



EEE 414: Electrical Services Design

Course Schedule:

Time: 11am-1:30pm, Wednesday, Venue - VLSI Lab

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EEE, BUET

EEE 414: Electrical Services Design

Lectures based on

BNBC 2020 (Vol. 3, Part VIII, Ch. 1): Electrical and Electronic Engineering Services for Buildings

Lecture1:	Module1:	INTRODUCTION
Lecture2:	Module2:	LIGHTING AND ILLUMINATION
	Module3:	DESIGN/DRAWING OF ELECTRICAL INSTALLATIONS
Lecture3:	Module4:	Distribution Wiring in a Building
	Module5:	Power Supplies in a Building
Lecture4:	Module6:	Earthing System Design
	Module7:	Lightning Protection System Design
	Module8:	Data/Telecom, FDAS, Security System Design
	Module9:	Compliance Issues of a Building

M2: LIGHTING AND ILLUMINATION- Outline

- Principle of Lighting
- Planning the Brightness Pattern
- Lighting Calculations
- Recommended Illumination Values
- Artificial Lighting to Supplement Daylight
- Selection of Appropriate Light Fittings
- Illumination of Exit Signs & Means of Escape
- Selection of Appropriate Type of Lamps

Determination of Illumination Levels for Different Applications (Principle of Lighting)

1.2.1 Principle of Lighting

The essential features of an efficient lighting system are:

- (a) Visual comfort through adequate illumination of the working surface,
- (b) Prevention of glare,
- (c) Avoidance of shadows, and
- (d) Ease of maintenance.

The design of a lighting system shall **involve**:

- (a) careful planning of the brightness and colour pattern within both the working areas and the surroundings so that attention is drawn naturally to the **important areas**, details can be seen quickly and **accurately**, and the appearance inside the room is free from any sense of monotony.

1.2.1 Principle of Lighting

- (b) use of **directional lighting** to assist perception of task detail,
- (c) controlling **direct and reflected glare** from light sources to eliminate visual discomfort,
- (d) **minimizing flicker** from certain types of lamps and paying attention to the **colour rendering properties** of the light,
- (e) the correlation of lighting throughout the building to prevent excessive differences between adjacent areas, so as to reduce the risk of accidents, and
- (f) the installation of **emergency lighting systems**, wherever necessary.

1.2.1 Principle of Lighting

The general **impressions** associated with different **illuminance** and **colour appearances** of light are shown in **Table 8.1.1**. The various **colour rendering groups** with examples of use are presented in **Table 8.1.2**.

Table 8.1.1: General Impressions Associated with Different Illuminance and Colour Appearances

Illuminance (lux)	Associated Impression (Colour Appearance)		
	Warm	Intermediate	Cool
≤ 500	Pleasant	Neutral	Cool
500 – 1000	Pleasant to Stimulating	Neutral to Pleasant	Cool to Neutral
1000 – 2000	Stimulating	Pleasant	Neutral
2000 – 3000	Stimulating to Unnatural	Pleasant to Stimulating	Neutral to Pleasant
≥ 3000	Unnatural	Stimulating	Pleasant

Table 8.1.2: Lamp Colour Rendering Groups

Colour rendering Group	Range of Index Ra	Colour Appearance	Examples of Use
1	$R_a \geq 85$	Cool	Textile industries, paint and printing industries
		Intermediate	Shops, hospitals
		Warm	Homes, hotels, restaurants
2	$70 \leq R_a < 85$	Intermediate	Offices, schools, department store, fine industrial work
3	$40 \leq R_a < 70$		Interiors where colour rendering is of comparatively minor importance

Note: Certain applications, e.g. colour matching, may be extremely critical with regard to the colour rendering properties of the lamps used. Here, the minimum colour rendering index used shall be 90.

Planning the Brightness Pattern

1.2.2 Planning the Brightness Pattern

The brightness pattern seen within an interior is composed of three parts:

- (a) Brightness of the **task** itself.
- (b) Brightness of the **immediate background** of the task and
- (c) Brightness of the **general surroundings** of walls, ceiling, floor, equipment, furnishing etc.

1.2.2.1 The illumination of all work areas within a building shall be a minimum of 150 lux.

1.2.2 Planning the Brightness Pattern

1.2.2.2 Where work takes place over the whole utilizable area of a room, the **general illumination** over that area shall be reasonably **uniform** and the **diversity ratio** of **minimum to maximum illumination** shall not be less than **0.7**. This diversity ratio does not however take into account of the effects of any local lighting provided for specific tasks.

1.2.2.3 When the brightness appropriate to an occupation has been determined, the brightness of the other parts of the room shall be planned to give proper emphasis to visual comfort and interest. The recommended brightness ratios are shown in Table 8.1.3.

Table 8.1.3: Brightness Ratios between Task, Adjacent Sources and Surroundings

For high task brightness (above 100 cd/m²) Maximum ratio between task brightness and the adjacent sources like table tops Maximum ratio between task brightness and illumination of the remote areas of the room not being used as work areas	3 to 1 10 to 1
For low and medium task brightness (below 100 cd/m²)	The task must be brighter than both the background and the surroundings; the lower the task brightness, the less critical is the relationship.

Specs of an Emergency LED Light

Actual Wattage (W)	12W
AC Luminous Flux (Lm) (Battery full charge)	1080
Efficacy (lumen/watt)	90 (in ac)
DC Luminous Flux (Lm), (initial) (charging)	420
Charging Time	6-8 Hours
Color Temperature (CCT)	6500k
Color Rendering index (CRI)	≥80
Input Voltage (V)	140-270V
Frequency (Hz)	50-60 Hz
Current (A)	0.048
Power Factor	≥0.5
Beam Angle	180°



Specs of an Emergency LED Light

Lifetime for AC input (Hours)	25000
Lighting Duration DC (Hours, Backup Time)	2 Hour
Overcharge Protection	YES (4.2V)
Over discharge Protection (For LV)	YES (2.4V)
AUTO ON (Available/Not)	YES
Battrey Capacity	2000mAH
Battery Type	18650 Li-ion
Housing/Fitting Material	heat-conducive & insulating Plastic
Cover Material	PC
Fitting Heat Material	Metal
Fitting Ring Colour	White
Product Dimension ø x H (mm), Weight	156*ø80.5, 250 gm

Lighting Calculations

1.2.3 Lighting Calculations

1.2.3.1 In order to determine the necessary number of lamps and luminaires for a specified illumination level or the average illuminance obtained from a particular lighting design, the **Lumen Method** of calculation shall be employed.

1.2.3.2 Unless the **reflection factors** are known to the lighting designer, the triplet **0.7/0.5/0.3** for the reflectance of **ceiling, walls and working plane** respectively shall be used for **offices** and the triplet **0.7/0.5/0.1** for **other premises**. Typical reflection factors of smooth coloured surfaces are given in **Table 8.1.4**.

Table 8.1.4: Reflection Factors of Smooth Coloured Surfaces

Colour	Reflection Factor	Colour	Reflection Factor
Flat white	0.75 – 0.85	Light green	0.40 – 0.50
Ivory	0.70 – 0.75	Grey	0.30 – 0.50
Buff	0.60 – 0.70	Blue	0.25 – 0.35
Yellow	0.55 – 0.65	Red	0.15 – 0.20
Light tan	0.45 – 0.55	Dark brown	0.10 – 0.15

Recommended Illumination Values

1.2.4 Recommended Illumination Values

The recommended values of illumination required for buildings of different occupancies, based on activity, are given in **Tables 8.1.5 to 8.1.14**. The initial illuminance should be higher than the recommended value as the illuminance **drops** below this value by the end of the **cleaning and replacing period**. A gradual transition (rather than a sudden change) of brightness from one portion to another within the field of vision is recommended to avoid or minimize glare discomfort.

