COURSE CODE: *ELE 506*
COURSE TITLE: *Electrical Service Design and Energy Utilization*
NUMBER OF UNITS: *3 Units*
COURSE DURATION: *Three hours per week*

COURSE DETAILS:

Course Coordinator: **Engr S.G. Oyangbinrin**
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Office Location: **College of Engineering building**
Other Lecturers: **None**

COURSE CONTENT:

Design and organization of power supply: rated voltages and frequency. Types of power consumers and their characteristics. Lighting systems and installation: Lighting control circuits. Electrical heating: heating of buildings, electrical furnaces, electrical welding, air conditioning and refrigeration. Electro-chemical processes. Motor control for industrial system: General and special factory drives. Regulations on installation and operation of electrical equipment. Metering and tariff systems.

COURSE REQUIREMENTS:

This is a compulsory course for all 500 level students in the College of Engineering. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

1. Theraja, B.L. and Therajo, A.K. "A textbook of Electrical Technology". S. Chard & Company Ltd, Ram Nagar, New Delhi – 110055 (2005).
2. Pabla, A. S. Electric Power Distribution 5th Edition New Delhi, Tata McGraw-Hill (2004)
3. Gupta, J.B. A Course in Electrical Power. New Delhi S. K. Kataria and Sons (2001)

LECTURE I

DESIGN AND ORGANIZATION OF POWER: RATED VOLTAGES AND FREQUENCY

1.1 Scope of Electrical Services

Electrical services are usually carried out at distribution voltages of 33kV or below. Very few services to exceptionally large consumers may however be done at a higher voltages; e.g. 66kV to petroleum refineries and 132kV to Ajaokuta steel plant.

Consumers requiring electrical services are grouped into three categories by PHCN for the purpose of billing.
These are:

- Residential consumers
- Commercial consumers
- Industrial consumers

A wide variation exits within each of these groupings in terms of the technical requirements that are imposed on their electrical supplies. The following list of consumer groupings is more selective of similarity in technical requirements:

- Domestic
- Residential estates
- Agriculture
- Industrial
- Recreational
- Transport
- Medical
- Public institutions
- Special supplies, e.g. on ships and aircrafts.

As a general rule, consumer loads less than 200kVA will be supplied from the nearest utility substation transformer at a voltage of 400/230V. For loads in excess of 200kVA, it is usual for one or more h.t. transformers to be installed on the consumer's premises, so that the supply voltage will be either of 11kV, 33kV, 66kV or even 132kV.

1.2 Structure of Supply System

The size of a consumer's load determines:

(i) the voltage at which he is supplied and

(ii) whether or not a resident transformer shall be installed on his premises or not.

1.3 Generation of Electrical Energy

There are basically two methods of generation of electrical energy

1. Conventional methods:
   a. Thermal
   b. Nuclear
   c. Fuel
   d. Hydroelectric

2. Non-conventional Methods:
   a. wind power
   b. Fuel Cells
   c. Photovoltaic cells
   d. The sun
   e. Biomass

1.3.1 Advantages of Electrical Energy

a. Clean
b. Convenient
c. Flexible
d. Easily transmittable

1.3.2 Disadvantages of Electrical energy

a. Cannot be stored
b. Disorganises the skyline

1.3.3 Electrical Energy Generation using Hydropower

Water power is used to drive water turbines which in turn drive the alternators. The water at a high level (P.E) is converted to mechanical energy then electrical energy.

A typical AC System using alternator provides 6.6k or 11kv or 33kv in some cases. The transformer steps up the voltage to 132kv or 110kv for long distance transmission. The receiving station steps the voltage down to 33kv and feeds the substation which further steps the voltage down to 3.3kv and radiates out in a high voltage distribution mains.

There are transformer stations placed at different points near the load centers where the voltage is further stepped down to 400/220 volts. The consumers draw their load at this point. Large consumers however can have their own transformers so that they are fed from 3.3kv lines.

1.4 Alternating current system

There are various ways in which alternating current can be transmitted

1) Single phase (two and three wire systems): The earthing may be done on the secondary of the transformer or in the generator winding itself.

2) Two-Phase Three and four wire systems

3)Three phase three and four wire systems: This is the most common method of a.c transmission.The Generator used has 3 windings spaced 120º apart such that their EMF are equal in magnitude by 120º apart in phase .They are either star or delta connected.

STAR (λ) CONNECTION

The common point in the star connection is the neutral point and is generally earthed either directly or through a resistance or inductance.

