgear must have means of isolating power, protection against excess current and means of cutting off the current if a serious earth fault occurs.

2.10.1 Reason for Power Supply Assessment.

Power supply assessment is carried out to determine:

- if the existing transformer sets and control equipment can sustain the total connected loads.
- the rating of transformers, cables, switch gear and other protective devices to be used.
- if the current power supply is adequate for the growing 'students' population.
- if there is need for generating sets, cables and transformer of higher capacity to replace the existing ones.

2.10.2 Consumer Factors in Power Supply Assessment

An individual consumer is not likely to use all available electrical devices, which constitute the connected load at the same time (or to their full capacity). It would be unnecessary to provide facilities to serve such a total possible load and much more economical to provide only for a probable load, the load creating the demand in the distribution facilities, (Thompson, 1988). So, the following factors have to be taken into consideration when assessing power supply to the consumers.

2.10.2a Maximum Demand (MD)

The actual load in use by a consumer creates a demand for electric energy that varies from hour to hour over a period of time, but reaches its greatest value at some points, (Turan, 1987).

2.10.2b Power Factor (PF)

It is the ratio of real power to the apparent power (product of the voltage and current). Also, it is the cosine of the angle of phase difference between voltage and current, which could be lagging or leading. If there is low PF, larger cables will be required to carry larger current, switches and transformer must be large with a greater increase in transmission losses.

2.10.2c Load Factor (LF)

It is the ratio of the average load demand for a period of time to the maximum demand during that period.

$$LF = \frac{A}{M}$$

Where A = Average load

M = Maximum load.

2.10.2d Diversity Factor (DF)

Diversity factor is a factor that is applied to sub-main and main cables and their associated switchgear to reduce

(a) the cross section area (c.s.a.) of the cable conductors, and

(b) the capacity of the switchgear.

The factor is based on the assumption that the whole of the connected load will not be on at the same time. A factor for diversity shall not be allowed for when calculating the size of circuit conductor and switchgear of final sub-circuits, other than specified circuits.

In the case of lighting for the Health Center, where virtually all the lights are on for most of the time, the diversity factor is taken to be 90 % (0.9). Diversity factor is the ratio of the sum of individual maximum load in the system to maximum demand load. Within a factory or premises, not all the installed equipment will be working simultaneously,(Donnelly,1980).

$$DF = \left(\frac{W}{M}\right) \times 100\%$$

Where W = Demand of actual load connected

M = Maximum load demand.

2.11 Power Supply Characteristics.

The following points are important where power supply is necessary:

- Cables used must be capable of carrying full load current,
- All conductors, cables and equipment used must be of correct voltage ratings,
- All conductors and equipment must be properly labeled,
- All equipment must be protected against high temperature, corrosion, mechanical damage and earth faults,
- The main D.B. must be located, if possible, at the center of the installation in order to reduce the length of cable,
- Sufficient capacity should be installed to allow for future expansion.

CHAPTER THREE

METHODOLOGY AND DESIGN ASPECT

3.1 Research Methodology

A comprehensive evaluation of the power requirement of FUTA Health Center was carried out. The staffs of the Health Center were interviewed in order to determine the power needs and the problems associated with electricity supply. The numbers of patients recorded at the Health Center over a period of fourteen years from 1990 to 2003 were obtained from their record books.

Students' enrolments were also obtained from Academic Planning Unit of the University. In this study, the peak student health demand was correlated with the student population. Trends were studied including the linear, power and exponential in power supply and consumption was studied.

The two sub-stations feeding the Health Center as well as the building consumer units were visited to facilitate an assessment of the power available to and the power consumed by the Health Center. The results were collated, analyzed and studied both graphically and statistically. All existing electrical equipment and appliances in the Health Center were assessed and their different individual power.requirements noted and recorded.

A comprehensive electrical installation design for the Health Center was developed to meet its energy requirement. With this, suitable protective devices and cable ratings that can successfully carry the required load without overheating were determined. An alternative supply (generator) in case of power failure was proposed for the Health Center.

3.2 Estimating Student Demand for the Health services

Since the University has primary function to serve students, it appears as if the actual health center needs should be obtained once the student population is known. A literature search to find possible indices to guide planning of institution on health center requirement was embarked upon with little success. It was therefore decided to study available data for any possible trends.

The peak number of students treated was determined and the ratio of student enrolment was determined. The result of each year was plotted against each year and student enrolment respectively. From the graphical analysis, the number of sick students at the health center at a particular period was determined.

If the student – staff ratio for higher institution (University) is known, then, the number of the institution staff could be estimated. A staff, by statutory rule, is entitled to a spouse and four children to be treated at the health center.

Although, not all sick students (patients) in the institution will attend the health center but the number of the sick student recorded was taken. The percentage of the sick student at the health center was used to estimate the total percentage of patients (that is, student, staff and their dependent relatives) at the health center.

The estimation of the total percentage of patients at any point in time, most especially during peak period to the university population was used to estimate the number of medical personnel needed at the health center at a particular period. This in turn could be used to determine the number of offices needed and their electrical energy requirements.

The result of this affords the University to have a future projection so as to take care of increment in student growth. It can as well be used to determine if the existing services (personnel) and facilities (electrical equipment) need to be upgraded. A new University to be established can as well make use of this result to project how many students or patients will be sick per student enrolment and facilities to put in place.

3.3 Electrical Services Design

3.3.1 Design Concept

All electrical systems should be designed to provide the following:

*. The ability to safely maintain, repairs, or replace electrical system elements while minimizing the need for outages on other systems or system elements.

*. The ability to readily make additions, or significantly increase their capacity, to meet future needs.

*. Coordination of all system elements with respect to the following parameters.

Since the present Health Center consists of converted classrooms and offices, the present electrical installation design which is that of classroom and offices is not suitable for the Health Center. This results in phase burn out and imbalanced distribution of load on the phases. Therefore there is need for the re-design of the electrical installation system.

The basic objective of any electrical design is to provide a safe, efficient, attractive, and comfortable environment for living, working and enjoyment, (Folarin and Petinrin, 2005). This basic objective must be met for successful operation. To achieve this, the designer should sadhere strictly to IEE Regulations, other electric installation codes and put his wealth of experience over years into use. All these help a lot in the design of this project.

Adequate attention was given to system protection, safety, reliability and cost reduction without affecting the basic electrical standard.

3.3.2 Power Requirement

The equipment and facilities that were provided to satisfy functional requirement in this building are those needed in Health Center. Below are some of them.

* Required illumination level
* Adequate 13A and 15A sockets
* Distribution Board
* Earth Leakage Circuit breaker

3.3.3 Design Procedure

Design starts from the various final sub-circuits and progress backwards to the service main cable. There are five classes of loads served by final sub-circuits:

* Lighting loads
* Heating loads
* Cooling loads
* Power loads
* Equipment

Each of these classes of final sub-circuit is confirmed to satisfy IEE Regulation. IEE Regulation A23 14th Edition states that where an installation comprises more than one final sub-circuit, each shall be connected to a separate way in a D.B. IEE Regulation A24 required that the wiring of each final sub-circuit, and the neutral conductors should be connected at the D.B. in the same order as the live conductor is connected. A final sub – circuit (to recapitulate), is the group of lighting fittings and their respective control switches, and small power outlet points that are wired and controlled by a D.B. in a building, (Oforeh,1998). It is basically an outgoing circuit fed from a D.B. intended to supply energy to current using equipment. They are commonly divided into those for lighting, those for heating and those for power, (Marrice, 1977).

3.4.1 Location of Outlets

The first step in design is to locate the position of various supply outlets on the architectural drawings. A plan and two elevations are always enough. The outlets to be marked are those of

- lights;
- socket outlet for fixed equipment ; e.g. water heater, air-conditioner, refrigerator; X – ray machine, etc;
- socket outlets for portable equipments e.g. TV's, Audio system, etc;
- controlling switches; and
- auxiliary services outlets, e.g. Telephones, Fire alarm, etc.

These outlets are marked using standard graphical symbols for each area of the building. Below is a guide on the number and location of each type of outlet required for different area of buildings. The Electrical installation design plans are presented in figures 3.1 to 3.6 and figure 3.7 shows the protective device connection.

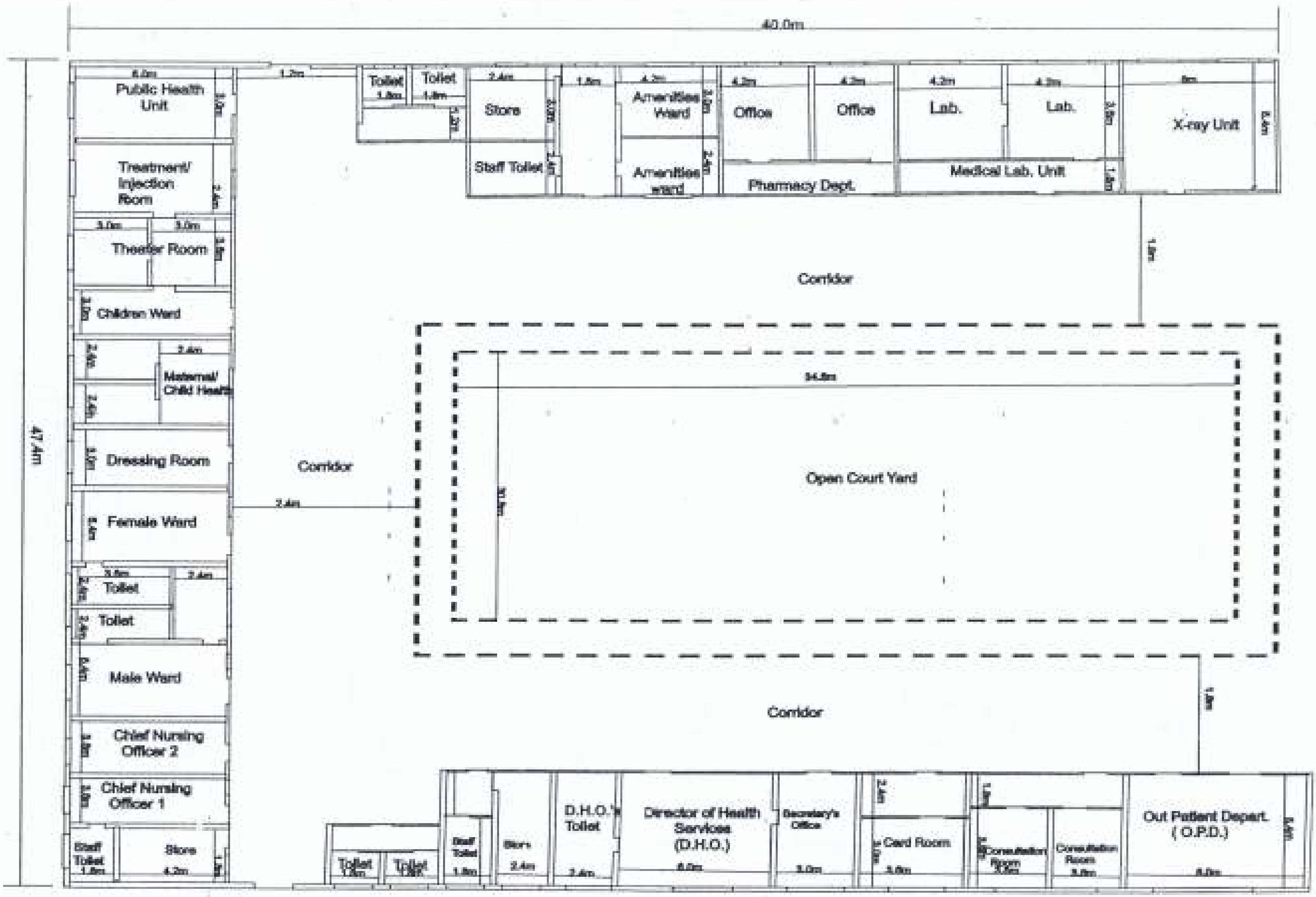


Fig. 3.1 Archtectural Design of FUTA Health Center

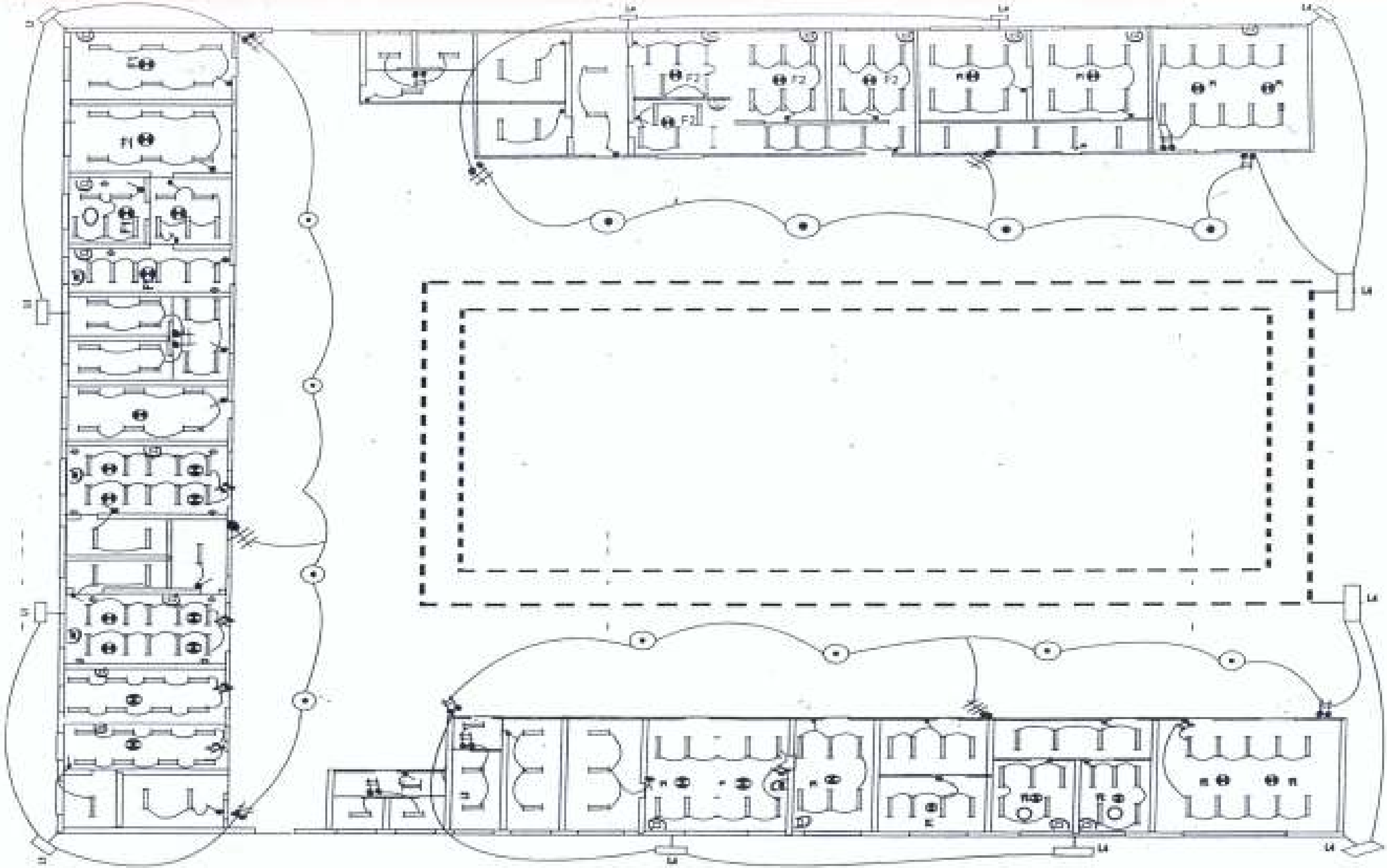


Fig. 3.2 Electrical Lighting Installation Design of FUTA Health Center.