Table 8.1.5: Recommended Values of Illumination for Residential Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Dwelling Houses			
Bedrooms		Entrance halls	150
General	70	Reception and accounts	300
Bed-head, Dressing table	250	Dining rooms (tables)	150
Kitchens	200	Lounges	150
Dining rooms (tables)	150	Bedrooms	
Bathrooms		General	100
General	100	Dressing tables, bed heads, etc.	250
Shaving, make-up	300	Writing rooms (tables)	300
Stairs	100	Corridors	70
Lounges	100	Stairs	100
Garages & Porches	100	Laundries	200

Table 8.1.6: Recommended Values of Illumination for Educational Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
School and College		Assembly halls	
General	150	Offices	300
When used for examinations	300	Staff rooms and common rooms	150
Platforms	300	Corridors	100
Class and Lecture Rooms		Stairs	100
Desks	300	Gymnasium	100
Black boards	300	General	150
Embroidery and sewing rooms	500	Matches	300
Laboratories	350	Library	see Table 8.1.8
Art rooms	400	Living quarters	see Table 8.1.5

Table 8.1.7: Recommended Values of Illumination for Health Care Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Hospitals and Clinics		Hospitals and Clinics (contd.)	
Reception and waiting rooms	150	Doctor's examination rooms	150
Outpatient department	150	Radiology departments	100
Wards		Casualty	150
General	150	Stairs and corridors	100
Beds	150	Dispensaries	250
Operating theatres			
General	300		
Tables (with adjustable operation lamp lighting)			
Minor	2000		
Major	5000		

Table 8.1.8: Recommended Values of Illumination for Assembly Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Cinemas			
Foyers	150	Foyers	150
Auditorium	100	Auditorium	70
Corridors	100	Corridors	90
Stairs	150	Stairs	150
Libraries			
Indoor Sports Centre			
Shelves (stacks)	150	Halls	200
Reading rooms (newspapers and magazines)	200	Swimming pools	250
Reading tables	300	Lawn or table tennis, badminton, volley ball	
Book repair and binding	300	Tournament	300
Cataloguing, sorting and stock rooms	150	Club	200
Museums and Art Galleries		Recreational	150
Museums			
General	200	Shooting ranges	
Displays	special lighting	On target	300
Art galleries			
General	250	Firing point	200
Paintings	250	Range	100
Restaurant			
Dining rooms	150	Football	
Cash desks	300		500
Self-carrying counters	300		
Kitchens	200		
Cloak-rooms and toilets	100		

Table 8.1.9: Recommended Values of Illumination for Business and Commercial Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Airport Building			
Reception areas (desks)	300	Waiting rooms and consulting rooms	150
Baggage, customs and immigration halls	300	Corridors	70
Circulation areas, lounges	200	Stairs	100
Banks			
Counter, typing and accounting book areas	300	Eyesight testing (acuity) wall charts and near vision types	450
Public areas, lobby	150	Jewellery and Watch-Making	
Offices	200	Fine processes	700
Book Binding			
Pasting, punching and stitching	200	Minute processes	3000
Binding and folding and miscellaneous machines	300	Gem cutting, polishing and setting	1500
Finishing, blocking and inlaying		Laundries and Dry-Cleaning Works	
Dental Surgeries			
Waiting rooms	300	Receiving, sorting, washing, drying, ironing (calendering) and dispatch	200
Surgeries	150	Dry-cleaning and bulk machine work	200
General	300	Fine hand ironing, pressing, inspection, mending and spotting	300
Chairs	special lighting	Offices	
Laboratories	300	Entrance lobby and reception areas	150
Offices (contd.)			
Conference rooms and executive offices	300	Stairs	100
General offices	300	Lift landings	150
Business machine operation	450	Telephone exchanges	
Drawing office		Manual exchange rooms (on desk)	200
General	300	Main distribution frame room	150
Boards and tracing	450	Shops and Stores	
Corridors and lift cars	70	General areas	150 to 300
		Stock rooms	200
		Display windows	500

Table 8.1.10: Recommended Values of Illumination for Industrial Buildings and Processes

Area or Activity	Illuminance (lux)
Aircraft Factories and Maintenance Hangars	
Stock parts productions	450
Drilling, riveting, screw fastening, sheet aluminium layout and template work, wing sections, cowing, welding, sub-assembly, final assembly and inspection	300
Maintenance and repair (hangars)	300
Assembly Shops	
Rough work, for example frame assembly and assembly of heavy machinery	150
Medium work, for example machined parts, engine assembly	300
Fine work, for example radio and telephone equipment, typewriter and office machinery assembly	700
Very fine work, for example assembly of very small precision mechanisms and instruments	1500
Automobile Manufacturing	
Frame assembly	200
Chassis assembly line	300
Final assembly and inspection line	600

Table 8.1.10: Recommended Values of Illumination for Industrial Buildings and Processes (contd. over 13 pages)

Area or Activity	Page Site	Pages
Automobile Service Garages	Beginning	4526
Chemical Works	End	
Chocolate and Confectionery Factories	Beginning	4527
Hand Tailoring	End	
Dairies	Beginning	4528
Electricity Generating Stations (Indoor Locations)	End	
Electricity Generating Stations (Outdoor Locations)	Beginning	4529
Forge Shops and Foundries	End	
Garages	Beginning	4530
Glove Making	End	
Hosiery and Knitwear	Beginning	4531
Rolling mill	End	

Table 8.1.10: Recommended Values of Illumination for Industrial Buildings and Processes (contd. over 13 pages)

Area or Activity	Page Site	Pages
Tin plate mills	Beginning	4532
Machine Shops	End	
Paint Works	Beginning	4533
Printing Industries	End	
Type foundries	Beginning	4534
Rubber Tyre and Tube Manufacturing	End	
Shoe Manufacturing (Leather)	Beginning	4535
Soap Factories	End	
Textile Mills (Cotton)	Beginning	4536
Textile Mills (Silk and Synthetics)	End	
Textile Mills (Silk and Synthetics) (contd.)	Beginning	4537
Textile Mills (Woollen and Worsted)	End	
Wood Working	Complete	4538

Table 8.1.11: Recommended Values of Illumination for Storage Buildings

Area or Activity	Illuminance (lux)
Storage Rooms of Ware House	
Inactive	50
Rough bulky	50
Medium	100
Fine	250

Table 8.1.12: Recommended Values of Illumination for Outdoor Stadiums Colour TV broadcasting

Area or Activity	Illuminance (lux)
Football Stadium	1700
Cricket Stadium	2200

Table 8.1.13: Recommended Values of Illumination for Outdoor open yards

Area or Activity	Illuminance (lux)
Outdoor Car Parking Lot	100
Airport Apron	200
Container Yard	200
Jetty	250

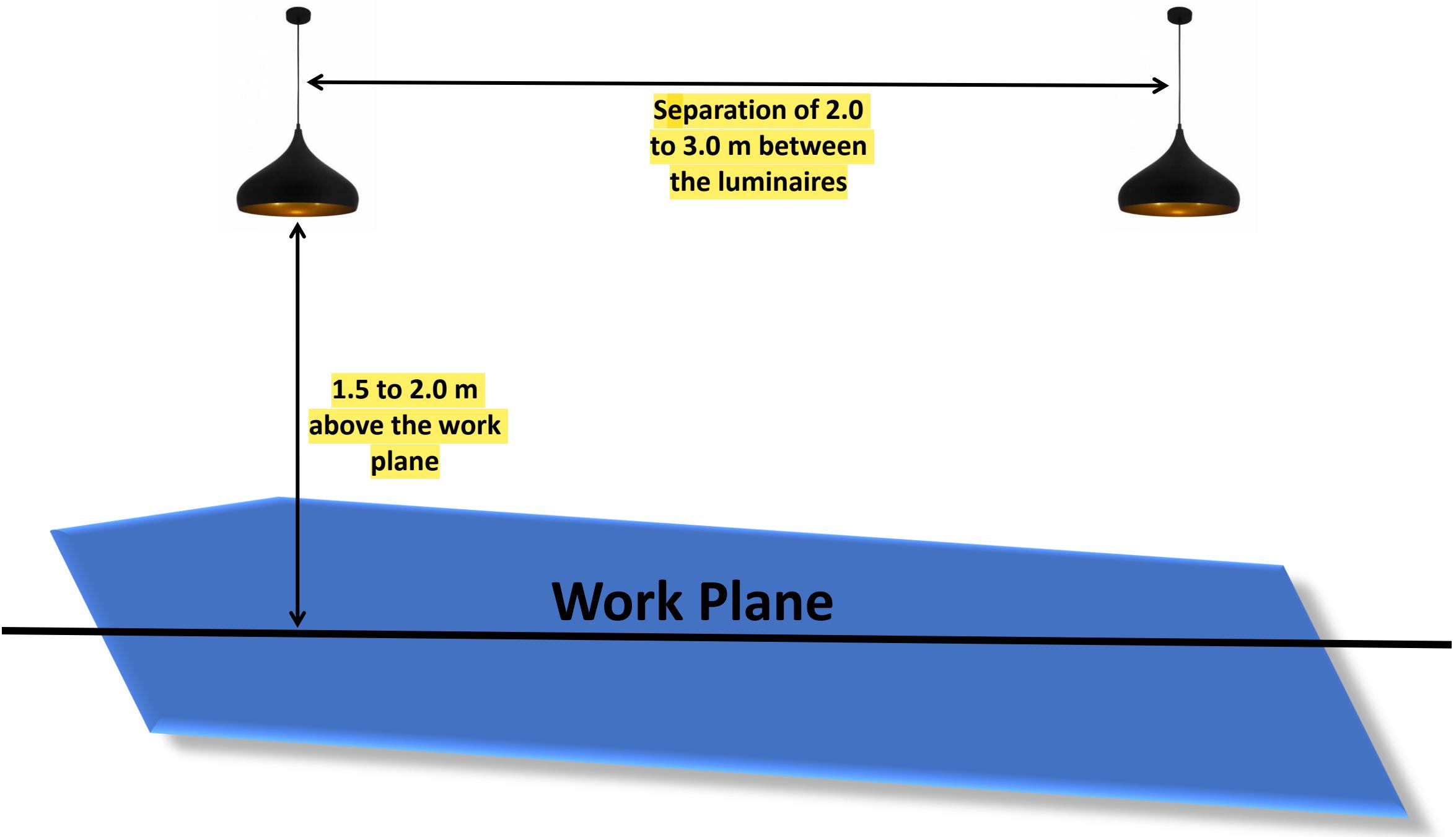
Table 8.1.14: Recommended Values of Illumination for Roads

Area or Activity	Illuminance (lux)
Roads inside a Housing Area	50- 100
Roads in a Congested Town / City Area	50- 100
Wide Roads with dividers	100 - 120
Avenues	100 - 120

Artificial Lighting to Supplement Daylight

1.2.5 Artificial Lighting to Supplement Daylight

Supplementary lighting shall be used when illumination from daylight **falls below 150 lux on the working plane.** For supplementary artificial lighting, when daylight availability becomes insufficient, **cool daylight fluorescent tubes with semi-direct luminaires** are recommended. To ensure a good distribution of illumination, the mounting height should be between 1.5 and 2.0 m **above the work plane** with a separation of 2.0 to 3.0 m between the luminaires.