In the star system, the line current and the phase current are the same .But the phase voltage is not the same as the line voltage

$I_L = Ip$

$V_L = \sqrt{3}\ Vp$

The power supplied by the star connected system is given to be

Power= Ep Ip CosΦ

Ep= r.m.s phase voltage

Ip= r.m.s phase current

The total power for the three phase system

= 3EpIp CosΦ

= $E_L I_L$ CosΦ

Where E_L and I_L are line voltage and current.

DELTA CONNECTION

In the delta connection, there is no neutral point as the coils are connected together.

The line and phase voltages are the same but the line voltage is √3 times the phase voltage

$I_L = \sqrt{3} I_p$

$E_p = E_L$

The power in a delta system is the same as the power in the star connect system.

P= 3EpIp CosΦ = √3 E_L I_L CosΦ

1.5 Three Phase substation (Three Phase 4-Wire distribution)

Transformer stations are built at or near load centers of the area.The substation contains

1. High voltage switch gear
2. A step down transformer
3. Low voltage fuses and links

The supply to the transformer primary is through a high voltage feeder cable

The low voltage busbars are distinguished by their colour markings,Red ,yellow ,and blue for the lines and black for the neutral

Domestic premises and others needing only a low voltage supply are connected to the distribution by a 2 wire service cable which are T-joined to the distributors. For the purpose of load balancing, consecutive services are connected to the different phase and neutral in turns.

1.6 Supply Systems

Below are the various ranges of supply voltages.

Extra low voltage- 30Vrms or less

Low voltage-250V or less

Medium voltage-251V – 650volts

High voltage -650V – 3000volts

Extra high voltage – above 3000volts

The supply available for distribution is

220v single phase at 50Hz

415v three phase 4wire at 50Hz.

1.7 Variation of Voltage and Frquency

Regulation allows voltages and frequency to vary at $\pm$6% and $\pm$1% respectively. This means that the voltage is stepped up whenever there is a 6% drop in voltage.

LECTURE II

WIRING SYSTEM

1.1 Introduction

Wiring system in general depends on technical and economic suitability for the condition of service.

A wiring system consists of the conductor, its insulation, its mechanical protection and the various accessories such as joint boxes, etc. the system are named in term of mechanical protection employed.

The following factors are considered when embarking upon the planning and the design of electrical installation works.

1 whether the system is to be installed during the construction of a building or in a complete building, or if it is to be an extension of an existing building.
2 safety to persons
3 the type of supply and earthing system available
4 the probable operating and maintenance cost, taking into account the electricity supply tariffs available
5 the relative cost of various alternative methods e.g of wiring in relation to the estimated life of the installation
6 the probable of maximum and minimum ambient air temperature in all parts of the installation
7 the possible presence of moisture or corrosive conditions
8 the probable future extension of the initial installation
9 provision of the future modification and rewiring during the life of the building
10 extent of mechanical protection required
11 possibility of fire or explosive dust, vapour or gas
12 supply continuity and the provision of emergency supply in case of outage or for special use
13 durability

14 aesthetics(appearance)

15 load to be served

16 voltage to be employed-low or medium

17 type of building

The relative weight of the factors listed above will vary with different project; the responsibility of making a choice therefore rests conversant with the condition applying to the particular situation.

Frequently a combination of wiring system may have to be used in one installation. For example, in an industrial installation, the main and sub main cables which will carry heavy currents may be MICC or PVC/SWA/PVC cable. The power circuits may be carried out using screwed conduit system while the lighting circuits may be of PVC-sheathed cables. The engineer who plans the installation will decide which system(s) to be used after due consideration to the various alternatives available.

2.2 Principal Types of Wiring Systems

The following are the types of wiring system employed in practice.

1. screwed metal conduit system. The conduit may be of steel, aluminium or copper.
2. plain unscrewed metal conduit system
3. non metallic conduit system
4. steel trunking
5. PVC insulated cable system
6. armoured cable system. This may be P.I.I.C-paper insulated lead-covered cable
7. mineral insulated copper sheathed system (M.I.C.S) and Alpyro
8. cable duct system
9. bus bar system
10. earthed concentric wiring system
11. bare conductors
12. cleated wiring or exposed wiring
13. wood casing
14. PVC/SWA/PVC, sheathed-PVC insulated, steel wire armoured, PVC covered cable

All cables except Alpyro, whose conductors cross-sectional area of 100mm^2 or less shall be of copper.

2.3 Conduit Work

A conduit may be defined as a tube or channel. In electrical installation work, conduit refers to metal tubing of comparatively light gauge, or to non metallic tubing.

The term conduit system is also used in connection with the underground pick-up system for electric trams. Before steel conduit (made to a specification defined by BS 31: 1940) was introduced and when an alternative to wood casing was being sought, cables were sometimes drawn into ordinary gas pipes.