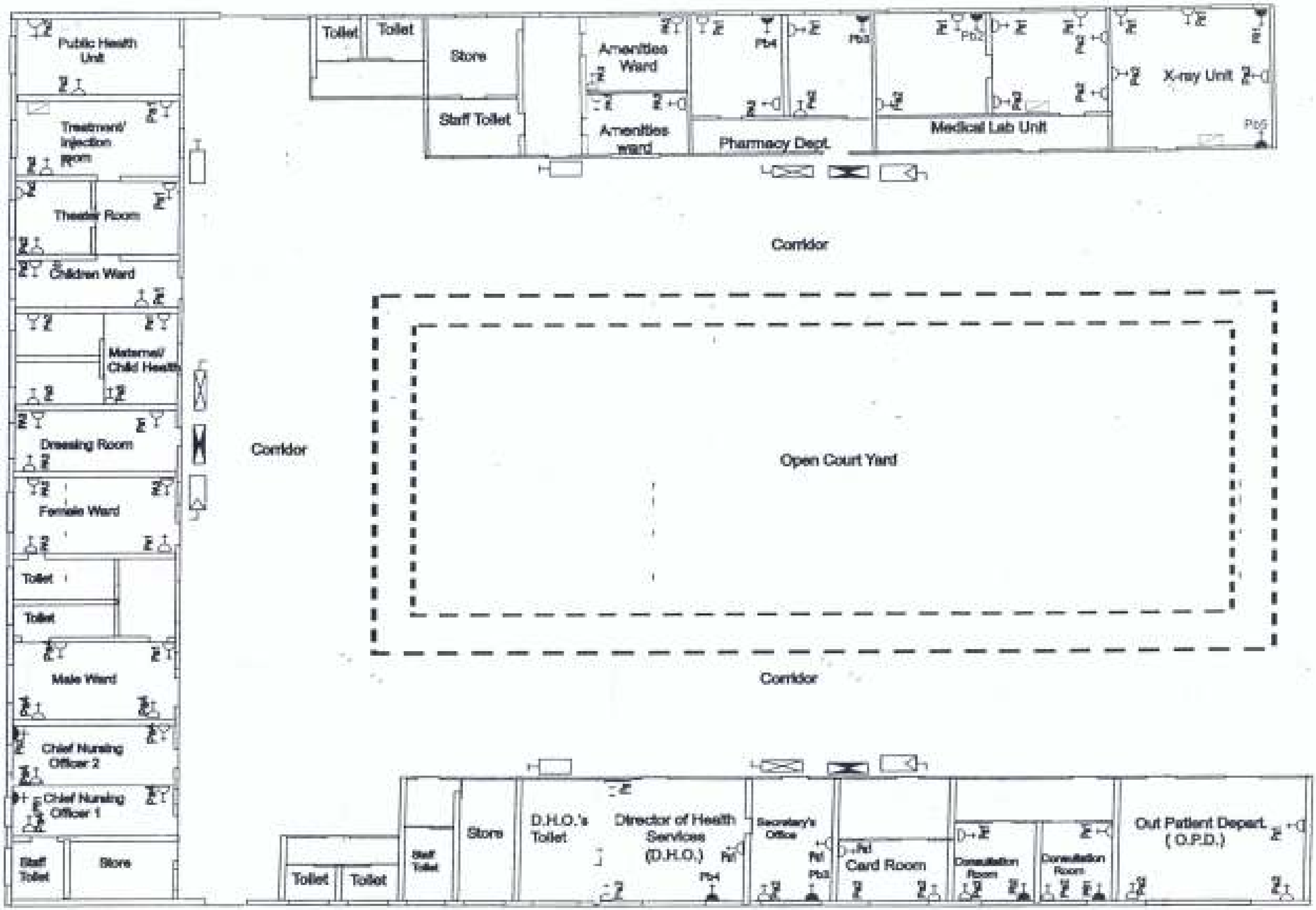


Fig. 3.3 Electrical Power Point Installation Design of FUTA Health Center

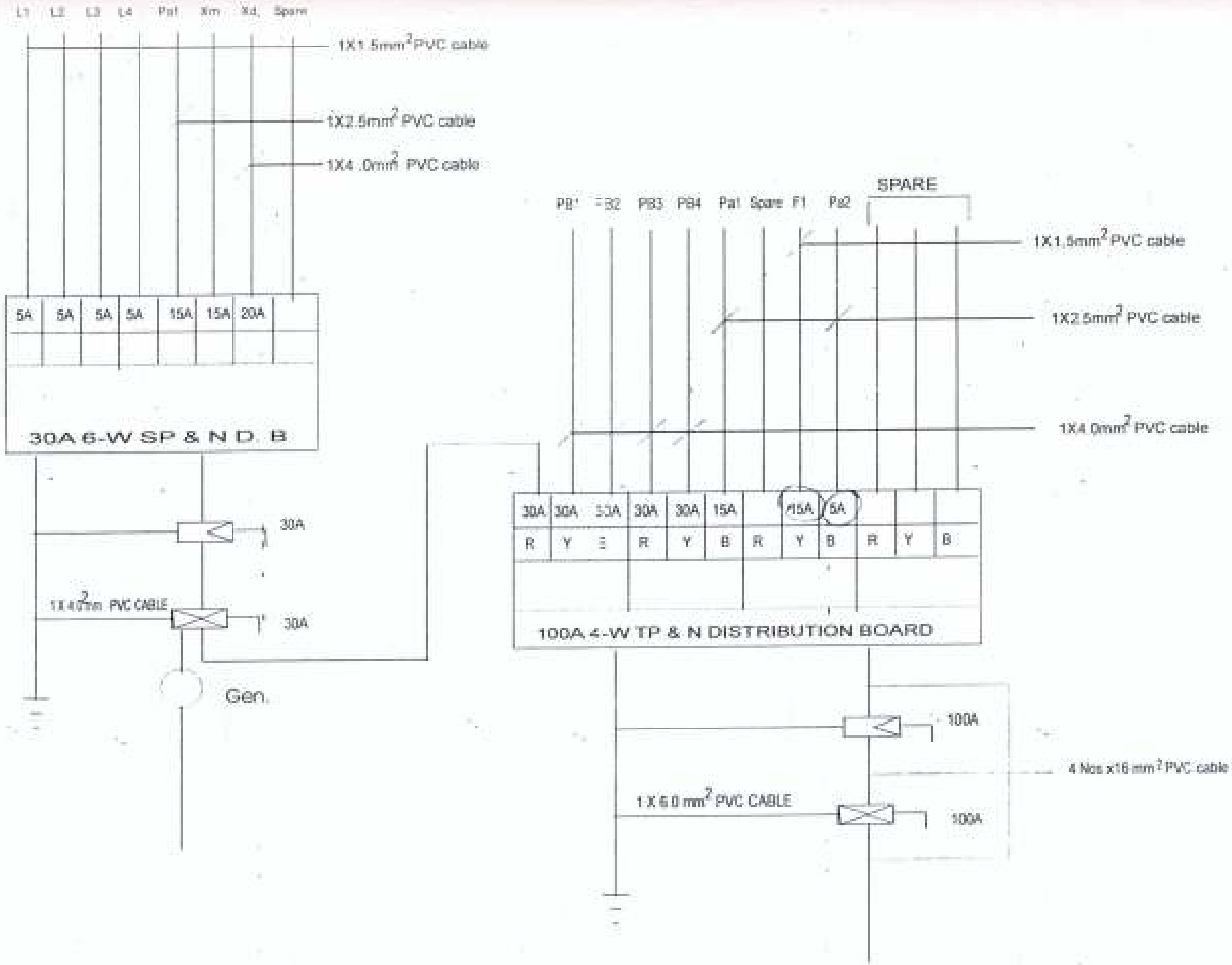


Fig. 3.4 Medical Laboratory Block Power Distribution.

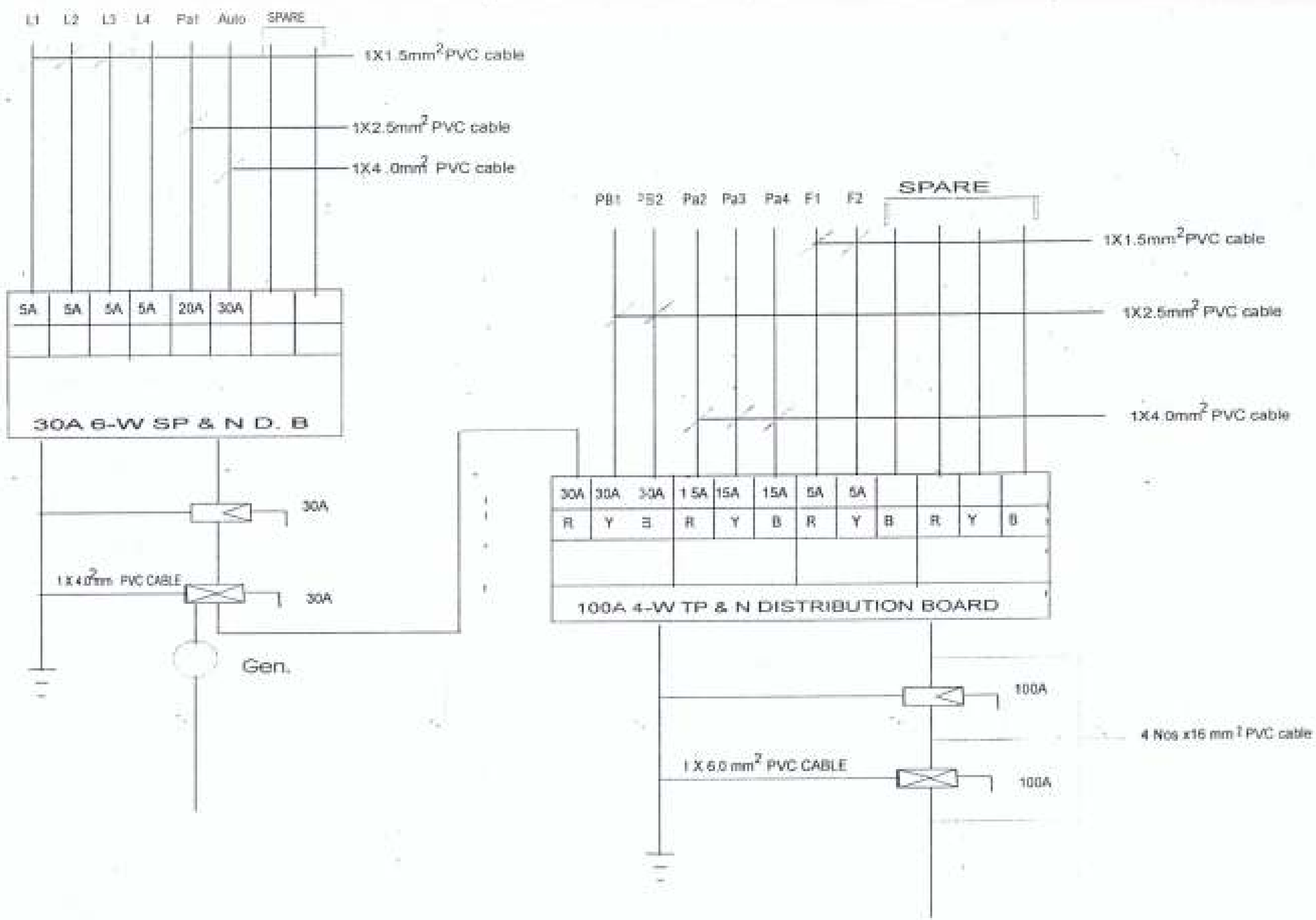


Fig. 3.5 Chief Nursing Officer's Block Power Distribution

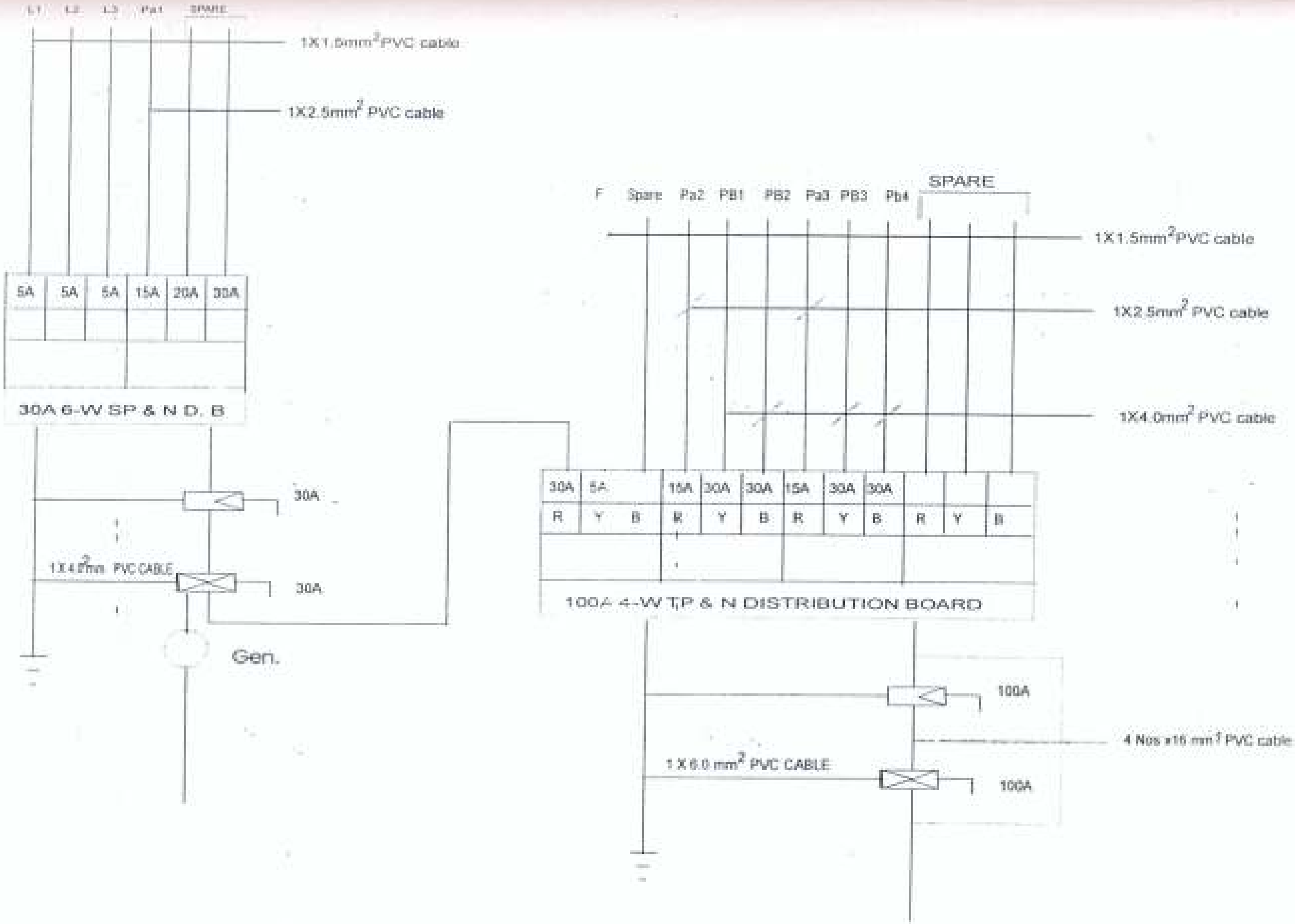


Fig. 3.6 Doctor's Block Power Distribution.