Selection of Appropriate Light Fittings

1.2.6 Selection of Appropriate Light Fittings

1.2.6.1 Light Fittings

An electric lamp and its fitting accessories, reflector, diffuser, mounting brackets, suspenders etc., shall be regarded as **one unit**. During design, an appropriate type of light fitting shall be selected to match the requirement of desired distribution of light. While selecting light fittings having **focus or aiming** arrangements which enable the light distribution to be varied by **adjustment of the lamp position**, care should be taken to select the appropriate type of fitting with appropriate **beam** to serve the aimed lighting applications.

1.2.6 Selection of Appropriate Light Fittings

1.2.6.2 Classification of light fittings

Light fittings may be classified into **five categories** according to the proportion of the total light output in the lower hemisphere. These are:

- **Direct** fittings, giving **90-100 %** light downwards
- **Semi-direct** fittings, giving **60-90 %** downwards
- **General diffusing**, giving **40-60 %** light downwards
- **Semi-indirect**, giving **10-40 %** light downwards
- **Indirect** fittings, giving **0-10 %** light downwards

1.2.6 Selection of Appropriate Light Fittings

(a) Direct fittings: Direct fittings shall be used in situations where **efficiency** of illumination is the **major criterion**, while contract of the light source with the surroundings, **shadows**, and **direct/reflected glare** may be considered to be of relatively **minor importance**.

(b) Semi-direct fittings: Semi-direct fittings shall be used in areas where it felt that the reduction of contrast resulting from the small indirect component of light directed towards the ceiling shall be sufficient for the purpose.

1.2.6 Selection of Appropriate Light Fittings

(c) General diffusing fittings: General diffusing fittings shall be used where, in addition to a **substantial indirect component** of light aiding materially to the **diffused character** of the general illumination, an upward component providing a **brighter background** against which to view the luminance, especially for **interiors with light-colored ceiling and walls**, is desirable.

(d) Semi-indirect fittings: Semi-indirect fittings shall be used when a **comfortable brightness ratio** between the ceiling and the luminaire is desirable but an **efficiency of illumination, higher than that obtainable from indirect fittings** is required.

1.2.6 Selection of Appropriate Light Fittings

(e) Indirect fittings: Indirect fittings shall be used in situations where an environment of **evenly distributed illumination** is to be achieved.

(f) Angle lighting: Lighting on **vertical surfaces** shall be done **avoiding shadow** using **interior or exterior light fitting** of appropriate type **concentrated source** light fitting depending upon the place and the **color tone** required. If creating shadows is necessary then appropriate type **concentrated source light fitting** should be chosen depending upon the place.

Illumination of Exit Signs and Means of Escape

1.2.7 Exit Signs and Means of Escape

1.2.7.1 Exit signs

- (a) All required exit signs shall be **illuminated at night, or during dark periods** within the area served.
- (b) Exit signs may be illuminated either **by lamps external to the sign or by lamps contained within the sign**. The source of illumination shall provide **not less than 50 lux** at the illuminated surface with a **contrast** of not less than **0.5**. Approved selfluminous signs which provide **evenly illuminated letters** having a **minimum luminance of 0.2 cd/m^2** may also be used.
- (c) Exit signs within an area where the normal lighting may be deliberately dimmed or extinguished, such as places of entertainment, shall be illuminated either by lamps contained within the sign or by self-luminous signs.

1.2.7.2 Means of Escape Lighting

- (a) Means of escape/exit in buildings requiring more than 1 exit shall be equipped with artificial lighting. The lighting facilities so installed shall provide required level of illumination continuously during the period when the use of the building requires the exits.
- (b) Intensity of illumination at **floor level** by means of escape shall not be less than **10 lux**, except that minimum required floor level illumination of **aisles** in assembly halls, theatres and cinema during **projection** by directed light shall not be less than 2 lux.
- (c) The illumination of exit signs and the lighting of the means of escape and exit access shall be powered by an **alternate or emergency electrical system** to ensure continued illumination for a duration of **not less than 30 minutes** after the failure of **primary power supply**.

Selection of Appropriate Type of Lamps

1.2.8 Selection of Appropriate Type of Lamp

The lamps which are used for various purposes are:

- (i) General Service Lamp (GSL)/Incandescent Lamp
- (ii) Fluorescent Lamp (FL)
- (iii) Compact Fluorescent Lamp (CFL) - Energy Saving Lamps
- (iv) LED Lights
- (v) Halogen Lamp
- (vi) Mercury Vapour Lamp
- (vii) Metal Halide Lamp
- (viii) HP Sodium Lamp
- (ix) Low Pressure Sodium Lamp
- (x) Solar PV Cell Powered LED Lights