2.4 The Steel Screwed Conduit System

The modern steel conduit system is divided into two classes: class A, which is plain conduit and class B- which is screwed conduit. Class B screwed steel conduit is made in standard sizes viz: ½″(13mm), 5/8″(16mm), 3/4″(20mm), 1″(25mm), etc.

These are external diameters of conduits. The screwed steel conduit system is the most popular for permanent wiring installation especially for modern commercial and industrial building.

Advantages:

1. good mechanical protection of conductors
2. permits easy rewiring when necessary
3. minimises fire risks
4. provides efficient earth continuity
5. good pleasing appearance when properly installed

Disadvantages:

1. very expensive compared to some system
2. difficulty of installation under wood floors in house and flats
3. corrosion effect due to acid, alkali and fumes
4. formation of condensed moisture under certain condition

The following types of cables may be drawn into steel conduits:

(a) PVC-insulated cables

(b) Butyl or silicon rubber insulated cables with copper or aluminum conductor

(c) PVC-insulated and sheathed cable

IEE regulation table B. 5M and B. 6M gives the maximum number of cables that can be drawn into a given steel conduit. The objective is to allow for easy drawing in (see Reg. B91). This table, along with knowledge of the various sizes of cable to be run in conduit will help the engineer to determine the size of conduit to be used.

Under no circumstances may ordinary flexible cords be drawn into conduits. Cable larger than $95mm^2$ may be drawn into steel trunking or aluminium conduit which is made up to 112mm diameter.

2.5 Screwed Copper Conduits

Advantages:

1. resistant to corrosion
2. provision of excellent continuity
3. increased lifespan of installation

Disadvantages:

1. high cost of installation

Areas of Application:

1. house of common buildings in England, where system is buried in concrete floors and walls.

These conduit can be screwed in the same manner as steel conduits. Connection can also be made by soldering. Bronze junction boxes should be used.

2.6 Aluminium Conduit System

Aluminium screwed conduit is another alternative to steel conduit

Advantages:

1. provision of good continuity
2. corrosion resistant
3. light weight
4. easy handling
5. easy install

6. non magnetic, hence no induction problems with unbalanced ac circuits
7. availability in greater sizes up to 112mm

Disadvantages:

1. corrosion occurrence with copper fittings & pipes
2. corrosion occurrence with damp cement
3. lesser mechanical strength, than steel conduit

2.7 Installation of Metallic (steel, aluminium & copper) Conduits

IEE regulation table B. 5M and B. 6M gives the maximum number of cables that can be drawn into a given steel conduit. The objective is to allow for easy drawing in. Not more than 90^0 bends or their equivalent are permitted between boxes to allow for easy drawing in. A little slack wire should always be left in draw-boxes: it facilitates rewiring and relieves tension on the cable.

Conduits require that generally a space factor of 40% must not be exceeded. The space factor takes into account, the percentage of space occupied by the cables, in the conduit.

Example:

Calculate the size of conduit require to enclose three $4mm^2$ and six $1.5mm^2$ 230v PVC insulated cables. Assuming a space factor of 40%.

Solution:

From IEE table B. 5M,

Overall diameter of $4mm^2$ PVC cable = 4.3mm

Overall diameter of $1.5mm^2$ PVC cable = 3.1mm

C.S.A of three $4mm^2$ cable = $\pi/4 \times 4.3^2 \times 3 = 43.54mm^2$

C.S.A of six $1.5mm^2$ cable = $\pi/4 \times 3.1^2 \times 6 = 45.26mm^2$

Total C.S.A= $88.8mm^2$

If x is the internal C.S.A (A) of required conduit then,

For space factor of 40%, $40/100 = 88.8/x$

$x = 222mm^2$

$A = \pi D^2/4$ where D = internal diameter of conduit

$D = \sqrt{(4 \times C.S.A)}/\sqrt{(\pi)} = 16.8mm.$

The chosen size of conduit is 20mm, the nearest diameter.

2.7 Trunking

This is used where a large number of cables are to be installed or where the cable sizes are large.

Trunking is a rigid system; it cannot be bent so the planning must be such that the runs are straight and direct as possible.

Bus Bar Trunking

Wiring systems consisting of copper bus bars supported on insulators are enclosed in steel trunking. This is used where large currents are to be handled. There are two types:

1. Vertical rising mains: - This is used in multi storeyed buildings to carry supply to each floor. A suitable tap off is provided for each floor level.
2. Over head bus bar system provides a convenient method of distributions in a factory or large workshop. It has a plug in tap off points at 3ft intervals allowing for the change of supply position when necessary.