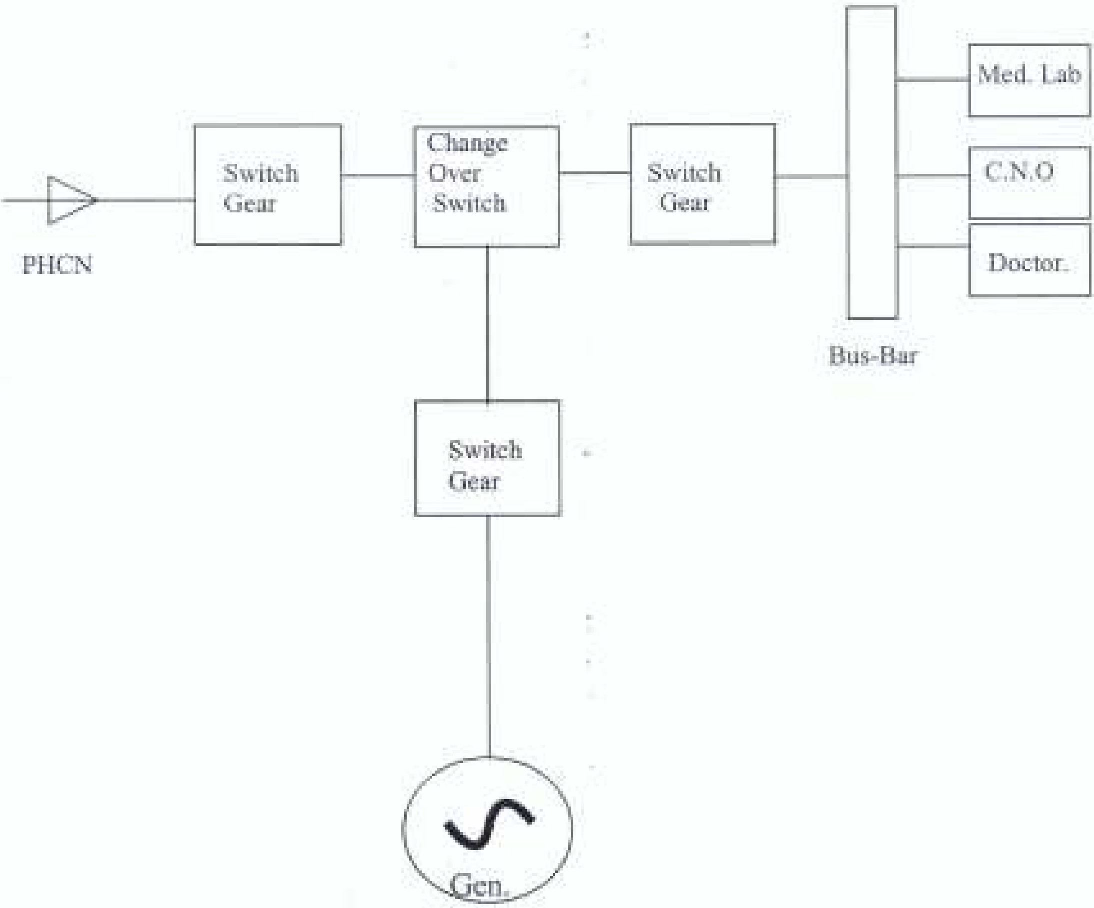
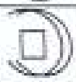
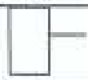
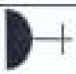
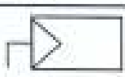
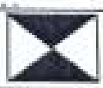


Fig. 3.7 Block Diagram of a 100A Protective Device Connection

Table 3.1 Summary List of Components and Devices

S/N	SYMBOL	~~DESCRIPTION~~
1.		1-gang 1-way Switch (Temby)
2.		Intermediate Switch
3.		2-gang 1-way Switch (Temby)
4.		Call Bell Socket
5.		T.V. Socket
6.		Telephone Socket
7.		75W Ceiling Fan (S.M.C.)
8.		Bulk Head Fittings
9.		60W Incandescent Filament
10.		100W Ceiling Fittings
11.		1.2m 40W Flourescent Fittings (Astral)
12.		13A Socket (Mem)
13.		15A Socket (Mem)
14.		100A TP&N ELCB (Voltage Operated)
15.		100A 3X4 TP&N D.B.
16.		100A TP&N Gear Switch/Change Over Switch
17.		Fire Extinguisher
18		100A 1-Way Control Switch

3.4.2 Lighting Outlets:

Decisions were taking on luminaries to be used, number of points and arrangement of fittings. The number of fittings depends on;

- Level of illumination required;
- Type of luminaries chosen;
- Height of fitting above the floor;
- Size of room.

The arrangement of the fittings shall be determined by

- The arrangement of furniture and other fixed equipment;
- Need to eliminate glare and sharp shadows;
- Visual presentation; and
- The need to create special effects.

3.5 Lighting Design Parameters

*	Luminous flux	θ measured in lumen
*	Luminous intensity	I measured in candela
*	Luminas	L measured in cd/m^2
*	Illumination	E measured in $Lumen/m^2$
*	Glare	
*	Colour	
*	Modeling	

3.6 Lighting Design Calculations

Standard service luminances used in this project are:

*	General Office	150 - 500 lux.
*	Ward	50 - 100lux
*	Toilet and lobby	50 - 100 lux
*	Store	50 - 100 lux

Lightning Design Lumen:

2 x 40W fluorescent fittings	5800 lumen
1 x 40W fluorescent fittings	2900 lumen
1 x 20W fluorescent fittings	1450 lumen
100W Bulk head	1260 lumen
60W incandescent lamp	650 lumen

3.7 Lighting Installation Circuit Arrangement

There is need for a well-planned arrangement for the circuit of this installation. It is necessary to divide the installation into circuits to minimize inconveniences in the event of a fault and to facilitate safe operation, inspection, test and maintenance.

3.8 Spacing of Lighting Fittings

The spacing of lighting fittings to obtain uniform brightness is very important. To achieve this objective in the concern areas, where points of lighting fitting are required, the fittings are spaced so that the distance between two fittings is twice that between the fittings and the walls.

3.9 Calculation of Number of Fittings

There are two methods of calculating the number of fittings required. They are:

(i) Lumen method and

(ii) Point by point method

The point by point method is more theoretical and laborious especially when reflection from ceiling and walls are necessary in determining the utilization factor. Lumen method is used in calculating number of fittings required in each area throughout this design. The mathematical expression used is stated in equation 3.1.

$$N = \frac{E \times A}{MF \times UF \times \Phi} \quad \text{..........} 3.1$$

Where	N	=	Number of Lamp required
	E	=	Illumination level required
	A	=	Area of the room
	$\varnothing$	=	Luminous flux of the lamp used
	MF	=	Maintenance factor (0.8)
	UF	=	Utilization factor for the room

Utilization factor (UF) is the ratio of the luminaries received on the working plane to the total lumen emitted by the lamp used in the luminaries. The value of UF varies widely and depends on the following factors:

* The type of lighting system (i.e. direct or indirect)
* The colour and surface of wall and ceiling
* The mounting height of the fittings
* The shape and dimension of the plan

The judgment of the designer determines the type of utilization factor to be used. The procedure for calculating the UF is as follows:

* Calculate the room index from the dimension of the place required being illuminated.
* Determine the U.F using the room index calculation.

And the reflectance % of 70 / 30 for ceiling /wall (See Appendix 1) he room index was calculated using the formula in equation 3.2

$$\text{Room index} \qquad I = \frac{L \times W}{h(L+W)} \quad \ldots\ldots\ldots\ldots 3.2.$$

Where L = length of the room

W = width of the room

H = actual height of the room

h = (H – 1) height, (i.e mounting height to the working place)

he Council of Illumination Engineering gives required values for each activity. Those eeded for this project were extracted and used for calculating the number of fittings.

laintenance Factor (M.F) further reduces the amount of useful light that is normally due to ccumulation of dirty on reflecting surfaces and ageing of the lamps. The value of aintenance factor assumed and used for the design is 0.8.

.10 Control Switch

hese are used to control the lights. They are usually located at the inner wall of the room, djacent to the door handle. Where there is more than one door leading into a room, onsideration may have to be given to the use of a two-way switch. Other uses of two-way witches are at corridors and staircases. Switches are to be located at about 1.5m above the oor level

.11 Security /Out Door Light

ufficient security / outdoor lighting fittings should be available in the design – whether sidential or commercial. Outdoor lightings is recommended to be a lamp covered with flector or bulkhead to prevent the fittings from getting damaged by rain, sunlight, and her extreme environmental condition.

The lighting fitting selected for outdoor installation must be capable of good visibility in foggy condition, long luminous efficiency and long service year (because of the mounting height). All entrances into a building must be properly illuminated at night to prevent intruder from taking advantage of poor illumination.

3.12 Auxiliary Outlets:

Serving telephones, alarms, and etc are to be considered separately.

3.13 Socket Outlets

Outlets for fixed equipment shall be located at anticipated position(s) of that equipment. Where there are more possible positions than one at which such equipment should be located, outlets should be provided at all such positions. The idea is to avoid the need to require an extension modification very soon after installation work is completed.

Outlets to portable equipments should be provided more generously. Depending on the size of the building, possible type of portable equipment (e.g. TV's, stereo systems, standing/table fans, electric kettle, etc) should be figured out and allowed for. In general, socket outlets should be located at least 15 cm from the floor or working surface.

3.14 Power and Socket Outlet Design

The design for the socket outlets and power outlets depend greatly on the following:

* The size of the area of activities

* The likely activities that are expected and this will give the knowledge of appliance to use.

* The distance between sockets to another, to discourage the use of multi - way adaptor.
* The need for air –conditioning equipment.

(a) 13A Sockets Outlet

In this design, the 13A sockets were designed to be connected in ring circuit and in radial form in accordance with IEE Regulations A30-41. The load estimated for each 13A socket was 500W.

The final sub circuits serving the 13A-socket outlet in ring form should be protected by 30A fuse, while the cable size is $2.5mm^2$ in accordance with the IEE Regulations. The final sub-circuit serving the 13A socket outlets in radial form should be protected by a minimum of 15A fuse depending on the load, while the cable size is single core 2.5 mm^2 1-core or $1.5mm^2$ 3-core PVC cable.

(b) 15A Sockets Outlets

The IEE Regulations states that separate final sub circuit must feed each of the air-conditioning circuit.

3.15 Load Distribution

Each circuit of a particular block is be divided into two D.Bs to enable the less important one to be switched off when running from a generator whenever there is power failure from PHCN.

In the Medical laboratory block, all the lighting points, socket outlets PA1, x-ray machine and x-ray dryer shall be connected on sub- D.B fed from a 30A MCB of the main D.B while the rest shall be on the main D.B.

In the Chief Nursing officer's (C.N.O.) block, all the lighting points, socket outlets PA1 and autoclave machine shall be connected on sub- D.B fed from a 30A MCB of the main D.B while the rest shall be on the main D.B..

In the Doctor's block, all the lighting points and socket outlets PA_1, shall be connected on sub- D.B fed from a 30A MCB of the main D.B while the rest shall be on the main D.B. The circuit arrangement was done by having several final sub-circuits to particular distribution board.

These are some of examples of final sub circuit.

- Final sub - circuits feeding lighting points
- Final sub - circuits feeding fan points
- Final sub - circuits feeding the 13A-ring circuit
- Final sub - circuits feeding the 13A radial circuit
- Final sub - circuits feeding air conditioning 15A socket outlet
- Final sub – circuit feeding X – ray machine
- Final sub – circuit feeding hotbox oven.
- Final sub- circuit feeding autoclave
- Final sub- circuit feeding resuscitation machine
- Final sub- circuit feeding suction machine
- Final sub- circuit feeding water heater

The load distribution in the D.B, sizes and ratings were shown in the design drawings (Fig.3.4 to Fig. 3.6). Calculation of loads of final sub-circuits and determination of fuses to protect them with the appropriate cable rating are calculated.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

The following methods were adopted to meet the desired objectives. Detailed knowledge of the Health Center and the electrical problems experienced at the Health Center were understood. The data of patients treated over a period of fourteen years revealed the number of patients attended to every month and year are as shown in Tables 4.1 and appendix A[1] to A14. The results of the students enrolment was also obtained from Academic Planning Unit of the University. A literature search to find possible indices to guide planning of institution on health center requirement was embarked upon with little success. It was therefore decided to study available data for any likely looking trends. In this study, the peak student health demand was correlated with the student population. Trends were studied including the linear, power and exponential. From the graphical analysis, it can be deduced that 0.16 (16%) of the total number of student enrolment will be sick.

This helps to determine whether the existing services (personnel) and facilities (electrical equipment) need to be upgraded because the more the number of patients, the more the number of personnel (doctors, nurses, ward attendants, etc) and the more the facilities needed like increase in number of offices, bed space in the wards, air conditioners, 13A outlets, lighting points and etc.

A comprehensive study of the two sub-stations feeding the Health Center was carried out and load delivered by each phase was taken with the use of a Clamp-ammeter. Similar activity was carried out on the D.B. in each block of the Health Center. The results are shown in Tables 4.2 to 4.6.

In the course of this work all the offices, wards, stores and toilets were visited. All existing electrical equipment in the Health Center was assessed and their different individual power requirements were noted and recorded as shown in Table 4.7 to 4.9.