(i) GSL/Incandescent Lamp

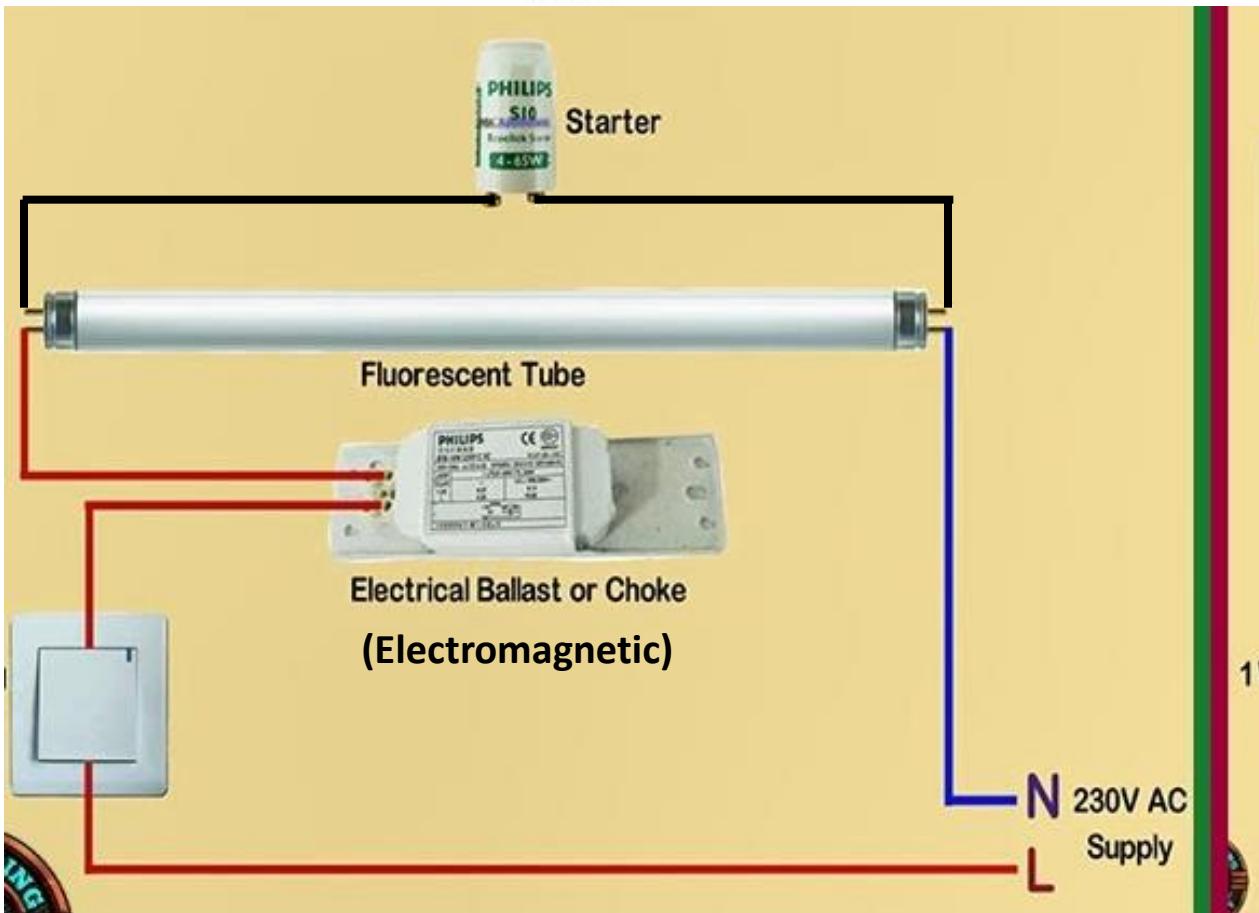
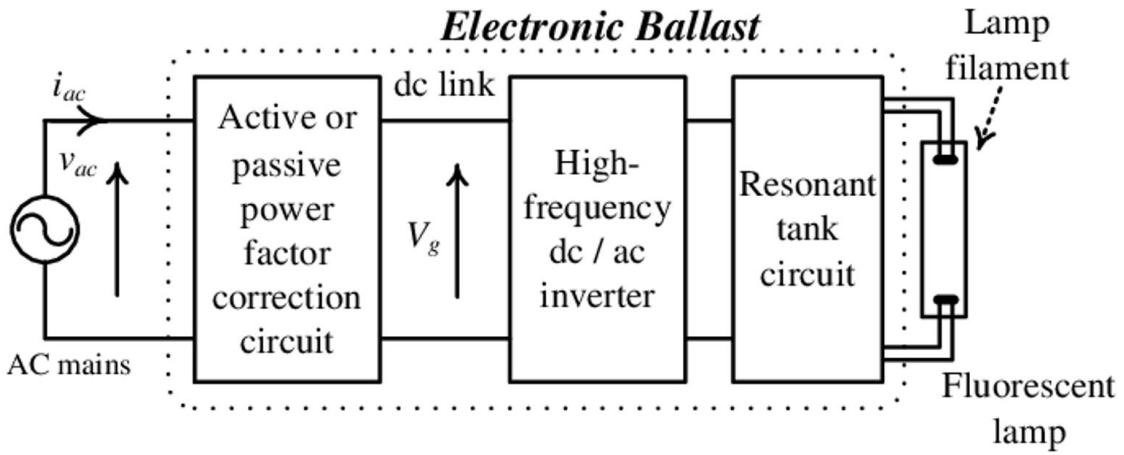
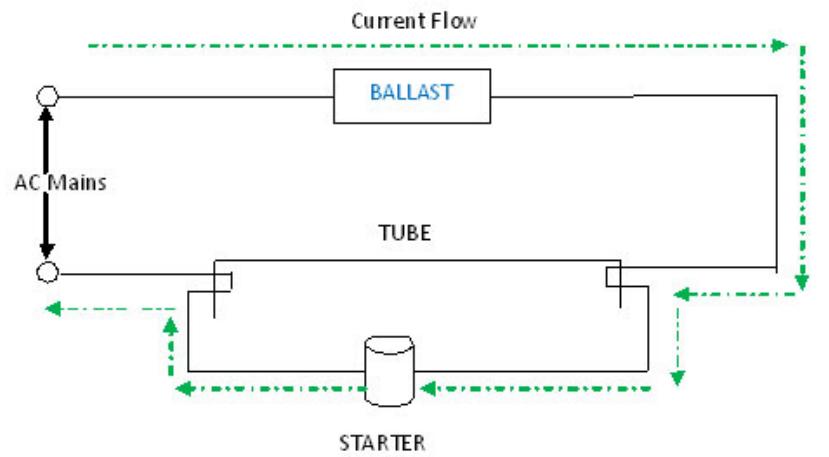


- Available in 40 W, 60 W, 100 W, 150 W and 200 W.
- These lamps produce heat, so **low efficiency**.
- For kitchen, cooking areas, serving counter of food shop/restaurant, porch these are essential because of their **CCT (2700K)**.
- For living room, toilet, corridor, veranda, bed room these have been used for long. Efficient choices are available nowadays, so being **obsolete**.

(ii) Fluorescent Lamp (FL)



- These are available in 20 W and 40 W ratings. These lamps are recommended for reading room, academic buildings, laboratories, office room, commercial space, factory, illumination of areas around industrial plant and machinery, exterior lighting applications.
- 40 W FL (more energy efficient compared to a 20 W FL) should be used wherever possible.
- These are long life lamps, have wide applications and are advantageous in many respects.



(iii) Compact Fluorescent Lamp (CFL)



- Available in watts ratings of 4 W, 7 W, 11 W, 14 W and 24 W.
- CFLs found wide application for their high light output to watt ratio (efficacy) before the commercial availability of LED light (so, began to call Energy Saving Lamp).
- It is worthwhile mentioning that fluorescent lamp with high quality (electronic) ballasts closely meet the energy saving purpose of CFL.

(iv) LED Lights



- An LED operates at very small (**DC**). These are good for lighting, energy efficient, have almost negligible heat dissipation.
- These are good for relaxed environment interior lighting.
- LED light has become more and more popular because of much lower power consumption (i.e. **high efficacy**) compared to other lamps.

(v) Halogen Lamp



- Halogen lamps are used for spot lights, decorative lights in shops and commercial spaces, inside show cases, stage lighting, and projection lights. Due to high temperature rise and UV light output these should be avoided for interior lighting unless needed.

(vi) Mercury Vapour Lamp



- These have been widely used for **shops**, streets, for high bay lighting, warehouse lighting and similar special lighting.
- Most likely, this type of lamp will be discontinued soon due some of it's ill effects. Metal halide is a better alternative to mercury vapour lamp.

(vii) Metal Halide Lamp



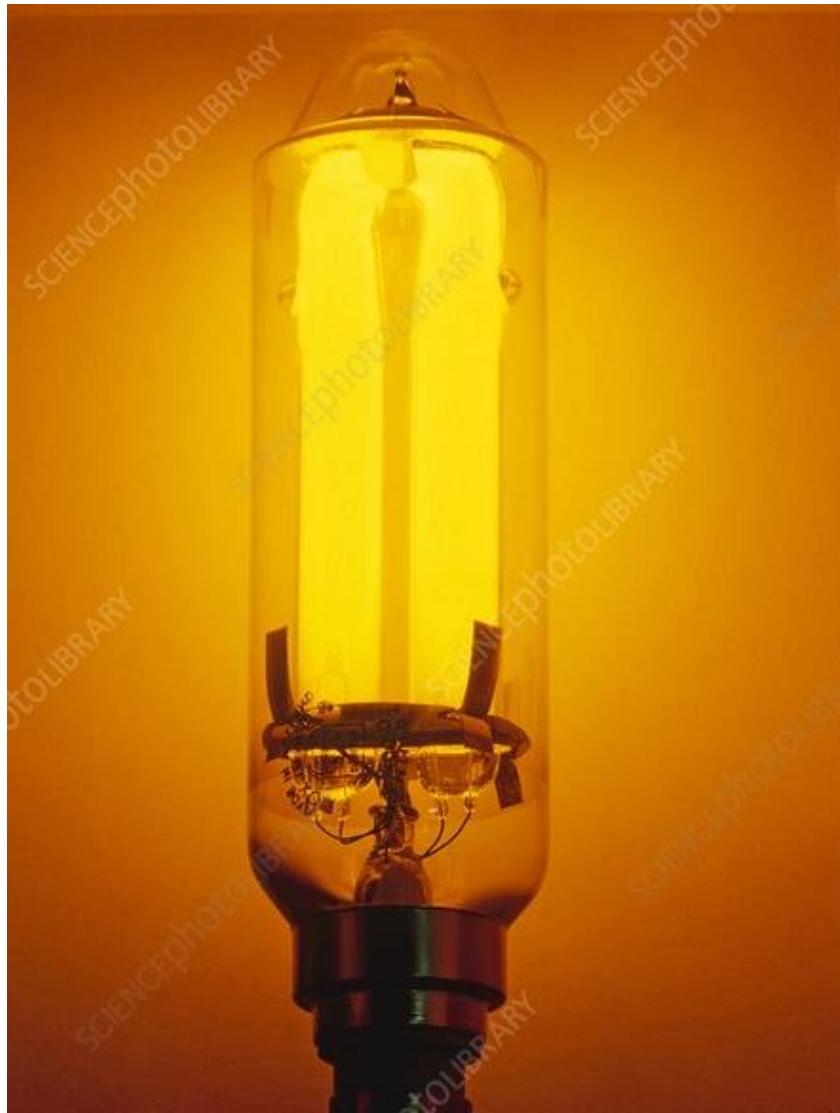
- Available in watt ratings of 150 W, 200 W, 250 W, 500 W, 1000 W, 2000 W.
- Good for **exterior** lighting, indoor and outdoor **athletic facilities**, for high bay lighting, warehouse lighting.
- These are required where **massive flood lighting** is required from high altitudes for coverage of large areas.

(viii) HP Sodium Lamp



- Available in watt ratings of 40 W, 50 W, 70 W, 100 W, 150 W, 250 W, 400 W, 1000 W.
- Good for **exterior lighting**, lighting for areas where **higher concentration of vehicles and people exist** e.g., avenue light, street light, building exterior lighting, security lighting.