LECTURE III

LIGHTING AND ILLUMINATION

3.1 Introduction

Artificial light is produced by raising a solid body or vapor to incandescence by applying heat to it. A body gradually heated above room temperature radiates energy to the surrounding in the form of electromagnetic waves of various wavelengths. As temperature s increased the wavelength of the **EM** wave reduces and the light emitted tends to white color.

3.2 Defination of some common Lighting terms

Solid Angle: - this is the angle of the area of a sphere covered by a point source.

The unit of a solid angle is called the steridian and it is defined as the angle substended at the center of the sphere by part of its surface having an area equal to $(\text{radius})^2$

Luminous intensity (I):- this is the illuminating power of the light source to radiate luminous flux in a particular direction. The SI unit for luminous intensity is called the **Candela**.

Candela: - this is the unit of luminous intensity of a source. A source of one candela (cd) emits one lumen per steridian hence, the total flux emitted by the point source all round is given to be

$4\pi \times I = \text{lumen}$

Luminous flux (F or Ø): **-** this is the light energy radiated out per second from a body in the form of luminous light wave. The unit of luminous flux is the **Lumen** and this is the amount of light flux emitted by a source of one candela in a unit solid angle. The relationship between the lumen and the power is given as

1 Lumen = 0.0016 watts(approx)

Illuminanace or illumination (E) : - this is the measure of light falling on a surface. This is also called incident radiation

$E = \text{flux}/\text{area} = \text{lumen}/\text{area} = \text{lm}/\text{m}^2$

The unit of illuminance is Lux

Luminance (L): - this is a measure of the brightness of a surface. It is also a measure of the light reflected from the surface. Objects vary in appearance due to the amount of light that reflect towards the eye. The SI unit of luminance varies with variation in the surface.

3.3 Laws of Illumination

The illumination (E) of a surface is guided by a number of factors depending on the assumption that the source is a pint source sufficiently away from the surface.

1. E is directly proportional to I: - illumination E is directly proportional to the luminious intensity I

$$E \quad \alpha \quad I$$

2. Inverse Square law: - the illumination of a surface is inversely proportional to the square of the distance of the surface from the source

$$E = I/d^2 \text{ (Lux)}$$

3. Lamberts Cosine Law: - this law states that E is directly proportional to the cosine of the angle made by the normal to the illuminated surface with the direction of the incident flux.

$$E = I\cos\theta/d^2 \text{ (lux)}$$

Example: -

A lamp of luminous intensity if 1000candela is suspended 2metres above a table. Calculate the illuminance directly below the lamp.

Solution:

$$E = I/d^2 \text{ (lux)} = 1000/2^2 = 250 \text{ lux}$$

If the table is lowered to 4meters away from the lamp then

$$E = 1000/4 \text{ x } 4 = 62.5 \text{ lux}$$

Exercise1

A street lantern suspends a 2000cd light source 4m above the ground. Determine the illuminance directly below the lamp and the 3m to one side of the lamp base.

Exercise2

A discharge lamp is suspended from a ceiling 4m above a bench. The illuminance in the bench below was 300lux find

1. The luminous intensity of the lamp
2. The distance along the bench where the illuminance falls to 153.6lux

Exercise3

A lamp giving out 1200lm in all directions in suspended 8m above the working plane. Calculate the illumination at a point on the working plane 6m away from the foot of the lamp.

Exercise4

A corridor is lighted by 4lamps spaced 10m apart and suspended at a height of 5m above the center line of the floor. If each lamp gives out 200 candela in all directional below the horizontal. Find the illumination at the point on the flooe midway between the second and third lamps

3.4 Illumination requirements for different purposes

The activities carried out in a particular location determine the illumination required. At full noon, the sun provides about 120,000 Lux while near the window values at about 600lux are available.

The eye has the capability of working with various illumination ranges. The table below displays illumination values for some applications

TASK	**WORKSTATION**	**ILLUMINANCE(LUX)**
Casual seeing	Storage rooms , stairs	100
Rough assembly	Workshop and Garages	300
Reading and writing	Classrooms and offices	500
Fine assembly	Electronic component assembly	1000

3.5 Design of Lighting Schemes and Layout

A well designed lighting scheme

1. Provides adequate illumination
2. Avoids glare and hard shadows
3. Provides sufficiently uniform distribution of light over the working plane.