The graphical analysis gives a clear and distinct picture at a glance.

Figures 4.1 and A1 to A14 show the population of patients treated in each month from 1990 to 2003.

Table 4.1 Patients Treated Between 1990 and 2003

S/NO	YEAR	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
1	1990	6,114	3,015	3,530	6,545	12,659
2	1991	4,282	3,136	3,077	6,213	10,495
3	1992	4,144	3,189	3,735	6,924	11,068
4	1993	3,433	2,728	3,464	6,192	9,679
5	1994	5,711	4,297	4,586	8,883	14,586
6	1995	6,384	4,104	5,166	9,270	15,662
7	1996	2,504	2,686	3,150	5,836	8,340
8	1997	7,753	3,518	4,536	8,054	15,806
9	1998	5,010	3,225	4,206	7,431	12,441
10	1999	7,051	3,725	4,314	8,039	15,090
11	2000	5,174	2,281	3,329	5,610	10,790
12	2001	4,089	2,868	4,217	7,085	11,114
13	2002	4,501	3,091	5,743	8,834	13,335
14	2003	2,269	1,770	2,780	4,550	6,819

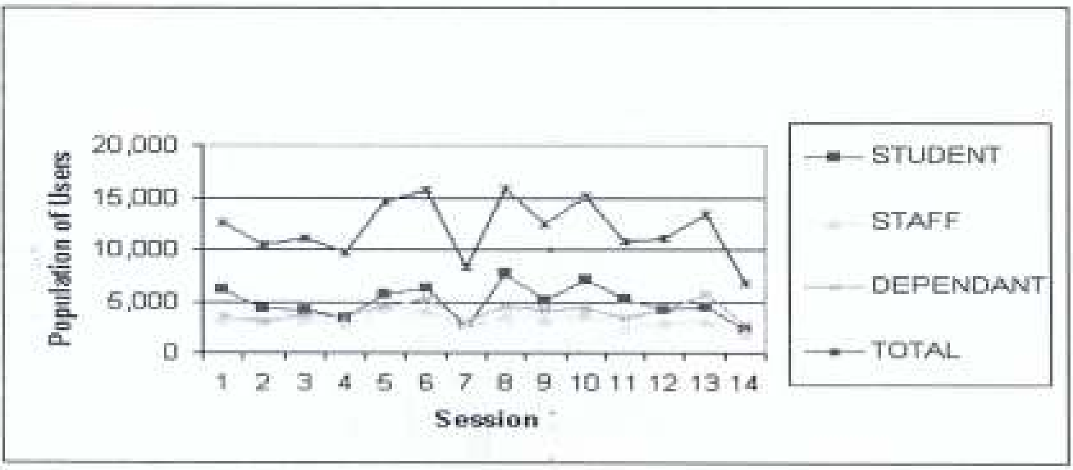


Fig. 4.1 Patients Treated Between 1990 and 2003

Table 4.2 **Loads on 500kVA Works Sub station**

DAY	RED PHASE (A)	YELLOW PHASE (A)	BLUE PHASE (A)
MON	144.8	142.7	182.3
TUE	149.7	139.8	184.1
WED	132.4	146.4	156.8
THUR	116.4	104.7	124.9
FRI	141.4	153.2	172.9
SAT	75.2	61.4	68.7
SUN	76.9	65.7	66.8

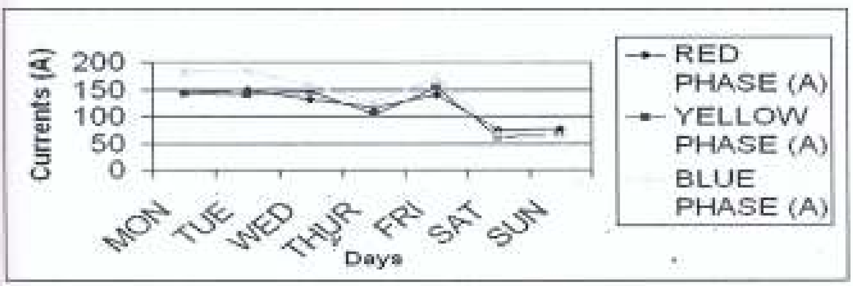


Fig. 4.2 **Loads on 500kVA Works Sub station**

Table 4.3 **Loads on 300kVA Obakekere Sub station**

	RED PHASE (A)	YELLOW PHASE (A)	BLUE PHASE (A)
MON	137.2	91.8	156.4
TUE	136.8	89.8	164.4
WED	124.5	92.7	159.8
THUR	139.1	90.7	168.2
FRI	139.8	87.2	170.4
SAT	101.2	64.9	115.6
SUN	99.8	65.4	117.2

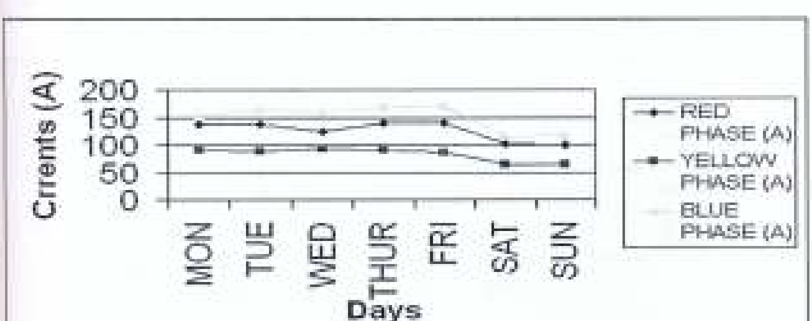


Fig. 4.3 **Loads on 300kVA Obakekere Sub station**

Table 4.4 Load Distribution on Medical Lab's. D B

DAY	RED PHASE (A)	YELLOW PHASE (A)	BLUE PHASE (A)
MON	9.7	12.1	13.7
TUE	9.6	12.6	13.6
WED	10	12.2	13.6
THUR	9.8	11.9	13.8
FRI	9.5	12.5	14.2
SAT	3.6	4.1	10.2
SUN	3.2	3.8	8.1

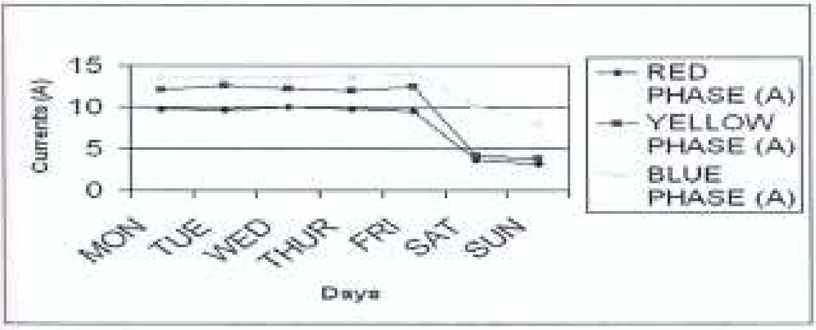


Fig. 4.4 Load Distribution on Medical Lab's. D B

Table 4.5 Load Distribution on C.N.O's. D. B

DAY	RED PHASE (A)	YELLOW PHASE (A)	BLUE PHASE (A)
MON	12.3	14.9	14.5
TUE	12.2	15.2	14.1
WED	11.8	15.8	13.9
THUR	12.5	14.8	14.6
FRI	11.9	15.1	14.7
SAT	11.1	12.9	12.1
SUN	11.2	12.6	11.5

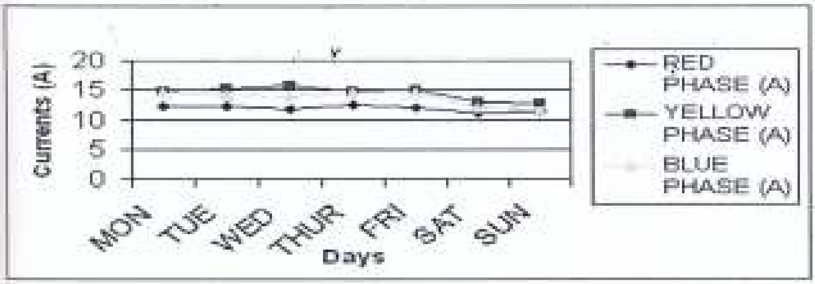


Fig. 4.5 Load Distribution on C.N.O's. D. B

Table 4.6 **Load Distribution on Doctor's D. B.**

DAY	RED PHASE (A)	YELLOW PHASE (A)	BLUE PHASE (A)
MON	29.8	27.3	32.8
TUE	28.2	26.4	35.2
WED	28.1	27.2	34.9
THUR	30.7	25.2	36.1
FRI	28.7	26.7	35.5
SAT	22.7	20.2	30.1
SUN	20.3	19.1	28.7

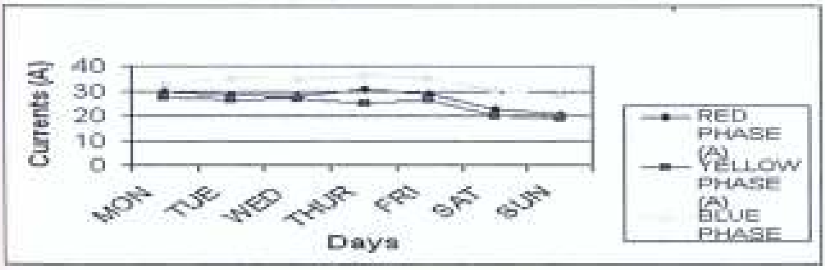


Fig. 4.6 Load Distribution on Doctor's D. B.

Power Rating of Existing Equipment in the Health Center

e power rating of the existing equipment and appliances at the Health

nter was examined and recorded in Tables 4.21 to 4.23.

Table 4.7 Power rating of Existing Equipment in the Medical laboratory Block

Location	Equipment / Appliances	Quantity.	Unit Rating (Watts)	Total Rating (Watts)
Pharmacy Rooms	Fluorescent	6	40 x 1.8	432
	Fan	2	75	150
	Air conditioner	2	1500	3000
Medical Lab.	Fluorescent	6	40 x 1.8	432
	Fan	2	75	150
	Standing fan	1	70	70
	Microscope	1	100	100
	Angle head	1	550	550
	centrifuge	1	880	880
	Hot box oven	1	3600	960
	Refrigerator	1	430	430
	Incandescent lamp	1	60	60
	Air conditioner	1	1500	1500
X – Ray Unit	Fluorescent	6	40 x 1.8	432
	Air conditioner	1	1500	1500
	X-Ray machine	1	2750	2750
	X-ray dryer	1	400	400
Toilet	Incandescent lamp	4	60	240
Stores	Fluorescent	2	40 x 1.8	144
Corridor	Ceiling fittings	4	100	400
Security	Bulk head fittings	3	100	200
Total load				15,180

Table 4.8 Power rating of Existing Equipment in the C.N.O. Block

Location	Equipment / Appliances	Quantity	Unit Rating (Watts)	Total Rating (Watts)
Chief Nursing Officer's office	Fluorescent	2	40 x 1.8	144
	Ceiling fan	1	75	75
	Refrigerator	1	430	430
	Air conditioner	1	1500	1500
	Electric bell	1	5	5
	Electric kettle	1	1000	1000
Amenities room	Fluorescent	2	40 x 1.8	144
	Ceiling fan	1	75	75
	Air conditioner	1	1500	1500
	Standing fan	1	70	70
Male ward	Resuscitation Machine	1	100	100
	Fluorescent	4	40 x 1.8	288
	Fan	2	75	150
	Television	1	300	300
Female ward	Suction machine	1	100	100
	Fluorescent	4	40 x 1.8	288
	Fan	2	75	150
	Television	1	300	300
Dressing room	Sterilizer	1	100	100
	Fluorescent	1	40 x 1.8	72
	Auto clave	1	750	750
Maternity/Child Health	Fluorescent	4	40 x 1.8	72
	Fan	2	75	150
	Refrigerator	1	430	430
Corridor	Ceiling fittings	4	100	400
Toilets	Incandescent lamp	2	60	120
Security	Bulk Head fittings	6	100	600
children Ward	Fluorescent	2	40 x 1.8	144
	Fan	1	75	75
	Television	1	300	300
Treatment/ Injection room	Fluorescent	4	40 x 1.8	288
	Fan	2	75	150
	Electric bell	1	5	5
	Refrigerator	1	430	430
Public Health Unit	Fluorescent	2	40 x 1.8	144
	Fan	1	75	75
Total load				10,924

Table 4.9 Power rating of Existing Equipment in the Doctor's block

Location	Equipment / Appliances	Quantity.	Unit Rating (Watts)	Total Rating (Watts)
O.P.D	Fluorescent Fan	6 4	40 x 1.8 75	432 300
Consultant Rooms	Fluorescent Fan Air condition	6 2 2	40 x 1.8 75 1500	432 150 3000
Card room	Fluorescent Ceiling Fan	1 1	40 x 1.8 75	72 75
Secretary's Office	Electric kettle Fluorescent Ceiling fan Electric bell Air condition	1 1 1 1 1	1000 40 x 1.8 75 5 1500	1000 288 75 5 1500
Med. Director's Office	Fluorescent Ceiling fan Air condition Computer system Refrigerator Rechargeable lamp	2 2 1 1 1 1	40 x 1.8 75 1500 800 430 50	144 150 1500 800 430 50
Corridor	Ceiling fittings	4	100	400
Toilets	Incandescent lamp Fluorescent	5 1	60 40 x 1.8	300 72
Security	Bulk Head fittings	3	100	300
Total load				11,471

Total actual load in the Health Center = 15,180W + 10,924W + 11,471W
= 37,575W = 37.575kW.

4.3 Load Estimation Applying Diversity Factor

The diversity factors used in determining the rating of cables and switches fuse are in conformity with IEE Regulation A 22 (14^{th} edition). The allowance for diversity factor for different types of installation call for special knowledge and experience in order to specify the appropriate one to be in accordance with IEE regulations.

4.3.1 Medical Laboratory's Block

Lighting Sub-Circuit

Example of calculations to determine the number of fittings in the building, using equations 3.1 and 3.2 is shown as follow:

X – RAY ROOM

Data:	Length	6.00m		
	Width	5.40m		
	Height	3.50m		
	Area	6.00 x 5.40	=	$32.4m^2$

$$\text{Room Index} = I = \frac{L \times W}{h(L+W)}$$

$$= \frac{6.00 \times 5.4}{2(6.00+5.4)} = 1.42$$

From U.F table 70/30 ceiling / wall (See appendix 1)

U.F = 0.42

Standard Service Luminance of an office is 150 lux

Talking M.F = 0.8

Lighting design Lumen (LDL) for 0.6 m, 20W fluorescent lamp is 1450 lumen

Hence the number of fluorescent lamp needed is

$$N = \frac{E \times A}{MF \times UF \times \Phi} = \frac{150 \times 32.4}{1450 \times 0.8 \times 0.42} = 9.97 = 10$$

$= \quad 10$ lamps

Therefore, the X – ray room needs only ten 0.6m, 20W fluorescent fittings.