(ix) LD Sodium Lamp



- For **outdoor** lighting such as street **lights** and **security lighting** where faithful color rendition (i.e. CRI) is considered **unimportant**.
- This type of lamps may be used for street **lights**, **observatory**, **parking lot** and similar types of areas.

(X) Solar PV Cell Powered LED Lights



- These fittings require a solar panel, a storage battery system apart from the cluster of LEDs.
- For outdoor lighting such as street lights, security lighting, outdoor parking area, rural market and other social gathering places, this type of light fitting are used.

High Power LED Lights



- LED lights are replacing almost all the low power lights.
- Now a days, all the **high power lights** discussed above, also have their **LED alternatives**.

Losses in Different Ballasts

Lamp	Lamp Watts	Ballast Watts	Total Watts
Mercury	100	20	120
	175	30	205
	250	40	290
	400	50	450
	1000	75	1075
Metal Halide	175	35	210
	25	50	300
	400	60	460
	1000	100	1100
	1500	125	1625
High Pressure Sodium	100	35	135
	150	50	200
	250	60	310
	400	75	475
	1000	100	1100

Q?

Thanks!

DESIGN/DRAWING OF ELECTRICAL/ELECTRONIC INSTALLATIONS IN BUILDINGS

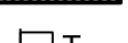
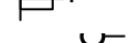
M3: DESIGN/DRAWING - Outline

- Symbols/Legends for Electrical Drawings
- Load Estimating for a building/a complex:
Maximum demand and diversity, Estimation of load in kW, in kVA and in Amperes.
- Fittings, Fixtures and Accessories: Switch boards, Load Densities. Socket outlets, switches, Ceiling rose, Light fitting, Permissible Weight of Twin Flexible Cords, Lighting point, Wires/cables used inside light fittings.
- Recommended Fan Sizes in Rooms.

Symbols/Legends for Electrical Drawings

1.3.1 List of Symbols used for Electrical Drawings

Table 8.1.15: Symbols used for Electrical Drawings

Serial No.	Description	Symbol
1	Main Distribution Board (MDB)	
2	Floor Distribution Board (FDB)	
3	Distribution Board (DB)	
4	Sub-distribution Board (SDB)	
5	Branch Distribution Board (BDB)	
6	Switch Board (SB)	
7	Telephone Outlet (PSTN)	
8	Telephone Outlet (PABX)	
9	Change over switch	
10	Energy meter	
11	Ammeter	
12	Voltmeter	
13	Power factor meter	
14	Circuit breaker	
15	Fuse	
16	Ceiling mounted Incandescent light fitting	
17	Wall mounted bracket light fitting	

Serial No.	Description	Symbol
18	Ceiling fan	
19	Exit light pendant	
20	Exit light-wall mounted	
21	2 pin socket Outlet (single phase)	
22	3 pin 13A switched socket Outlet (single phase)	
23	Weatherproof and waterproof socket outlet	
24	SPST Single – pole, one-way switch	
25	DPST Two - pole, one-way switch	
26	TPST Three - pole, one-way switch	
27	SPDT Two – way switch	
28	Push button switch	
29	Buzzer	
30	Single fluorescent lamp on ceiling	
31	Double fluorescent lamp on ceiling	
32	Double fluorescent lamp on wall	
33	Spot light	

Serial No.	Description	Symbol
34	Wall mounted bracket fan	
35	Exhaust fan	
36	Pull box	
37	TV socket outlet	
38	Fire Alarm bell	
39	Fire detector	
40	Smoke detector	
41	Speaker	
42	Microphone	
43	Conduit, concealed in ceiling or in wall	
44	Conduit, concealed in floor or through under ground	
45	Telephone conduit	
46	Television antenna conduit	
47	Earth Electrode	

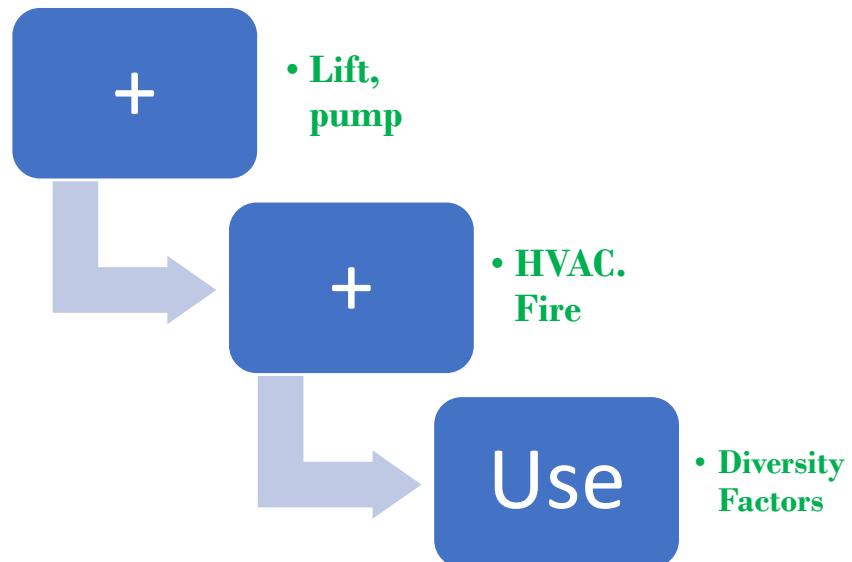
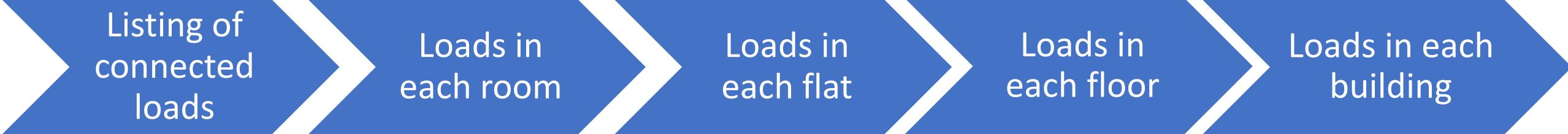
Estimating the Load of a Building/Complex

1.3.2 Estimating the Load of a Building

Estimating the total load of a building has to be started with the **listing of the connected loads** in a building. The steps are to list the loads in each of the **rooms**, in each of the **flats/offices** of a floor, in each of the **floors** and the load of the **total building**. In this way an account of the total building area/the **total complex** has to be prepared.

Loads of the **Lift(s)**, **water pump(s)**, bulk **ventilating** system in the **basement** and any other equipment (**HVAC**, **Fire**) installed in the building must also be **added**. For completing the load calculation, practical value of appropriate **diversity factors** will have to be applied at each stage.

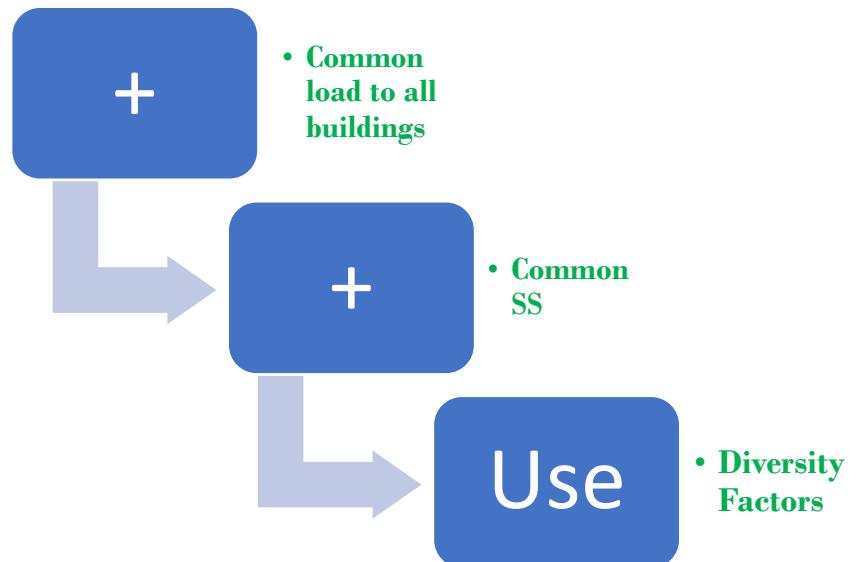
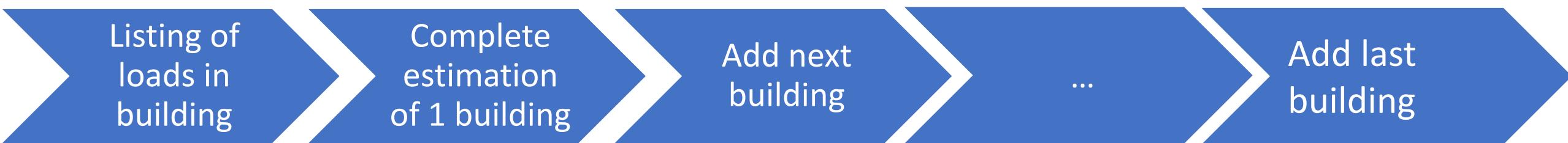
Load Estimating of a Building



1.3.2 Estimating the Load of a Complex

Estimating the total load of a **complex** consisting of a number of buildings has to be started with the **listing** of the connected load of each of the building, they are lighting load, water pump and any other equipment installed in the complex. For completing the load calculation, practical value of appropriate **diversity factors** among the buildings will have to be applied.