There are several approaches to an efficient design

3.6 Calculation of Illumination by Lumen method

This method assumes that in a room or workshop, the lamp total output in lumen is available tp give a uniform level of illumination on the working plane or desktop. The formula used is given below:

$$N = E \times A / Ø \times CU \times MF = \text{No of luminances required}$$

Where E = illumination, A= area, Ø= flux, CU = coefficient of utilization, MF= maintenance factor

3.7 Coefficient of Utilization(CU) or Utilization Factor (UF) or Illumination efficiency

This factor allows for the losses incurred by absorption of light by walls, floor furniture etc. Dark colors absorb more light than pale colors. It is the ratio of the lumens actually received by a particular surface to the total lumens emitted by that source.

= lumens actually received / lumens emitted by light sources

The factor is affected by

1. The type of lighting system
2. The mounting height of the fittings
3. The color, surface and dimensions of the walls and ceilings

Tables exist which give values of coefficient of utilization for different types of light and absorption factor of the walls.

3.8 Maintenance Factor (MF)

This factor is used based on the assumption that the illumination is reduced due to the accumulation of dust and dirt on the lamp and fitting. A figure of 0.8 is often assumed for MF

3.9 Depreciation Factor

This is also the maintenance factor. It is defined as

P = illumination under actual conditions/illumination when everything is perfectly clean

From the formula discussed, the total useful flux that must reach work area is given as

Total lumens = = E x A / CU x MF

Example

An exam hall is 40m x 20m and requires an illumination at the table level of 350lux. Calculate the no of lamps required when using

a. 80 watts fluorescent lamps giving out 5000lumens
b. 200 watts tungsten lamps giving out 2000lumens

CU = 0.6 and MF – 0.8

Solution

a. N = E x A / x CU x MF = 350 x 40 x 20 / 5000 x 0.6 x 0.8 = 116.7 approx 117 lamps
b. N = E x A / x CU x MF = 350 x 40 x 20 / 2000 x 0.6 x 0.8 = 291.7 approx 292 lamps

Exercise 1

A room 8m x 12m is lighted by 15lamps to a fairly uniform illumination of 100lux. Calculate the CU given that the output of each lamp is 1600lumens

3.10 Spacing of Lamps (Layout of Luminance)

In spacing of lamps, it is done in such a way that they are not placed in the line of vision to cause glare or placed too high to cause a rapid reduction of illuminance (inverse square law) and also make replacement difficult. Large spaces between fixtures may also result in a fall off of illuminacne on work area. It is always assumed that the spacing (distance) between lamp centers in any row is approximately equal in distance between adjacent rows. It is also assumed that the distance between the outside is half the spacing distance. This is done to maintain an even distribution of illumination on the work area.

Space- Mounting height ratio

This is given by the ratio = horizontal distance between two lamps/ mounting height of the lamps

It should not be greater than 1.5 . For higher or more uniform illumination the factor should be less than 1.5.

Space mounting height ratio = x/h. The lamps must be placed symmetrically to have a uniform illumination.

x	2x					
		2y				
		y				

Illuminating a hall 40m X 20m at a level of 350lux with a CU of 0.6 and MF of 0.85, ϕ = 5000 for the fluorescent.

No of fluorescent = 350 x 40 x 20 / 5000 x 0.6 x 0.85 = 109.8 = 110

40 X 20 = 800

xy = 110

20/x = 40/y = distance between two lamps.

Therefore 20y = 40x ; y = 2x

(2x)x = 110 ; $2x^2 = 110$

$x^2 = 55$; x = 7.4

xy = 110 ; y = 110/7.4 = 14.8

approximating, xy = 110

7 X 15 = 105 or 8 X 14 = 112

112 is nearer than 105 to 110 so the total number of bulbs used is 112.

Distance from the wall to the lamp on the last ratio is half the distance between two lamps.

The spacing between the lamps = 20 / 7.4 or 40/14.8 = 2.7

The spacing mounting height ration can be calculated for a table top 2m from the ceiling.

= 2.7/2 = 1.35; This is less than 1.5.

Example:

Estimate the number and wattage of lamps which would be required to illuminate a workshop space of 60 X 15 m using lamps mounted 5 metres above the working plane average illumination required is 100lux, Cu = 0.4, lumuous efficiency = 16lm/w, space mounting height ratio = 1 and a candle power depreciation of 20%(MF = 0.8)

Solution:

Total flux = EA/CU x MF = 100 x 60 x 15 / 0.4 x 0.8 = 281750 lm

Wattage = 281750/16 = 17578 watts = = 17.578 kW

For a space mounting height ratio of 1

Space between the lamps = 5m. The hall lighting layout will be

60/5 = 12

15/5 = 3

Total number of lamps required= 36

Wattage of each lamp = total watage/36 = 17578/36 = 488.28, so 500 watts bulbs are used.