The theatre room has a special shadow less movable lamp to be put ON during operation while the consulting room has a special movable lamp directly on the couch.

The choice of appropriate switch and switch ratings depend upon the number of points to be controlled at a particular switch location. The ways of control, the number and type of load the switch is called upon to interrupt.

For example, the lobby and the two toilets in the medical laboratory block. Total load in the lobby and the two toilets = 20W + 2(100W) = 220W

Current I drawn by the load $= \dfrac{220}{220 \times 0.8} = 1.25A$

The switch recommended is 5A, 3 – gang, 1 – way switch.

This is the smallest readily available switch and can interrupt the load without arcing. The same procedure should be used to determine the choice of other switches.

Total lighting load in the building is calculated as follows:

Total number of fluorescent fittings = 63

Total number of incandescent fittings = 8

Therefore, total load in watts = (63 x 20W x 1.8) + (8 x 100W) = 2268 + 800

= 3068W.

Apply diversity factor, appendix 2, serial number 3 gives 90% of total current demand.

Therefore, 90% of 3068W = 2761W

On a single phase 220V 50Hz supply with assumed P.F of 0.8.

Current I = $\dfrac{3068}{220 \times 0.8} = 17.43A$

Each lighting sub-circuit is usually rated 5A. This is done in accordance with IEE Regulations A10 (14th Edition) that states that every cable and flexible cord shall have a current rating not less than that of the fuse element or 2/3 of circuit breaker, it is therefore, usual to use 1.5mm^2 1 – core PVC sheathed cable.

Therefore, number of lighting sub circuits $= \dfrac{\textit{Total load}}{\textit{Supply voltage} \times p.f(5A \textit{ fuse rating})}$

Number of sub circuits $= \dfrac{17.43}{5} = 3.49$

Therefore, the number of the lighting sub circuits = 4.

Fan Sub Circuit

There are eight points of ceiling fans rated 75 W each

Total load $= 75 \times 8 = 600$ W

Therefore, 90% of 600W = 540W

13A Socket Outlet

There are 19 points of 13A socket outlets divided to three final sub circuits. Assuming 500W per point. Allowance for diversity factor, appendix 2, serial number 9 gives 100% of current demand of largest Point of utilization + 50% of current demand of every other point of utilization. Load on Pa_1 is seven 13A socket outlets each while Pa_2 and Pa_3 is six 13A socket outlets.

Load on Pa_1 with seven 13A socket outlets = 500W x 7 = 3500W.

Load on Pa_2 and Pa_3 with six 13A socket outlets = (500W x 6) + 50% of (500W x 6)

= 4500W

X – Ray machine

Rated value is 2750W, 220V, 50Hz socket incorporated.

Design current I $= \dfrac{2750}{220 \times 0.8} = 15.63A$

X-Ray Dryer

Rated value is 1000W

Design current I $= \dfrac{1000}{220 \times 0.8} = 5.68A$

Air Conditioner Circuits

Rated value is 2.0hp (1500W), 220V, 50Hz. There are four points.

Total load = 1500W + 50% of (1500 x 3) = 3750W

The circuit is divided into two D.Bs to enable one to be switched off when supply is from a small generator.

The sub circuit D.B. consists of all the lighting points for proper illumination, sockets Pa1, X-ray machine and X-ray dryer while the main D.B. shall consist of all other 13A sockets, fan circuit, hot box oven and Air condition circuits with the sub circuit D.B..

P = $\sqrt{3}VI\cos\theta$

Therefore, design current I = $\dfrac{p}{\sqrt{3}V\cos\theta}$ for the D.B is shown in table 4.10.

Table 4.10 Design Current for Medical Lab's. D.B.

D.B.	Total Power (W)	Design Current (A)
Sub D.B.1	9,511	16.54
Sub D.B.2	11,790	20.50
Main D.B.	21,301	37.04

4.3.2 C.N.O's. Block

Lighting Sub-Circuit

Total lighting load in the building is calculated as follows:

Total number of fluorescent fittings = 90

Total number of incandescent fittings = 8

Total number of operating lamp = 1

Therefore, total load in watts

$$= (90 \times 20W \times 1.8) + (8 \times 100W) + 150W = 3240 + 800 + 150$$

$$= 4190W$$

Therefore, 90% of 4190W = 3771W

On a single phase 220V 50Hz supply with assumed P.F of 0.8.

$$\text{Current I} = \frac{3771}{220 \times 0.8} = 21.43A$$

$$\text{Number of sub circuits} = \frac{19.28}{5} = 3.86$$

Therefore, the number of the lighting sub circuits = 4.

Fan Sub Circuit

There are 16 points of ceiling fans rated 75 W each

Total load = 75 × 16 = 1200 W

Therefore, 90% of 1200W = 1080W

13A Socket Outlet

Load on each sub circuit are 13A socket outlets

Load on Pa_1= 500W x 7 = 3500W.

Total load on Pa_2, Pa_3 and Pa_4= 3500 + 50% of (3500 x 2) = 7000W

Hot box oven

Rated value is 3.0Kw, 220V, 50Hz socket incorporated.

Design current I $= \dfrac{3.0 \times 10^3}{220 \times 0.8} = 17.05$ A

Autoclave machine

Rated value is 2000 W, 220V. 50Hz.

Design current I $= \dfrac{2000}{220 \times 0.8} = 11.36A$

Air Conditioners

Rated value is 2.0hp (1500W), 220V, 50Hz. There are two points.

Total load = 1500W + (50 % of 1500) = 2250W

The circuit is divided into two D.Bs to enable one to be switched off when supply is from a small generator.

The sub circuit D.B. consists of all the lighting points for proper illumination, sockets Pa1, autoclave, while the main D.B. shall consist of all other 13A sockets, fan circuit, and Air Condition circuits with the sub circuit D.B..

P = $\sqrt{3}\, VI \cos\theta$

Therefore, design current I = $\dfrac{P}{\sqrt{3}\, V \cos\theta}$ for the D.B is shown in table 4.11.

Table 4.11 Design Current for C.N.O's. D.B.

D.B.	Total Power (W)	Design Current (A)
Sub D.B.1	9,271	16.12
Sub D.B.2	8,580	14.92
Main D.B.	17851	31.04

4.3.3 Doctor's Block

Lighting Sub-Circuit

Total lighting load in the building is calculated as follows:

Total number of fluorescent fittings = 6

Total number of incandescent fittings = 8

Total number of operating lamp = 2

Therefore, total load in watts

$$= (60\text{x } 20\text{W x } 1.8) + (8 \text{ x } 100\text{W}) + (150\text{W x } 2) = 2160 + 800 + 300$$

$$= 3260\text{W}$$

Therefore, 90% of 3260W = 2934W

On a single phase 220V 50Hz supply with assumed P.F of 0.8.

$$\text{Current I} = \frac{2934}{220 \times 0.8} = 16.67A$$

$$\text{Number of sub circuits} = \frac{16.67}{5} = 3.34$$

Therefore, the number of the lighting sub circuits = 4.

Fan Sub Circuit

There are 8 points of ceiling fans rated 75 W each

Total load = 75×8 = 600 W

Therefore, 90% of 600W = 540W

13A Socket Outlet

Load on each sub circuit are 13A socket outlets

Load on Pa_1= 500W x 7 = 3500W.

Total load on Pa_2 and Pa_3 = 3500 + (50% of 3500) = 5250W =

Air Conditioners

Rated value is 2.0hp (1500W), 220V, 50Hz. There are four points.

Total load = 1500W + 50 % of (1500 x 3) = 3750W

The circuit is divided into two D.B's to enable one to be switched off when supply is from a small generator.

The sub circuit D.B. consists of all the lighting points for proper illumination, and sockets Pa_1, while the main D.B. shall consist of all other 13A sockets, fan circuit, and Air Condition circuits with the sub circuit D.B.

P = $\sqrt{3}VI\cos\theta$

Therefore, design current I = $\dfrac{P}{\sqrt{3}V\cos\theta}$ for the D.B is shown in table 4.12

Table 4.12 Design Current for Doctor's D.B.

D.B.	Total Power (W)	Design Current (A)
Sub D.B.1	6,434	11.19
Sub D.B.2	9,540	16.59
Main D.B.	15,974	27.78

Figures 4.27 to 4.29 show the analysis of fittings and equipment to be installed in the Health Center.

Table 4.13 Analysis of Fittings and Equipment in the Medical Lab's Block

Location	Length (m)	Breadth (m)	L + B (m)	Area (m^2)	Room Index	U.F	M.F	Ø	E	No of Lamp	Rating (W)	Watt	Socket 13A	Outlet 15A	Machine
X-ray	6	5.4	11.4	32.4	1.42	0.42	0.8	1450	150	10	20×1.8	360	5	2	2
Medical Lab I	4.2	3.6	7.8	15.12	0.97	0.31	0.8	1450	150	6	20×1.8	216	5		
Medical Lab II	4.2	3.6	7.8	15.12	0.97	0.31	0.8	1450	150	6	20×1.8	216	2	1	
Lobby	8.4	1.8	10.2	15.12	0.74	0.24	0.8	1450	100	5	20×1.8	180			
Pharm. Lobby	8.4	1.8	10.2	15.12	0.74	0.24	0.8	1450	100	5	20×1.8	180			
Pharm. Office I	4.2	3.6		15.12	0.97	0.31	0.8	1450	150	6	20×1.8	216	2	1	
Pharm Office II	4.2	3.6	7.8	15.12	0.97	0.31	0.8	1450	150	6	20×1.8	216	2	1	
Amenities I	4.2	3	7.2	12.6	0.875	0.31	0.8	1450	150	5	20×1.8	180	2		
Amenities II	4.2	2.4	6.6	10.08	0.78	0.24	0.8	1450	150	5	20×1.8	180	2		
Lobby	5.4	1.8	7.2	9.72	0.65	0.24	0.8	1450	100	2	20×1.8	72			
Store	3	2.4	5.4		0.67	0.24	0.8	1450	100	2	20×1.8	72			
Staff Toilet	2.4	2.4	4.8	7.2	0.6	0.24	0.8	1450	100	2	20×1.8	72			
Other Toilet	1.8	1.8	3.6	5.76	0.6	0.24	0.8	1450	100	3	20×1.8	108			
Security										4	100	400			
Passage										4	100	400			
											TOTAL	3068			

Table 4.14 Analysis of Fittings and Equipment in the C.N.O's Block

Location	Length (m)	Breadth (m)	L + B (m)	Area (m^2)	Room Index	F	M.F	Ø	E	No of Lamp	Rating (W)	Watt	Socket 13A	Outlet 15A
Public Health Unit	6	3	9	18	1	0.37	0.8	1450	150	6	20×1.8	216	2	
Treatment/Injection Room	6	2.4	8.4	14.4	0.86	0.31	0.8	1450	150	6	20×1.8	216	2	2
Theatre Room	3.6	3	6.6	10.8	0.82	0.31	0.8	1450	150	5	20×1.8	180	2	
*Theatre Lamp										3	50	150		
Theatre Office	3.6	3	6.6	10.8	0.82	0.31	0.8	1450	150	5	20×1.8	180		
Children Ward	6	3	9	18	1	0.37	0.8	1450	150	6	20×1.8	216	2	
Maternities/ Child Health	4.8	2.4	7.2	11.52	0.8	0.31	0.8	1450	150	4	20×1.8	144	2	
Office I	3.6	2.4	6	8.64	0.72	0.24	0.8	1450	150	4	20×1.8	144	1	
Office II	3.6	2.4	6	8.64	0.72	0.24	0.8	1450	150	4	20×1.8	144	1	
Dressing Room	6	3	9	18	1	0.37	0.8	1450	150	6	20×1.8	216	3	
Female Ward	6	5.4	11.4	32.4	1.42	0.42	0.8	1450	150	10	20×1.8	360	4	
Male Ward	6	5.4	11.4	32.4	1.42	0.42	0.8	1450	150	10	20×1.8	360	4	
CNO I	6	3.6	9.6	21.6	1.125	0.37	0.8	1450	150	8	20×1.8	288	2	1
CNO II	6	3.6	9.6	21.6	1.125	0.37	0.8	1450	150	8	20×1.8	288	2	1
Store	4.2	1.8	6	7.56	0.53	0.24	0.8	1450	100	2	20×1.8	72		
Toilet								1450	100	6	20×1.8	216		
Security										4	100	400		
Passage										4	100	400		
											TOTAL	4190		

Table 4.15 Analysis of Fittings and Equipment in the Doctor's Block

Location	Length (m)	Breadth (m)	L + B (m)	Area (m^2)	Room Index	U.F	M.F	Ø	E	No of Lamp	Rating (W)	Watts	Socket 13A	Outlet 15A
OPD	6	5.4	11.4	32.4	1.42	0.42	0.8	1450	150	10	20×1.8	216	3	
Consulting Room I	3.6	3.6	7.2	12.96	0.9	0.31	0.8	1450	150	5	20×1.8	180	2	1
Consulting Room I Couch										3	50	150		
Consulting Room II	3.6	3.6	7.2	12.96	0.9	0.31	0.8	1450	150	5	20×1.8	180	2	2
Consulting Room II Couch										3	50	150		
Consulting Waiting Room	7.2	1.8	9	12.96	0.72	0.24	0.8	1450	150	4	20×1.8	180		
Card Room	3.6	3	6.6	10.8	0.82	0.31	0.8	1450	150	4	20×1.8	144	2	1
Card Waiting Room	3.6	2.4	6	8.64	0.72	0.24	0.8	1450	150	4	20×1.8	144		
Sec. Office	6	3	9	18	1	0.37	0.8	1450	150	6	20×1.8	216	2	1
Doctor's Office	6	6	12	36	1.5	0.47	0.8	1450	150	10	20×1.8	360	4	1
Doctor's Toilet	6	2.4	8.4	14.4	0.86	0.31	0.8	1450	100	3	20×1.8	144		
Store	6	2.4	8.4	14.4	0.86	0.31	0.8	1450	100	3	20×1.8	144		
Other Toilet										6	20×1.8	180		
Security										4	100	400		
Passage										4	100	400		
											TOTAL	3188		

4.4 Determination of Sizes and Ratings of Distribution Boards

The number of final sub circuits determines the size of the D.B. with provision for spares. The rating on the other hands depends on the total load on the D.B without application of diversity. The reason for non-application of diversity factor is that the D.B. must have capacity to carry the entire connected load.

The following factors are considered in deciding the location of D.B, main switch, and circuit breaker. The location should be at a point easily accessible to the consumer; this is to facilitate easy isolation and maintenance when necessary.