Load Estimating of a Complex



1.3.2.1 Maximum Demand and Diversity

Two items need to be determined, which are: (i) **Maximum Demand** and (ii) **Diversity Factor**. These are needed in completing the load calculation and in the computation of current.

In determining the maximum demand of an installation or parts thereof, diversity shall be taken into account.

Appendix A gives some information on the determination of the maximum demand of an installation and includes the current demand to be assumed for commonly used equipment together with guidance on the application of allowances for diversity.

PART VIII, Appendix A

Maximum Demand and Diversity

It is **impossible** to specify the **appropriate allowances** for diversity for **every type** of installation. The figures shown in **Table 8.A.1** are therefore, intended to act as **guideline**. The current demand of a final circuit is determined by summing the current demands of all points of utilization and equipment in the circuit.

Typical values to be used for this summation are given in **Table 8.A.2**. For **blocks of residential dwellings, large hotels, and industrial and large commercial premises**, allowances are to be assigned by a **competent Engineer**.

PART VIII, Appendix A

Maximum Demand and Diversity

The current demand of a circuit supplying a number of final circuits may be assessed by applying the allowances for diversity given in **Table 8.A.2** to the total current demand of all the equipment supplied by that circuit. In the Table, the allowances are appraised either as percentages of the current demand or, where followed by the letters f.l., as percentages of the rated full load current of the current using equipment. After the design currents for all the circuits have been determined, enabling the conductor sizes to be chosen, it is **necessary to check that the limitation on voltage drop is met.**

Table 8.A.1: Allowances for Diversity

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of Premises		
	Individual household installations, including dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Cooking appliances	10 amperes + 30% f.l. of connected cooking appliances in excess of 10 amperes + 5 amperes if socket outlet is incorporated in unit.	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of Premises
3. Motors (other than lift motors which are subject to special consideration)	<p>Individual household installations, including dwellings of a block</p> <p>100% f.l. of largest motor + 80% f.l. of 2nd largest motor + 60% f.l. of remaining motors.</p>
4. Water heater (thermostatically controlled)	No diversity allowable

Table 8.A.2: Current Demand to be Assumed for Points of Utilization and Current using Equipment

Point of Utilization or Current-using Equipment	Current Demand to be Assumed
15 A socket outlets	15 A with diversity applied
13 A socket outlets	13 A with diversity applied
5 A socket outlets	At least 0.5 A
Protected outlets other than the above mentioned socket outlets	Rated current
Lighting outlet	Current equivalent to the connected load, with a minimum of 100 W per lamp holder
House hold cooking appliance	The first 10 A of the rated current plus 30% of the remainder of the rated current plus 5 A if a socket outlet is incorporated in the control unit
All other stationary equipment / Appliances	Standard rated current or nominal current.

1.3.2.2 Estimation of load in kW, in kVA and in Amperes

An estimation of loads is necessary initially for design purposes and later for keeping a track of the growth of load. Estimation of loads means estimation of watts in small scale. In bigger scale the kVA is assessed together with the power factor. A calculation of current is then to be performed for the selection of breakers/fuses and the current carrying cables.

1.3.2.3 Estimation of electrical load in Watts

Energy efficient and **energy saving** should be considered in estimating the electrical load, the watts rating of individual equipment/fittings connected to the system need to be listed and added. Typical watt ratings of some of the equipment/fittings are shown in **Table 8.1.16** which may be used for estimation if the actual values are not known or specified.

Table 8.1.16: Estimated Load for Different Fittings/Fixtures

Type of Fitting/Fixture	Ratings in Watts	Type of Fitting/Fixture	Ratings in Watts
CFL	5-65	15 A Socket outlets	1500
LED and Solar Panel Powered	10-60	Microwave Oven (domestic)	1200-
LED Security /Street Lights			1500
Fluorescent lamp with accessories:		Washing machine (domestic)	350-500
Nominal length 600 mm	20	Television (medium size)	120-200

Type of Fitting/Fixture	Ratings in Watts	Type of Fitting/Fixture	Ratings in Watts
Nominal length 1200 mm	40	Computer (without printer)	200
Photo copiers	1200- 1500	Computer with printer	700-800
Ceiling fans	100 (Max)	Window type A.C. machine (12000 BTU/hr)	1500
Electric	1500	Split type A.C. machine (12000 BTU/hr)	1300
Table fans	85 (Max)	Geyser (water heater, domestic)	1000- 1200
Pedestal fans	120 (Max)	Toaster (domestic)	800-1000
Exhaust fans	100 (Max)	Electric calendar	700-1000
5A socket outlets	300		

1.3.2.4 Calculation of Current

For the calculation of current (for the selection of **cables and breakers**) of the **fluorescent lamps** the ratings are to be multiplied by a factor of **1.65** to take care of the **power factor** (0.6) and the starting current situation.

Similarly, for the calculation of current of the **fans** (ceiling, table, pedestal, exhaust) the ratings are to be multiplied by 1.65.

For the calculation of current (cables & breakers selection) of the **small inductive loads** ($\leq 1 \text{ kW}$) the multiplying factor shall be 1.65. The factor shall be **higher** for higher rated motors.

1.3.2.5 Minimum Load Densities

While estimating the electrical load, the minimum load densities to be considered are those shown in **Table 8.1.17**.

Table 8.1.17: Minimum Load Densities

Type of Occupancy	Unit Load (Watts/m²)	
	Non A/C	A/C
Residence/ Dwelling : Single family	20	75
Residence/ Dwelling : Multi-family (other than hotels)	20	75
Hospitals	32	80
Hotels, including apartment house (excluding any provisions for electric cooking)	24	75
Office and commercial multi-storeyed buildings	28	75
Industrial building (excluding the loads for machines)	16	-

Type of Occupancy	Unit Load (Watts/m²)	
	Non A/C	A/C
Departmental stores	28	75
Banks	20	75
Restaurants (excluding any provisions for electric cooking)	16	75
Barber shops and beauty parlours	32	75
Schools and colleges	12	70
Parking area in commercial buildings	4	-
Warehouses, large storage areas	2	-

Fittings, Fixtures and Accessories

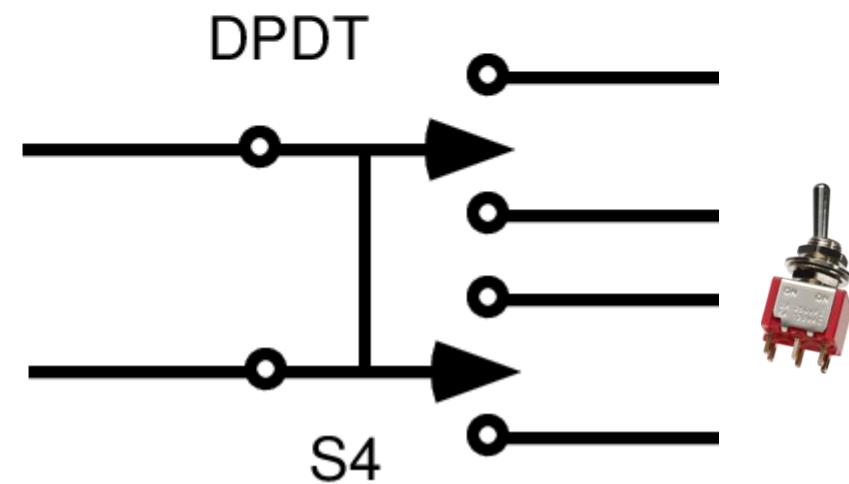
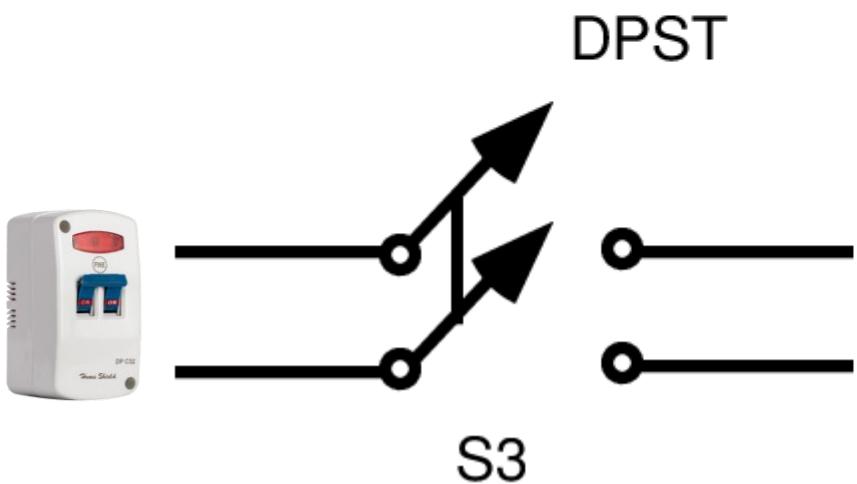
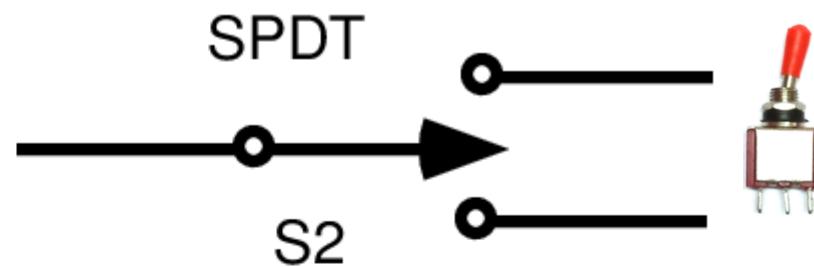
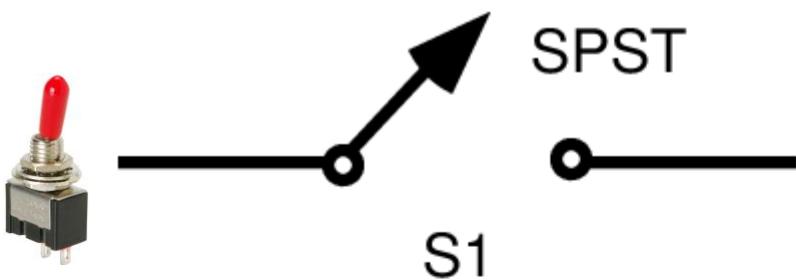
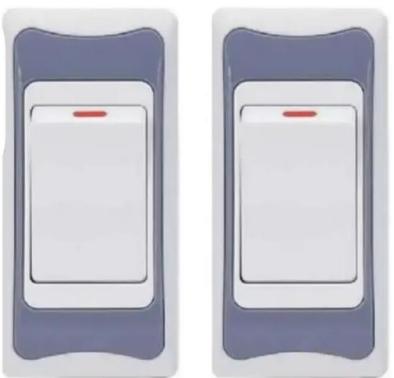
1.3.3.1 Switch boards