Exercise

A hall 40m x 25m x 6m(high) is to be illuminated with filament lamps to an average illumination of 90lm/m^2 on a working plane placed 1m above the floor. Estimate the suitable number, size and mounting height of the lamps. Sketch the spacing layout. Assume the following. Coefficient of utilization (CU)=0.5, depreciation factor(1/MF)=1.2, spacing height ratio of 1.2.

Size of lamps	200w	300w	500w
Luminous effiency(lm/w)	16	18	20

3.11 Calculation of Illumination by the Point to Point Method

This method is used for the illumination of open places like street. In open places it's permissible to calculate the illumination on the basis of the polar distribution of the light from the lamps using the cosine law.

Exercise

The street lamps along UNAAB Street are rated at 125w each placed 6m above ground level and 20m apart. Compare the illumination midway between the lamps with that illumination 5m from L_1 and L_2 and the illumination below the lamp. Note 1w = 670lumen.

3.12 Zonal Cavity Method

In this method the CU or UF(utilization factor) is estimated by dividing the room space into three separate cavities.

hc, hr and hf are the height of ceiling, room, and floor cavities respectively. hc = 0, if the lamps are ceiling mounted or recessed fitted. hf = 0, if the working plane is to be the floor surface.

The cavity ratios are obtained from:

Cavity ratio = 5 x height (length + width)/length x width

Thus, ceiling cavity ratio = 5hc(length + width)/length x width

Room cavity ratio = 5hr(length + width)/length x width

and floor cavity ratio = 5hf(length + width)/length x width

The length and width refer to the plan dimensions of the room. Having obtained the various cavity ratios, the following steps are followed to obtain the estimated CU or UF.

1. Estimate the ceiling and floor reflectances. Table 1 below is a useful guide.

2. Using the cavity ratios and the reflectance figure assumed in 1 above, obtain the effective reflectances for ceiling and floor cavities (check IES table on this).

3. Next obtain the coefficient of utilization CU or utilization factor UF for the particular lamp fitting to be used (check IES table on this).

IES- Illumination Engineering Society

The maintenance factor depends on

1. Type of lamp 2. Regularity of re-lamping and / or cleaning 3. The environment

The IES has five classifications of dirt and six categories of luminare fittings. The approximate maintenance factors for one category of fitting are shown in Table 2

Table1: reflectance values (source = IES)

Surface	Reflectance range %	
	Office	Industries
Ceiling finishes(white paint)	80-92	80
Walls	40-60	60
Furniture	26-44	35
Floors	21-39	25

Table 2: approximate maintenance factors for one category of fitting

Categories of dirt	MF
Very dirty	0.65
Dirty	0.80
Medium	0.85
Clean	0.90
Very clean	0.95

3.13 Exterior Illumination

Flood Lighting

This is the art of flooding large surfaces with light from powerful projectors for the purpose of beautification, advertisement and commercial or industrial uses.

Flood lights utilize suitable reflectors with 250, 500 or 1000W gas filled tungsten lamps. The projectors can be located on the building or billboard to be lit or located away from it.

Total luminous flux required is given by

$$= E \times A \times W / CU \times MF$$

where W is a waste factor due to overlap. It is taken to be 1.2 for regular surfaces and 1.5 for irregular surfaces.

Example

A billboard 42m wide and 16m high is to be floodlit using projectors of 30^0 beam spread and 1000W lamps giving 20lm/W of the illumination level is $75lm/m^2$ with projectors located at 17m away. Design the flood light scheme.

CU = 0.4, MF = 1/Depreciation factor = 1/1.3, w = 1.2

$$= EAw/CU \times MF = 75 \times 42 \times 16 \times 1.2 / 0.4 \times 0.769 = 196500lm$$

each 1000W lamp at 20lm/watt gives 10000 x 20 = 20000lm

no of lamps = 196500/20000 = 10lamps

LECTURE IV

ELECTRICAL INSTALLATION DESIGN IN DOMESTIC ENVIRONMENTS

4.1 The Consumer Circuit

The consumer circuit consists of the connection in parallel of a group of loads in a final sub circuit to local distributing bus bars in a distribution board.

Each individual load may be separately controlled by a switch in its own circuit. The separate groups are controlled by fuses or electrical breakers. From this we see that any individual load or groups of load is controlled by circuit breakers, switches or fuse.

From the public utility supply, service is dropped to each residential building. Power flows through the service fuse to the meter. From the meter which serves to measure the energy consumption of the building the power is taken to the distribution board through the isolator (consumer switched fuse). The distribution board comprises of a bank of fuses and circuit breakers. The final sub circuits are all linked to the appropriate fuses for over current and over voltage protection.