- In order to avoid long run of sub-circuit cables, it is desirable that the D.B. be as close as possible to the electrical load center of the whole installation.
- The sub-main cable carries a large current and a cable of large cross-sectional area. Usually $10mm^2$ and above. In order to reduce voltage drop and power loss on this cable and at the same time save cost, it is desirable to keep its length short. Therefore, the D.B. should not be far from the supply.

These conditions are not often supportive of one another. A compromise may therefore have to be worked out. In addition, where a consumer's installation comprises installation in two or more detachable buildings, separate means of isolation should be provided in each building in compliance with IEE Regulation A5.

Therefore, the D.B. of the Health Center should be located at the passage of the building. Putting a slight future expansion of load into consideration, 100A 6-way TP & N D.B., 100A TP & N Electric Leakage Circuit Breaker (Voltage operated) and 100A TP&N switch gear will be appropriate for the main D.B. while 30A 8-way single-phase will be suitable for the sub D.B. The important point to note is that the sub-circuit fuse and circuit breaker are installed to protect the sub-circuit cable and not the terminal equipment. IEE Regulation A10, 14^{th} Edition states that the current rating of a fuse shall not exceed the current rating of the smallest cable in the circuit protected by the fuse.

4.5 Determination of Sub-main Cable

The factors that determine the cable ratings needed for particular installations are load current, types of installation, grouping factor, ambient temperature and maximum allowable voltage drop. The requirement of IEE Regulation B23, 14^{th} Edition states that, the size of every bare conductor or cable conductor shall be such that the drop in voltage from the origin of the installation to any point in the installation shall not exceed 2.5% of the nominal voltage when the conductors are carrying full load current. For any given size of conductor, the greater capacity of a high – temperature conductor is established by the ability of the conductor insulation to withstand the I^2R heat produced by the higher current flowing through the conductor (McPartiand, 1981). Values of volt drop per ampere per meter are given in the current rating table in Appendix 4 of the IEE Regulations.

To determine the size of cable required to carry a specific load, the load current will need to be calculated, and then the corresponding cable will have to be selected from the cable-rating table. A cable may have capacity to carry the rated current; it may still not be suitable for the load. The actual voltage at the terminal determines the suitability of the cable. The actual voltage at the terminal depends on the voltage drop, which is also a function of the distance from the load center. Therefore, to make a right choice of cable one needs to test for voltage drop on the cable using this formula.

Voltage drop = (Volt drop/Amp/meter) (V) x Design current (A) x length of run (m).

4.5.1 Medical Laboratory's Block

The design total current is 37.04A Estimated length of run is 35meters. From IEE regulation table 9DI (BS 6004, BS 6364) column 8 and 9, 15^{th} edition, the corresponding cable size is $6.0mm^2$, PVC insulated cable, non-armored copper, conductor has a current carrying capacity of 45A and voltage drop of 6.2mV per ampere per meter (See appendix 3).

Now, to check whether the cable size is suitable for use, the formula Voltage drop = (Volt drop/Amp/meter) (v) × Design current (A) × length of run (m)

$$= 6.2 \times 10^{-3} \times 37.04 \times 35$$

$$= 8.04V.$$

But maximum permissible voltage drop on a three-phase supply is 2.5% of 415V

$$= 10.38V.$$

Since the voltage drop on the sub main cable is less than 10.38V, therefore $6.0mm^2$ cable is suitable.

4.5.2 C.N.O's. Block

The design total current is 31.04A Estimated length of run is 35meters. From IEE regulation table 9DI (BS 6004, BS 6364) column 8 and 9, 15^{th} edition, the corresponding cable size is $4.0mm^2$, PVC insulated cable, non-armored copper, conductor has a current carrying capacity of 36A and voltage drop of 9.2mV per ampere per meter (See appendix 3).

Voltage drop = (Volt drop/Amp/meter) (v) × Design current (A) × length of run (m)

$$= 9.2 \times 10^{-3} \times 31.04 \times 35$$

$$= 9.99V.$$

But maximum permissible voltage drop on a three-phase supply is 2.5% of 415V

$$= 10.38V.$$

Since the voltage drop on the sub main cable is less than 10.38V, therefore $4.0mm^2$ cable is suitable.

4.5.3 Doctor's Block

The design total current is 27.78A Estimated length of run is 85meters. From IEE regulation table 9DI (BS 6004, BS 6364) column 8 and 9, 15th edition, the corresponding cable size is $4.0mm^2$, PVC insulated cable, non-armored copper, conductor has a current carrying capacity of 36A and voltage drop of 9.2mV per ampere per meter (See appendix 3).

Voltage drop = (Volt drop/Amp/meter) (v) × Design current (A) × length of run (m)

$= 9.2 \times 10^{-3} \times 27.78 \times 55$

$= 14.05V.$

But maximum permissible voltage drop on a three-phase supply is 2.5% of 415V

$= 10.38V.$

Since the voltage drop on the sub main cable is more than 10.38V, therefore $4.0mm^2$ cable is not suitable.

A higher cable need to be chosen which is $6.0mm^2$, PVC insulated cable, non-armored copper conductor has a current carrying capacity of 45A and voltage drop of 6.2mV per ampere per meter (See appendix 3).

Voltage drop = (Volt drop/Amp/meter) (v) × Design current (A) × length of run (m)

$= 6.2 \times 10^{-3} \times 27.78 \times 55$

$= 9.47V.$

But maximum permissible voltage drop on a three-phase supply is 2.5% of 415V

$= 10.38V.$

Since the voltage drop on the sub main cable is less than 10.38V, therefore $6.0mm^2$ cable is suitable.

From the mathematical analysis, it is observed that the designed power is greater than the assessed power as reveal in Table 4.30. This is as a result of future extension and additional equipment that may be introduced.

Table 4.16 Comparison between Assessed Load and Designed Load

Block	Assessed Load	Designed Load
Medical Laboratory	15,180W	21,301W
Chief Nursing Officer	10,924W	17,851W
Doctor	11,471W	15,974W

4.6 Determination of the Main Cable

The estimated length of run is 45 meters. Assuming the three Distribution Boards will use a single three – phase, four – core, armoured cable from supply.

Therefore, total design current is 37.04 + 31.04 + 27.78 = 95.86A.

From IEE regulations, table 9D3 (BS 6346) 15^{th} Edition. The suitable cable size is $25.0mm^2$, four – core, armoured cable with a current carrying capacity of 97A and a voltage drop of 1.6mV per ampere per meter (See appendix 4).

$$\text{Volt drop} = 1.6 \times 10^{-3} \times 95.86 \times 45$$

$$= 6.90V.$$

Since the voltage drop on the main cable is less than 10.38V, the chosen cable is suitable.

Therefore, the associated switchgears rating for the Health Center should not be less than 100A while the generating set capacity of 100kVA will be suitable to carry the Health Center successfully in case of PHCN failure.

4.7 Discussion of the Results.

The statistics and graphical analysis of the data obtained reveals that the two transformers feeding the Health Center have imbalanced load which pose serious danger on the transformer and there is poor load distribution on the distribution boards installed at the Health Center. Table 4.30, Table 4.31, Figure 4.21 and Figure 4.22 show the imbalanced load. Although, there is allowance to further load the transformer, the load needs to be balanced. The imbalanced load caused tripping of breakers, burnt fuses, burnt contact and even insulation breakdown on the phase that is overloaded

Table 4.1, Figure 4.1 and Appendix 5 reveal that more patients were treated between May and July; students in particular, are usually treated between April to July and between October and November and that at least 0.16 (16%) of the student enrolment will be sick at the peak period. These periods were during first and second semester examination. It then, means that more personnel and facilities will be required (most especially during those periods) which justify the upgrading of the protective devices to meet the need at such a time.

It is equally observed that in most cases three-phase supply to the building has been rendered ineffective. The building was connected on a single phase looped together to serve the three- phase D.B. because of burnt contact terminals. Some of the contact terminals were not electrically clean and firm, that is, rust, corroded and not firm which brought about undue heat that damage the insulation of both sub-main cable and main cable. The protective devices like earth leakage circuit breaker and cut out have been by passed while there is no switchgear at all.

Table 4.17 Load Distribution on the Transformers

PHASE	W (A)	OB (A)
RED	149.7	139.8
YELLOW	139.8	87.2
BLUE	184.1	170.4

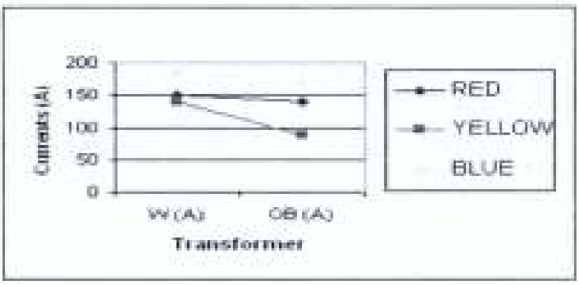


Fig. 4.8 Load Distribution on the Transformers

Table 4.18 Load Distribution in the D B.

PHASE	Med Lab.	C. N. O.	Doctor
RED	9.5	11.8	30.7
YELLOW	12.5	15.8	25.2
BLUE	14.2	13.9	36.1

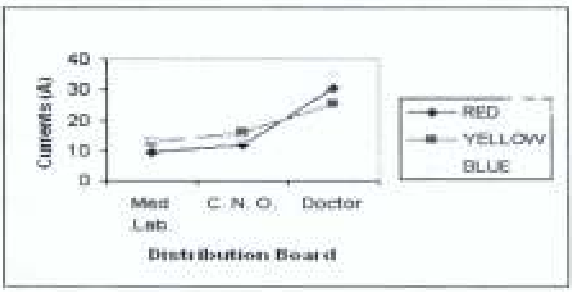


Fig. 4.9 Load Distribution in the D B.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The purpose of electricity supply regulation is to secure safety of the public and ensuring a proper and sufficient supply of electricity. The results of this project have revealed that the power supply to the University Health Center, FUTA is adequate but imbalanced, both load and service cables are standard but has poor termination and the safety devices need to be installed. In addition, facilities available at the Health Center need to be upgraded.

It has also shown the causes of power instability, power failure and insulation break down of the electrical system. Necessary modification and precautions are highlighted and also supported by the results. The proposed generator as backup supply to Power Holding PLC will take care of any Power Holding failure.

This study has established a clear guideline for the design of electrical services for Health Centers in tertiary institutions. It has also provided a procedure for upgrading the electrical installations. Provision for maintenance culture on electrical installations, apparatus and equipment has equally been made.

5.2 Recommendation

As the Health Center is temporarily housed in its present location, the results of this project will be very useful and should be considered and applied when putting up the Health Center physical structures in the "Master plan" location of the University Health Center.

The isolator at the intake on the 11kV line must be repaired and the Health Center should be fed by one sub-station instead of two, therefore the building should be fed from the 500kVA Works Sub-Station. This is to avoid accidental bridging of the distribution transformer which could be catastrophic. The feeder at the 500kVA Works sub-station should have three sseparate uprisers instead of one upriser looped together. This will prevent burning of the upriser contact terminals.

Proper electrical connection at terminals and splices are absolutely essential to ensure safe installation. Therefore, improper connections must be avoided to prevent failure of wiring devices, equipment breakdowns and electrically oriented fires.

Preventive maintenance is very important and this need to be carried out regularly on all the protective devices such as cleaning of terminals and re-tightening of screws, bolts and nuts to avoid corrosion, rust and dirt at the terminals which draw more current that burn the contact terminals.

Appropriate protective devices like switchgear, voltage operated earth leakage circuit breaker and miniature circuit breaker (cut out) must be installed for safety of lives and property.

Log book of patients treated should be part of the things kept in the Health Center, and should be in the custody of the Medical Record Officer. This will enable the University authority to have future projection for facilities to be provided and upgraded at the Health Center.

Three things are important in life, money, materials and men. Money and materials lost may be recovered but men lost are lost forever. Therefore electricity is very important and indispensable in life (the Health Center), therefore, all the generators in the powerhouse should be put in order to serve the community most especially the Health Center. If, otherwise a separate standby generating set of 100kVA with its associate devices should be installed at the Health Center in case of PHCN failure. By this safety of money, materials and men are guaranteed.

Future researcher should endeavour to write a programme for the electrical design sconcept.

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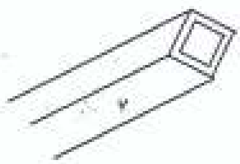
APPENDIX 1

Luminare and typical output	Typical outline	Basic DLOR %	Ceiling	Reflectance 0.7		
			walls	0.5	0.3	0.1
			Room Index			
Plastic Diffuser		50	0.60	0.27	0.21	0.18
			0.80	0.34	0.29	0.26
			1.00	0.40	0.35	0.31
			1.25	0.44	0.39	0.35
			1.50	0.47	0.42	0.38
			2.00	0.52	0.47	0.44
			2.60	0.56	0.61	0.48
			3.00	0.60	0.54	0.51
			4.00	0.61	0.57	0.54
			5.00	0.63	0.59	0.57

Source: Durrant D.W. (1977)

APPENDIX 2

Allowance for diversity

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of premises+		
	Individual household installations, including individual dwellings of a block	Small shops, stores, office and business premises	Small hotels, boarding house, guest houses, etc
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Heating and Power (but see 3 to 8 below	100% of total current demand up to 10 amperes + 50% of any current demand in excess of 10 amperes	100% f.l. of largest appliances + 75% f.l. of remaining appliances	100% f.l. of largest appliances +80% f.l. of 2^{nd} largest appliances + 60% f.l. of remaining appliances
3. Cooking appliances	10 amperes + 30% f.l of connected cooking appliances in excess of 10 amperes + 5 amperes if socket outlet incorporated in unit	100% f.l. of largest appliances +80% f.l. of 2^{nd} largest appliances + 60% f.l. of remaining appliances	100% f.l. of largest appliances + 80% f.l. of largest appliances + 60% f.l. of remaining appliances
4. Motors (other than lift motors which are subject to special consideration		100% f.l. of largest motors + 80% f.l. of 2^{nd} largest motor + 60% f.l. of remaining motors	100% f.l. of largest motors + 50% f.l. of remaining motors
5. Water-heaters (instantaneous type)	100% f.l. of largest appliances 100% f.l. of 2^{nd} largest appliances +25% f.l. of remaining appliance	100% f.l. of largest appliances 100% f.l. of 2^{nd} largest appliances +25% f.l. of remaining appliance	100% f.l. of largest appliances 100% f.l. of 2^{nd} largest appliances +25% f.l. of remaining appliance
6. Water-heaters (thermostatically type)	No diversity allowable		
7. Floor warming installation	No diversity allowable		
8. Thermal storage space heating installations	No diversity allowable		
9. Standard arrangements of final circuits in accordance with appendix 5	100% of current demand of largest circuit + 40% of current demand of every other circuit	100% of current demand of largest circuit + 50% of current demand of every other circuit	
10. Socket outlets other than those included in 9 above and stationary equipment other than those listed above	100% of current demand of largest point of utilization + 40% of current demand of every other point of utilsation	100% of current demand of largest point of utilization + 75% of current demand of every other point of utilization	100% of current demand of largest point of utilization + 75% of current demand of every other point in main rooms (dining rooms, etc) + 40% of current demand of every other point of utilization

- For blocks of residential dwelling, large hotels, large commercial premises, the allowance are to be accessed by a competent person
- Source IEE regulation (Table 4B), 15^{th} Edition .