Tumbler switches have been used for **surface wiring** and **piano** switches have been used for **concealed wiring**. Now a day piano switches are also used with surface wiring. Piano switches are mounted on either a plastic back box or a metal back box. These piano switches are available in gangs. The other alternative is to have piano switches mounted on a **Perspex** or **Ebonite** sheet which is then mounted on a metal back box.

1.3.3.1 Switch boards

The Switches must conform to the relevant BS standard. The **minimum ampere rating** of switch shall not be **below 5 A**. Switches may be **SPST** or **SPDT** depending on the operation. For some application, **DPST DPDT** are also available. Usually the DPST switches are made for 10 A, 15 A and 20 A rating.

The phase (Live) wire (Brown PVC insulated cable) connection to the point must go through the switch. The **metal/sheet steel** back boxes of a switch board must have an earthing terminal to terminate the Earth Continuity Conductor (**ECC**) coming from a BDB or an SDB.



1.3.3.2 Socket Outlets and Plugs

(a) General requirements of socket outlets

Socket outlets shall be 13 A switched **shuttered 3 pin flat pin type**. All socket outlets must be switched (combined) and shuttered and shall be for 3 pin Flat pin type (rectangular cross section) 13 A plugs fitted with tubular fuse.

The corresponding plugs must be fitted with fuse. The maximum fuse rating shall be 13A for 13A Sockets. The fuse rating may be smaller depending upon the current rating of the appliances used.

1.3.3.2 Socket Outlets and Plugs

The phase wire (shall be connected to the L terminal of the socket outlet through the combined switch and the neutral wire (blue cable) shall be directly connected to the N terminal of the socket. ECC (Yellow + Green bicolour cable) for such a socket outlet shall be connected to the Earth terminal of the socket.

The plug for each **13A socket** outlet provided in a building for the use of domestic appliances shall be provided with its own individual fuse. The feed cables for such a circuit must have fuse MCB at the originating point in the DB or SDB or BDB. For high current applications, additional fuses/CBs adjacent to the sockets are recommended.

Each socket outlet shall also be controlled by a switch which shall normally be located immediately adjacent thereto or combined therewith.

Copper size of the **ECC** for such a socket outlet shall not be smaller in size than **1.5 mm²** PVC insulated cable.

1.3.3.2 Socket Outlets and Plugs

(b) 15 A/20 A rated socket outlets

(c) Round pin socket outlets of 15A/20 A rating may be used for air conditioner outlets and water heater outlets under special circumstances, for air conditioner outlets (requiring 15 A or 20 A), 15 A/20 A rated socket outlets for round pin plugs may be used along with a circuit breaker or fuse protection in a box adjacent to the sockets.

Each 15 A/20 A socket outlet provided in a building for the use of domestic appliances such as **air-conditioner, water cooler**, etc. shall be provided with its own individual fuse.

1.3.3.2 Socket Outlets and Plugs

The feed cables for such a circuit must have fuse or miniature circuit breaker (MCB) at the **originating point** in the DB or SDB or BDB. For some **high current** applications, **additional** fuses/CBs **adjacent to the sockets** are recommended.

The maximum fuse rating shall be 15 A for 15 A Sockets. For a 15 A rated socket outlet a 15 A rated fuse or a 15 A circuit breaker must be placed **adjacent to the socket**.

For a 20 A rated socket outlet a 20 A rated fuse or a 20 A circuit breaker must be placed **adjacent to the socket**.

Wiring for sockets shall be **radial type** of wiring. However, **ring type** wiring may be used by strictly following the rules given in **IEE Wiring regulations BS 7671** and by using appropriate size of cable.

1.3.3.2 Socket Outlets and Plugs

(d) Earth Continuity Conductor (ECC) for a socket

The ECC for a socket outlet shall not be smaller than 1.5 mm² PVC insulated annealed copper cable. The colour of the ECC cable insulation shall be Yellow + Green bi-colour.

(e) Mounting height of a 3-pin switched socket outlet

3-pin socket outlets shall be mounted on a wall at a height **250 mm** above floor level. **Switched shuttered** socket are essential for **safety** particularly for **infants**.

For certain applications like computers, printers, UPS, IPS such sockets may be mounted at a higher level for the ease of operation.