4.2 Installation of Distribution Boards in Storey Buildings or Separate Premises

1) <u>Two wire looped-in distribution board:</u>

In this approach, different distribution boards are used for different floors. The different DBs are connected by looping-in from one to another.

<u>Advantages</u>

1. This method requires less wiring

Disadvantages

1. If a fault in any part of the rising occurs in any part of the rising mains due to any of the flats, the main fuses will blow disconnecting the entire installation.
2. High capacity service fuses are required.
3. All the flats utilize one meter so no separate bill is possible

(2) Two wire installation (separately controlled)

This approach utilizes a main distribution board from which the various flats are fed. The fuse ratings of the distribution board is such that faults from any flat blows only the fuse for that flat without bringing down the whole installation.

Advantages

1. The system is more immune to failure.

Disadvantages

1. More DBs are required (Main DB).
2. More wiring is required for each of the DBs in the flats.

4.3 Wiring for Industrial and/or Commercial Environments

The energy requirements for Industrial or Commercial environments required to cater for the following types of load.

1. Single phase lighting loads.
2. Single motor loads (star connected) e.g. grinding m/c, small cranes.
3. Three phase motor loads (delta connected).

The power flow to the motor loads is routed through the control panels before getting to the various loads. The lighting loads can also be routed through the control panels but it is not mandatory.

From the dedicated step down transformer, power is fed to the 3 phase meter through the different service fuses for each phase.

LECTURE V

WIRING FOR INDUSTRIAL AND/OR COMMERCIAL ENVIRONMENTS

The energy requirements for Industrial or Commercial environments required to cater for the following types of load.

4. Single phase lighting loads.
5. Single motor loads (star connected) e.g. grinding m/c, small cranes.
6. Three phase motor loads (delta connected).

The power flow to the motor loads is routed through the control panels before getting to the various loads. The lighting loads can also be routed through the control panels but it is not mandatory.

From the dedicated step down transformer, power is fed to the 3 phase meter through the different service fuses for each phase as shown below.

LECTURE VI

WIRING FOR LIGHTING

6.1 Introduction

Looping-in is the normal method for wiring final subcircuits. It eliminates the need for soldering in the circuit wires. A figure is used to show the wiring system for 7 lamps. 2 of these lamps are controlled by a one way switch, 3 are grouped together and controlled by a one way switch and another 2 by a one way switch.

With the loop-in method, individual sections can be isolated and they can also be expanded. All the neutrals are joined together. For the actual installation of the lighting wiring, the 3 plate ceiling rose fixture is used. The 3 plate ceiling rose has three terminals. One for the live, one for the neutral and one for the switch.

Looping-In Switches

The ceiling rose which provides a better alternative to the junction box provides an extra terminal for the purpose of looping the light feed

Intermediate Switching

The control of a lighting point or a number of lighting points from 3 or 4 separate positions is made possible by the use of 1 or 2 intermediate switching arrangements. An intermediate switch is a double two way switch made in such a way that when one half is on the other half will be off.

Four Point Control of 3 Lights

This will utilize 2 intermediate switches and 2 way switches as shown below.

The lamps will be on with the switch settings above. A charge of state of any of the switches will put the lamps off.

Series-Parallel Switching

These are special switches used where alternative levels of brightness are required e.g. in hospitals. The switch has three positions (i) OFF (ii) DIM (iii) FULL.

When the switch is in DIM position the lamps are connected in series with each (for a two lamp/switch installation) receiving half voltage. When the switch is on FULL the lamps are then in parallel.

6.2 Location of Switches

1. Light switches must be easily accessible when entering a room

A switch placed behind the door will require the person to enter the room first and search for the switch before putting on the light. This is not good enough. The better position is shown in fig(b) where the position does not need to enter the room before switching on the light.

2. When a room has two or more entrances, each entrance to that room must have a switch to put on the light in the room.

3. All hallways and stairs must be lighted by switches located at both ends. The light sources may be located midway.

4. All work areas (sinks, bath tubs etc.) must be lighted in such a manner as avoid shadows on the work surface. An example of kitchen is shown

The light source should be located over the work area to avoid shadows on the work area.

5. All outside features must be water proof.

6. Switches are to be placed outside the bathrooms and not inside.

BILL OF ENGINEERING MEASUREMENT AND EVALUATION(BEME)

The BEME is a document prepared by the engineer to give a client the cost of his job based on the unique conditions of his site. Each section of building required is listed and the cost of labour per section is listed. These are then added up to become the cost of the total project presented in the total sum.

BEME enables the work to be valued as constructed.

Billing in Engineering Project is concerned with

1. Material specification – This involves specifying the right material that is best suited for the job based on criteria such as availability etc.
2. Material Quantification – This involves quantifying the materials needed for each section.
3. Bill – This involves writing of the cost of each of the materials and everything hat has to do with the project. This is the addition of the money column to the quantities.