APPENDIX 3

Current-carrying capacities and associated voltage drops for single-core p.v.c. insulated cables, non-armoured, with or without sheath (copper conductors)

BS 6004
BS 6346

Conductor operating temperature: 70°C

Conductor cross-sectional area	Installation methods A to C of Table 9A (Enclosed)				Installation methods E to H of Table 9A (Clipped directly)			
	2 cables, single-phase a.c or d.c.		3 or 4 cables, three-phase a.c		2 cables, single-phase a.c or d.c.		3 or 4 cables, three-phase a.c	
	Current carrying capacity	Volt drop per amper per meter	Current carrying capacity	Volt drop per amper per meter	Current carrying capacity	Volt drop per amper per meter	Current carrying capacity	Volt drop per amper per meter
1	2	3	4	5	6	7	8	9
mm²	A	mV	A	mV	A	mV	A	mV
1.0	14	42	12	37	17	42	16	37
1.5	17	28	14	24	21	28	20	24
2.5	24	17	21	15	30	17	26	15
4	32	11	29	9.2	40	11	36	9.2
6	41	7.1	37	6.2	50	7.1	45	6.2
10	55	4.2	51	3.7	68	4.2	61	3.7
16	74	2.7	66	2.3	90	2.7	81	2.3
25	97	1.7	87	1.5	118	1.7	106	1.5
35	119	1.3	106	1.1	145	1.3	130	1.1
		a.c. d.c				a.c d.c		
50	145	0.97 0.91	125	0.84	175	0.93 0.91	160	0.82
70	185	0.71 0.63	160	0.62	220	0.65 0.63	200	0.59
95	230	0.56 0.45	195	0.48	270	0.48 0.45	240	0.45
120	260	0.48 0.36	220	0.42	310	0.40 0.36	280	0.38
150	-	- -	-	-	355	0.34 0.29	320	0.34
185	-	- -	-	-	405	0.29 0.24	365	0.30
240	-	- -	-	-	480	0.24 0.18	430	0.27
300	-	- -	-	-	560	0.22 0.14	500	0.25
400	-	- -	-	-	680	0.20 0.12	610	0.24
500	-	- -	-	-	800	0.18 0.086	710	0.23
630	-	-	-	-	910	0.17 0.068	820	0.22

Source: IEE Regulation (Table 9D1), 15th Edition.

APPENDIX 4

Current-carrying capacities and associated voltage drops for twin and multicore armoured p.v.c. insulated cables (aluminium conductors).

BS 6346

Conductor operating temperature: 70°C

Conductor cross-sectional area	Installation methods E, F and G of Table 9A (Clipped directly)					Installation methods E to H of Table 9A ('Defined condition')				
	One twin cables, single-phase a.c or d.c.			One three or four-core cable, three-phase		One twin cables, single-phase a.c or d.c.			One three or four-core cable, three-phase	
	Current carrying capacity	Volt drop per ampere per meter		Current carrying capacity	Volt drop per ampere per meter	Current carrying capacity	Volt drop per ampere per meter		Current carrying capacity	Volt drop per ampere per meter
		a.c	d.c.				a.c	d.c.		
1	2	3	4	5	6	7	8	9	10	11
Mm2	A	mV	mV	A	mV	A	mV	mV	A	mV
16	63	4.5	4.5	55	3.9	66	4.5	4.3	58	3.9
25	83	2.9	2.9	67	2.5	87	2.9	2.9	71	2.5
35	100	2.1	2.0	88	1.8	105	2.1	2.0	93	1.8
50	124	1.6	1.5	105	1.3	130	1.6	1.5	110	1.3
70	157	1.1	1.0	138	0.93	165	1.1	1.0	145	0.93
95	185	0.79	0.77	166	0.68	195	0.79	0.77	175	0.68
120	-	-	-	195	0.54	-		-	205	0.54
150	-	-	-	219	0.45	-		-	230	0.45
185	-	-	-	257	0.37	-		-	270	0.37
240	-	-	-	304	0.30	-		-	320	0.30
300	-	-	-	347	0.25	-		-	365	0.25

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE

Ambient temperature	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Correction factor	1.06	0.94	0.87	0.79	0.71	0.61	0.50	0.35

Source: IEE Regulation (Table 9K3), 15th Edition.

APPENDIX 5

Patients Treated Between 1990 to 2003

Table A1 Patients Treated in 1990

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	743	222	214	436	1179
Feb	826	205	281	486	1312
Mar	447	169	188	357	804
Apr	339	244	236	480	819
May	911	310	341	651	**1562**
Jun	761	212	271	483	1244
Jul	797	274	326	600	1397
Aug	27	312	397	709	736
Sep	11	288	393	681	692
Oct	80	325	349	674	754
Nov	752	239	344	583	1335
Dec	418	225	206	431	849
Total	6,114	3,015	3,530	6,545	12,659

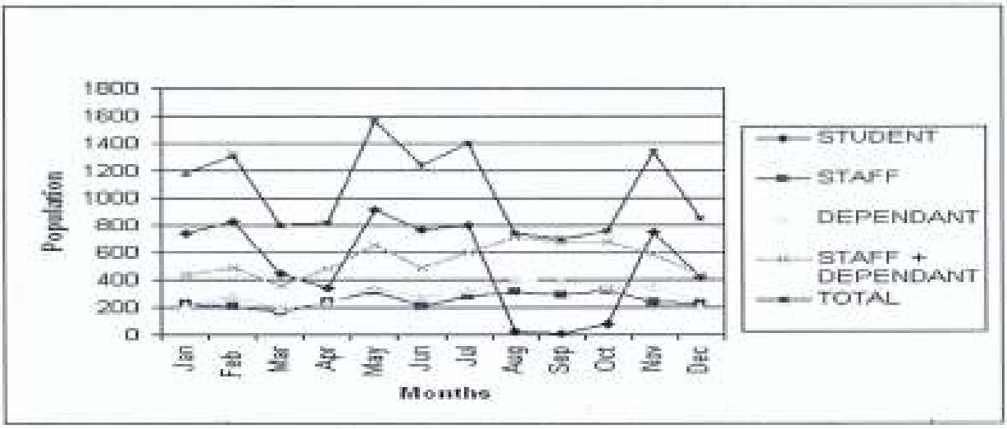


Fig. A1 Patients Treated in 1990

Table A2 Patients Treated in 1991

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	56	235	278	513	1079
Feb	399	237	241	478	877
Mar	440	242	266	508	948
Apr	600	259	267	526	1126
May	427	240	251	491	918
Jun	588	240	312	552	1140
Jul	224	368	333	701	925
Aug	14	198	201	399	413
Sep	3	179	159	338	341
Oct	72	384	265	649	721
Nov	461	278	239	517	978
Dec	408	276	265	541	949
Total	4,282	3,136	3,077	6,213	10,496

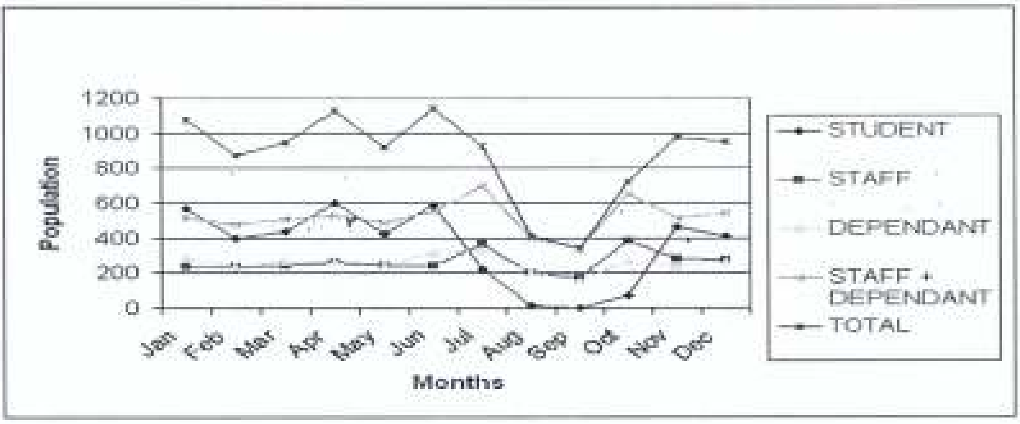


Fig. A2 Patients Treated in 1991

Table A3 Patients Treated in 1992

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	595	267	235	502	1097
Feb	520	282	261	543	1063
Mar	414	255	269	524	938
Apr	633	249	398	647	1280
May	101	293	384	677	778
Jun	11	322	431	753	764
Jul	348	368	436	804	1152
Aug	234	256	253	509	743
Sep	424	274	259	533	957
Oct	727	295	352	647	1374
Nov	187	103	150	253	440
Dec	60	225	207	432	492
Total	4,144	3,189	3,735	6,924	11,068

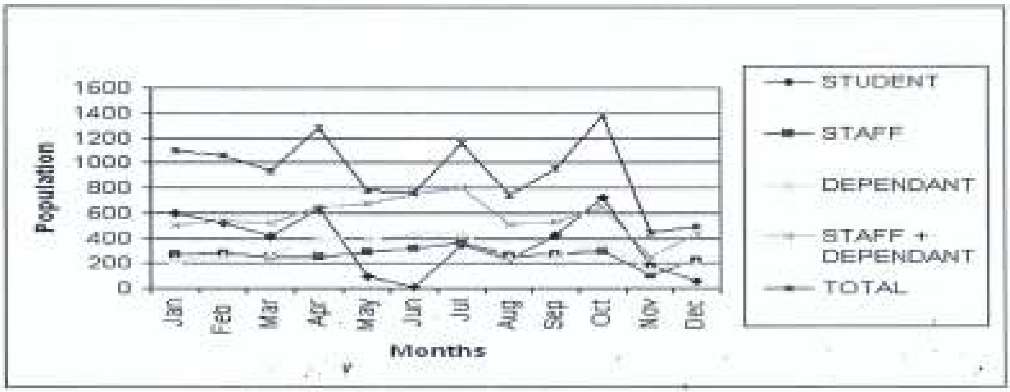


Fig. A3 Patients Treated in 1992

Table A4 Patients Treated in 1993

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	354	246	231	477	831
Feb	1	-	-	-	1
Mar	410	107	101	208	618
Apr	776	244	307	551	**1327**
May	139	291	400	691	801
Jun	69	298	449	747	816
Jul	58	335	479	814	871
Aug	17	212	321	533	550
Sep	20	235	226	461	481
Oct	412	291	406	697	1109
Nov	664	221	202	423	1087
Dec	525	312	342	654	1179
Total	3,433	2,728	3,464	6,192	9,679

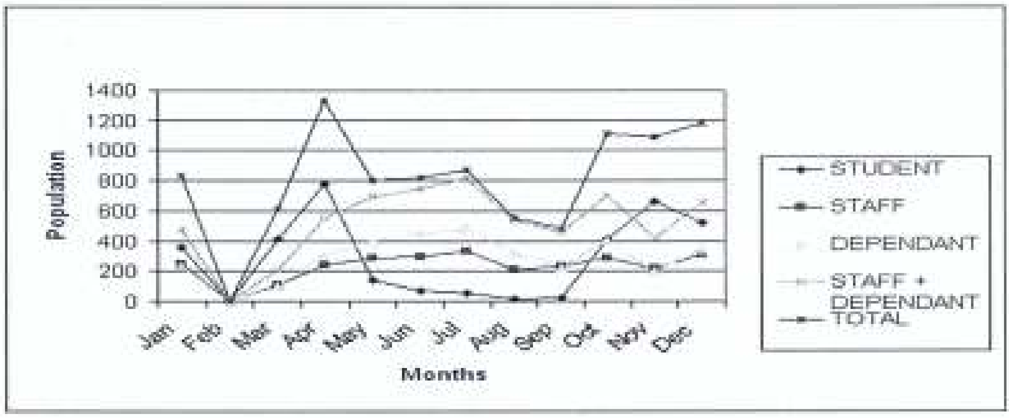


Fig. A4 Patients Treated in 1993

Table A5 Patients Treated in 1994

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	717	279	277	556	1273
Feb	461	294	359	653	1141
Mar	512	330	410	740	1252
April	645	626	335	661	1306
May	1039	338	401	739	1778
June	1304	333	299	632	1936
July	496	415	396	811	1307
Aug	300	412	265	677	977
Sep	74	374	444	818	892
Oct	66	418	448	866	932
Nov	65	436	447	483	548
Dec	32	342	375	717	749
Total	5,711	4,297	4,586	8,883	14,586

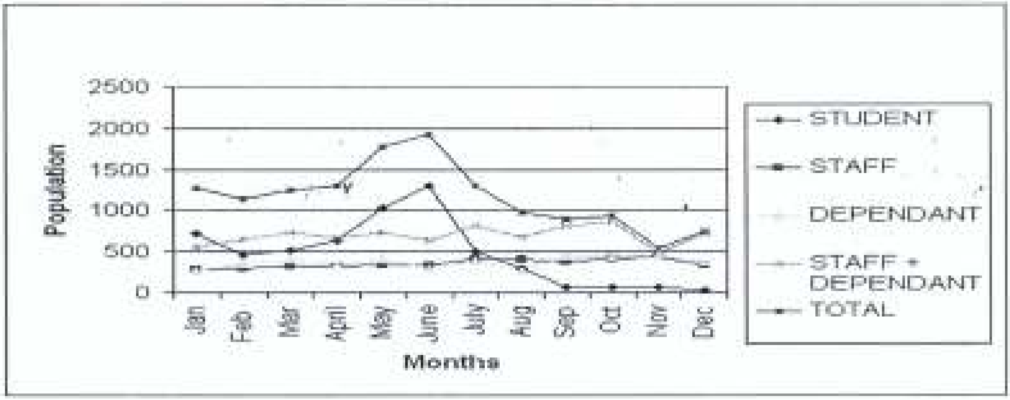


Fig. A5 Patients Treated in 1994

Table A6 Patients Treated in 1995

	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	240	392	495	887	1127
Feb	950	369	406	775	1725
Mar	1025	383	483	766	1791
Apr	920	301	395	694	1614
May	1038	356	482	838	1876
Jun	1089	429	506	935	**2024**
Jul	106	376	494	870	976
Aug	145	331	371	702	847
Sep	59	454	464	918	977
Oct	50	300	446	746	796
Nov	417	285	372	657	1074
Dec	292	228	252	480	772
Total	6,384	4,104	5,166	9,270	15,662

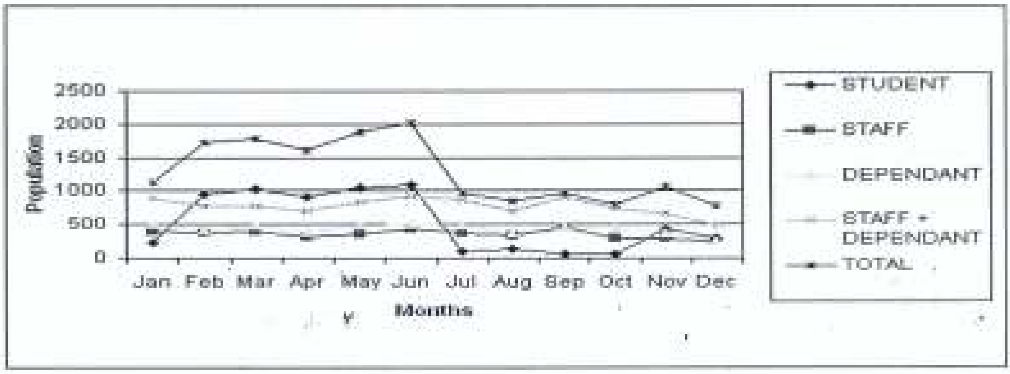


Fig. A6 Patients Treated in 1995

Table A7 Patients Treated in 1996

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	-	2	-	2	2
Feb	-	-	-	-	0
Mar	-	-	-	-	0
Apr	5	93	71	164	169
May	19	318	354	672	691
Jun	12	359	351	710	722
Jul	36	480	595	1075	1111
Aug	21	368	401	769	790
Sep	228	330	389	719	947
Oct	1123	328	477	805	**1928**
Nov	680	182	354	536	1216
Dec	381	228	258	486	867
Total	2,504	2,686	3,150	5,836	8,340

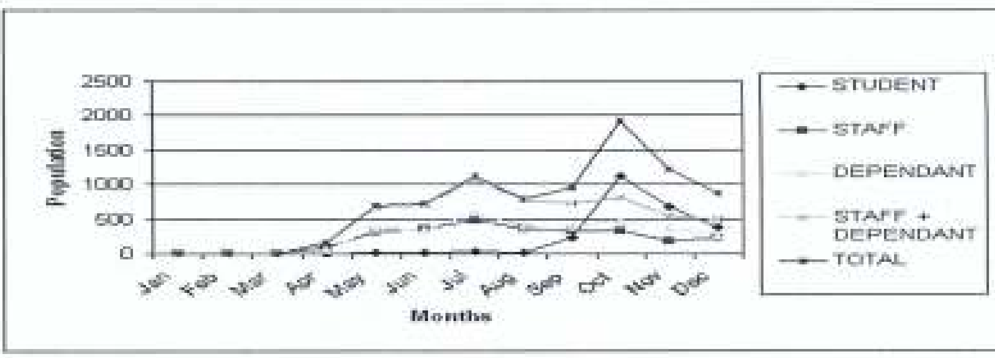


Fig. A7 Patients Treated in 1996

Table A8 Patients Treated in 1997

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	592	236	335	571	1163
Feb	679	196	307	503	1182
Mar	296	285	306	591	887
Apr	98	296	427	723	821
May	618	373	502	875	1493
Jun	988	305	483	788	1776
Jul	1213	304	463	767	1980
Aug	820	262	303	565	1385
Sep	372	307	362	669	1041
Oct	765	379	378	757	1522
Nov	819	319	430	749	1568
Dec	592	256	330	586	1178
Total	7,753	3,518	4,536	8,054	15,806

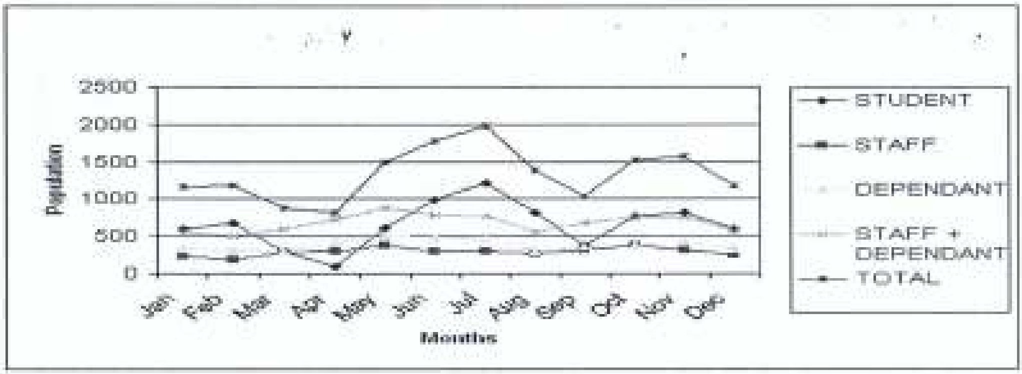


Fig. A8 Patients Treated in 1997

Table A9 Patients Treated in 1998

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	79	260	378	638	717
Feb	316	223	325	548	864
Mar	574	288	261	549	1123
Apr	464	181	187	368	832
May	915	269	384	653	1568
Jun	434	385	550	935	1369
Jul	585	319	418	737	1322
Aug	639	211	277	488	1127
Sep	445	281	280	561	1006
Oct	418	307	439	746	1164
Nov	83	273	451	724	807
Dec	58	228	306	534	592
Total	5,010	3,225	4,206	7,431	12,441

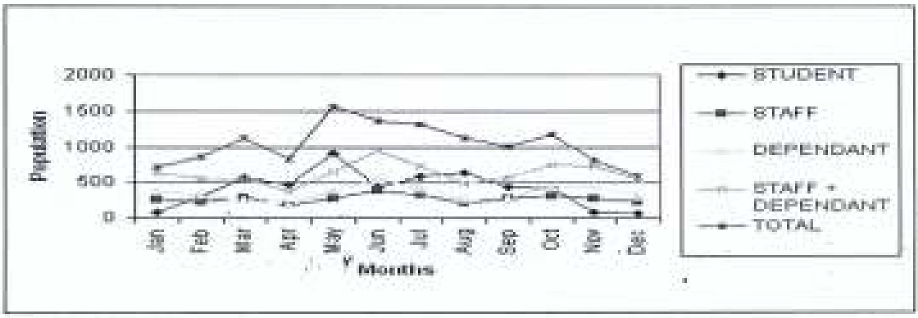


Fig. A9 Patients Treated in 1998

Table A10 Patients Treated in 1999

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	442	211	311	522	964
Feb	238	264	350	614	852
Mar	507	207	289	496	1003
Apr	939	289	388	677	1616
May	953	309	398	707	1660
Jun	1226	431	567	998	**2224**
Jul	190	473	298	771	961
Aug	560	354	397	751	1311
Sep	676	370	447	817	1493
Oct	280	369	426	795	1075
Nov	133	205	297	502	635
Dec	242	252	240	492	734
Total	7,051	3,725	4,314	8,039	15,090

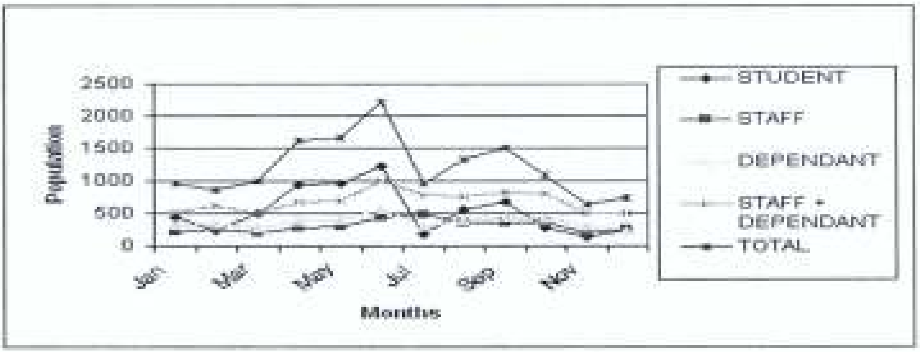


Fig. A10 Patients Treated in 1999

Table A11 Patients Treated in 2000

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	664	843	409	752	1416
Feb	115	100	141	241	356
Mar	-	-	-	0	0
Apr	-	-	-	0	0
May	462	201	264	465	927
Jun	724	224	349	573	1297
Jul	1136	362	568	930	**2066**
Aug	758	301	396	697	1455
Sep	382	339	439	778	1160
Oct	395	318	536	854	1249
Nov	798	310	466	776	1574
Dec	409	321	311	632	1041
Total	5,174	2,281	3,329	5,610	10,790

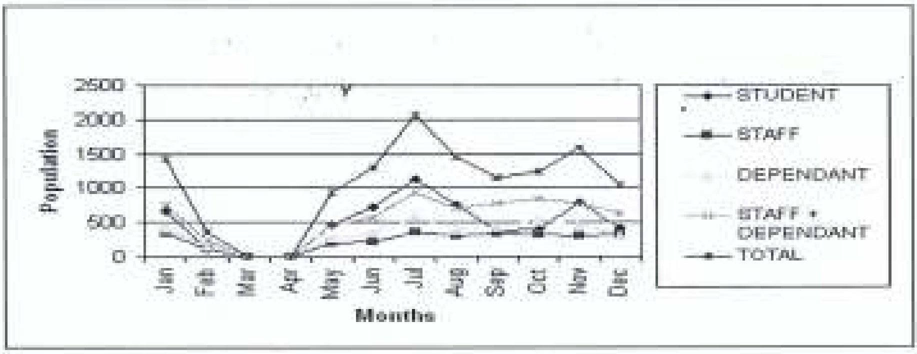


Fig. A11 Patients Treated in 2000

Table A12 Patients Treated in 2001

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	149	232	296	528	677
Feb	140	199	338	537	677
Mar	132	212	280	492	624
Apr	131	278	442	720	851
May	129	889	595	1484	1613
Jun	50	330	512	842	892
Jul	236	238	376	614	850
Aug	372	184	340	524	896
Sep	417	292	341	633	1050
Oct	722	293	486	779	1501
Nov	392	122	274	396	788
Dec	25	39	57	96	121
Total	4,089	2,868	4,217	7,085	11,114

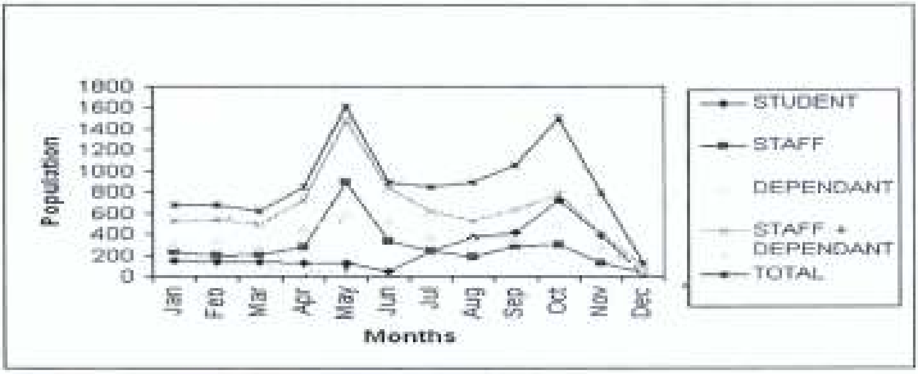


Fig. A12 Patients Treated in 2001

Table A13 Patients Treated in 2002

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	193	220	258	478	671
Feb	460	268	382	650	1110
Mar	379	314	401	715	1094
Apr	418	292	478	770	1188
May	205	288	490	778	983
Jun	204	255	629	884	1088
Jul	399	286	541	827	1226
Aug	610	268	1214	1482	**2092**
Sep	509	177	351	528	1037
Oct	734	184	419	603	1337
Nov	304	234	348	582	886
Dec	69	199	335	534	603
Total	4,501	3,091	5,743	8,834	13,335

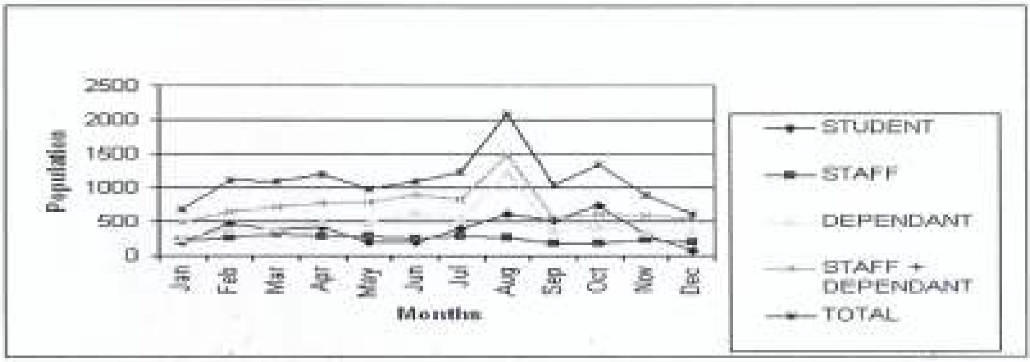


Fig. A13 Patients Treated in 2002

Table A14 Patients Treated in 2003

MONTH	STUDENT	STAFF	DEPENDANT	STAFF + DEPENDANT	TOTAL
Jan	57	388	362	750	807
Feb	-	-	-	0	0
Mar	-	-	-	0	0
Apr	-	-	-	0	0
May	46	44	57	101	147
Jun	240	255	316	571	811
Jul	491	262	479	741	**1232**
Aug	145	84	107	191	336
Sep	420	247	441	688	1108
Oct	177	273	423	696	873
Nov	326	166	331	497	823
Dec	337	151	264	415	752
Total	2,269	1,770	2,780	4,550	6,819

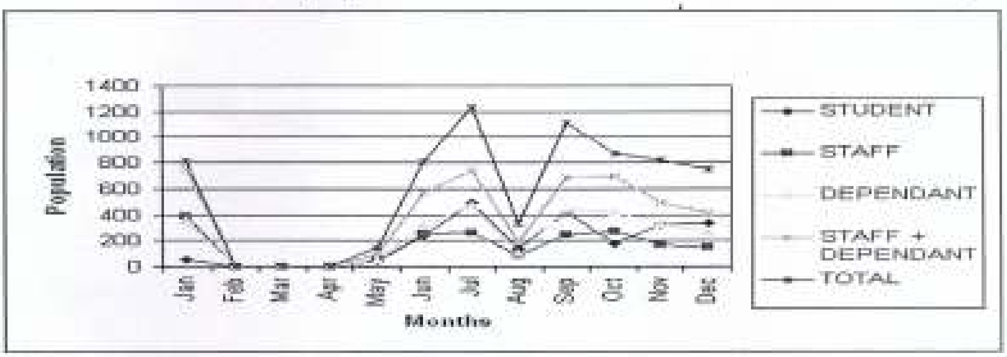


Fig. A14 Patients Treated in 2003