BEME provides the engineer the opportunity to prepare all the three aspects of billing in an Engineering project. With this, the projects can be easily quantified and the issue of variation which leads to abandonment of project is reduced.

The preparation of BEME is divided into three stages:

1. Measurement of the dimensions from the drawings (take off)
2. Working out the volumes, areas etc and entering the results on the abstract which collects and classifies them in a recognized order.
3. Casting up the abstracts: - This involves reducing the totals to recognize units and transferring the results to a bill having a money column ready for pricing.

Stages 2 and 3 are known as working up.

TAKING OFF

Taking off refers to the method of starting with the writing of the bill. It involves measuring the dimensions from the drawings and quantifying the work. A special format shown below is used. A four column table shown below is used for the dimensioning.

(1)	(2)	(3)	(4)

Column 1 – Time-sing column. It is used to indicate the number of similar items.

Column 2 – Dimension column. It is used to set down the measurements as taken.

Column 3 – Squaring column. This is used for setting out the calculated areas or volumes etc of the measurement in column 2.

Column 4 – Description column – This is used to write down the description of the work to which the dimensions in column 2 apply.

On the extreme right hand side of the sheet (called waste) calculations can be made. There are two sets of columns on a single A4 or foolscap paper and this paper is called the dimension paper. Several sheets can be used with the first one called the master sheet and the others as slave sheets.

All dimensions are to be in any of the four forms below

1. Cubic measurement for volume
2. Square measurements for areas
3. Lineal measurements for lines
4. 'Numbers' for numerical items

In setting out dimensions, they are assumed to be in meters in the form, horizontal length, horizontal width, vertical depth or height. Errors in the dimensioning are to be indicated by a 'nil' in the squaring column and the total number of items nilled are to be bracketed together.

WORKING-UP

Working up is the process whereby the measured dimension and descriptions are converted to the finished bill (BEME). It involves squaring dimensions, casting up their totals and entering the result on the abstract which collects and classifies them in a recognized order in preparation for writing the bill ready for pricing

Abstracting is the process where similar items are grouped together according to a format for the purpose of attaching the cost.

BILLING

This involves the biller writing out full and proper descriptions for the items in the taking off from the abstract and transferring them to a format for costing. The bill of each section and subsections are preceded with a clause to describe the bill content.

Preliminary section of BEME

Preliminaries is the first section of BEME. It covers all temporary work that are to be executed for the main work to be carried out efficiently. Examples include temporary office site, power supply, water etc.

The BEME document contains the following:

1. Day work schedule: - This is included if there is a probability of unforeseen work (outside the items included in the bill) when it is high. It is made up of
    a. A list of various classes of labour, material and plants for which the basic day work rates or prices are to be inserted by the bidder.
2. Provisional Sums: - These are sums used to cover
    a. Work to be executed which has not been specified in detail.
    b. Work to be executed by a sub contractor.
    c. Contingencies
3. Prime Costs: - This is the cost of specialized work or goods to be supplied by other contractors. This is entered into the BEME as a prime cost item (P.C item) e.g. Machinery, Electrical Work, Special doors etc. The engineer must know the cost of these items and include them in his bid.

Preparation of Realistic cost Estimates

The probable constitution cost of a project is prepared from the BEME, working drawings and specifications.

The following steps are used for accurate costing:

1. Carry out market survey to know the prevailing price the components.
2. Make allowance for handling and freight
3. Plant, machine costs (assumed to be 30 – 35% of cost of materials)
4. Overhead (utility cost, staff salaries, fueling etc.)(1% - 2%)
5. Profit (10 – 15% of total cost).

The items that go into the BEME include

1. Preambles stating the standard to which the BEME was prepared
2. Work items
3. Grand summary
4. Provisional sum
5. Prime cost

6. Billed items

The final contract sealing amount is made up of

= contract sum + contingencies + personal sum + prime sum cost

The contingency is not part of the contract sum. It is 10% of the total sum. The provisional sum, prime cost or contingency will be released to the contractor only when the engineer approves.

CONTRACT

The contract is the written and signed agreement between the employer and the contractor stating the obligation of each party. The contract documents in engineering includes the following

1. Drawings
2. Conditions of the contract (General & specific conditions for the payment)
3. BEME (Priced BEME)
4. Signed Agreement
5. Letter of award
6. Completed form of tender

The contractual agreements also contains the

i. Performance bond
ii. Insurance of works
iii. Insurance of workers

BEME Format

s/no	Item describtion	Unit	Quantity	Rate	Amount