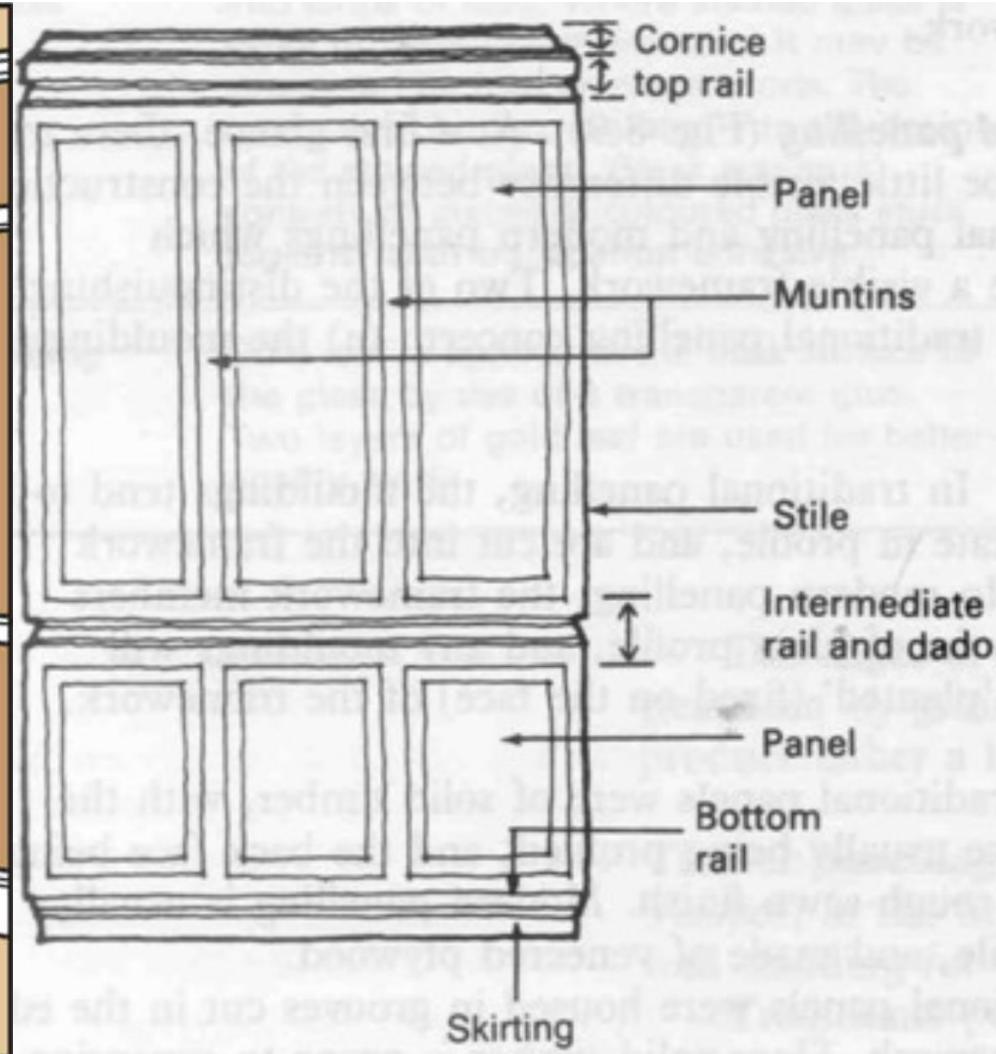
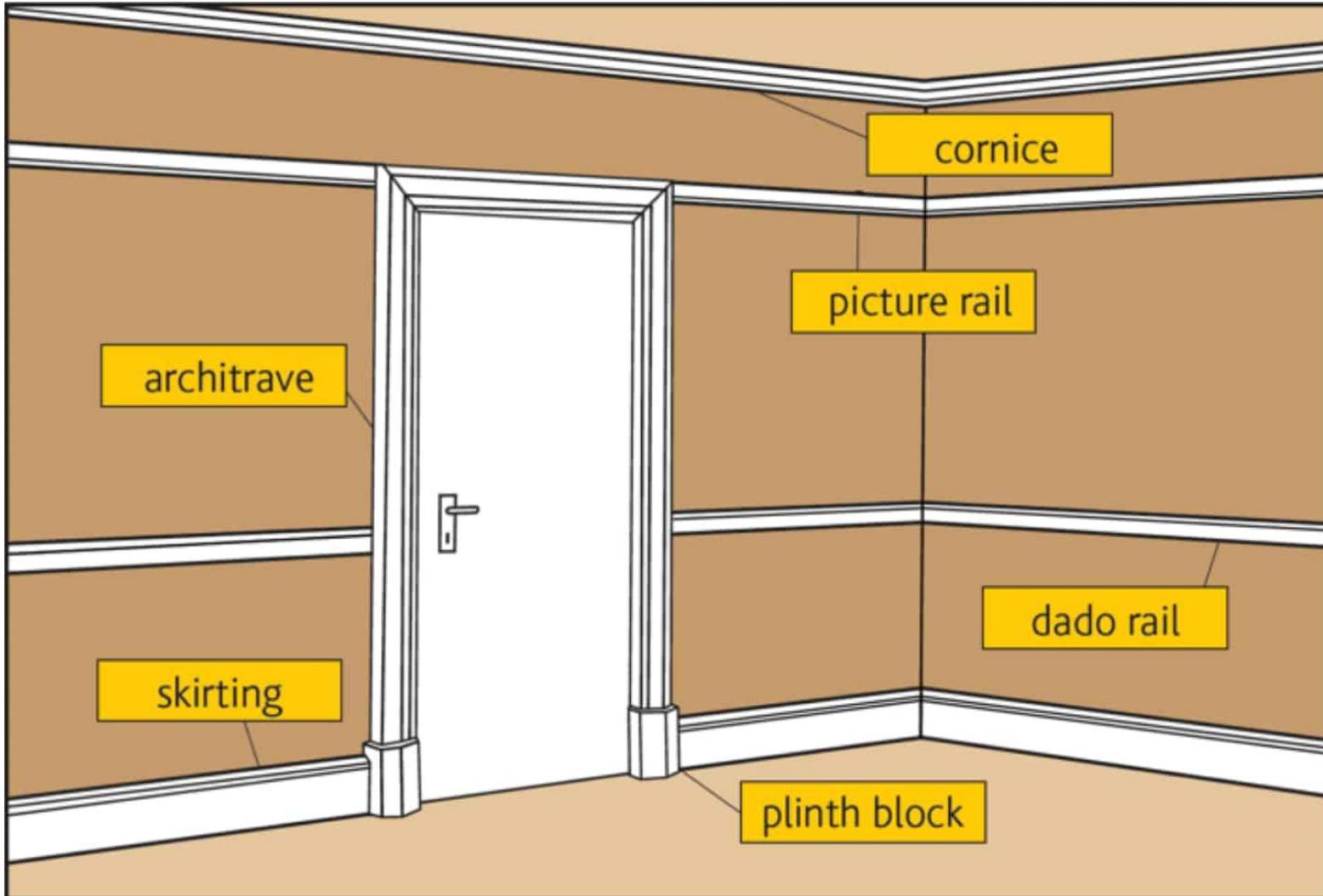
1.3.3.2 Socket Outlets and Plugs

(f) Restriction on mounting socket outlets in wet places

No socket outlets shall be provided inside **bath rooms/ toilets** or any other place where floor may remain wet.

(g) 5 A rated 2 pin socket outlets

5 A rated 2 pin socket outlets may be used along with the light and fan **switch boards only**. Such sockets shall **not** be used as socket outlets at the skirting level.



1.3.3.2 Socket Outlets and Plugs

(h) Number of socket outlets in a room/in a building

The number of socket outlets in a building depends upon the specific requirements of occupants and the type of building.

Adequate number of **13 A** switched **flat pin** shuttered socket outlets shall be provided and arranged around the building to cater to the actual requirements of the occupancy.

15 A round pin socket outlets shall be provided for specially Air-conditioners and water heaters of such ratings only.

For residential buildings, the **minimal guidelines** given in **Table 8.1.18** shall be used to determine the required number of **13 A** switched flat pin shuttered socket outlets, when actual requirements cannot be **ascertained**. All socket outlets shall conform to **BDS 115**.

Table 8.1.18: Minimum Number of 13 A flat pin Socket Outlets

Location	No. of Switch Socket Outlets
Bed room	2
Living room	3
Drawing room	3
Dining room	1
Toaster/Snack toaster	1
Kitchen	1
Bathroom	0
Verandah	1
Refrigerator	1
Air-conditioner	one for each room

1.3.3.2 Socket Outlets and Plugs

(i) Restriction of 2 socket outlets in a room fed from 2 phases

Installation of two socket outlets in a room fed from **2 different phases** should be avoided as far as possible. However, in unavoidable cases, **the minimum distance between two such socket outlets in a room fed from two different phases must not be less than 2 m under any circumstances.**

(j) Exterior/outdoor sockets

Socket outlets in exposed places where chances of **dripping/falling rain** water exist, should not be placed. In case of necessity, **weather proof/waterproof** **covered sockets** may be mounted with appropriate **precautions**. In such a case the **back box** should preferably be of **Bakelite or Acrylic or Plastic** material.

1.3.3.2 Socket Outlets and Plugs

(k) Exterior/outdoor switches

Switches in exposed places where chances of dripping/falling rain water exist should not be placed. In case of necessity, weather proof/waterproof covered switches may be mounted with appropriate precautions. In such a case the back box should preferably be of Bakelite or Acrylic or Plastic material.

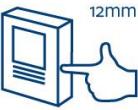
Ingress Protection (IP) ratings guide

Solids

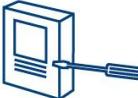
1 Protected against a solid object greater than 50mm such as a hand.



2 Protected against a solid object greater than 12.5mm such as a finger.



3 Protected against a solid object greater than 2.5mm such as a screwdriver.



4 Protected against a solid object greater than 1mm such as a wire.



5 Dust Protected. Limited ingress of dust permitted. Will not interfere with operation of the equipment. Two to eight hours.



6 Dust tight. No ingress of dust. Two to eight hours.



Water

1 Protected against vertically falling drops of water. Limited ingress permitted.



2 Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.



3 Protected against vertically falling drops of water. Limited ingress permitted.



4 Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes.



5 Protected against jets of water. Limited ingress permitted.



6 Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities.



7 Protection against the effects of immersion in water between 15cm and 1m for 30 minutes.



8 Protection against the effects of immersion in water under pressure for long periods.



9 Protection against the effects of high pressure and temperature water jet.



1.3.3.3 Ceiling Rose

A ceiling rose is needed for terminating the point wiring for a Light or a Fan in the ceiling.

- (a) A ceiling rose shall **not** be installed in any circuit operating at a voltage exceeding **250** volts.
- (b) Normally, a single pendant be suspended from only **one ceiling rose** using a **flexible cord**. A ceiling rose shall **not** be used for attachment of **more than one** outgoing flexible cord **unless it is specially designed** for multiple pendants.
- (c) A ceiling rose shall **not** contain a **fuse terminal** as an integral part of it.
- (d) The ceiling rose shall conform to **BS 67**.
- (e) Luminaires supporting couplers are designed specifically for the mechanical support as well as for the electrical connection of luminaires and shall not be used for the connection of any other equipment.



1.3.3.4 Light Fitting

Switches shall be provided for the control of **every light fitting**. A switch may control an individual light point or a group of light points. Where control at more than one position is necessary for a lighting fitting or a group of lighting fittings, as many **two-way** or **intermediate switches** may be provided as the required number of control positions.

In **industrial premises** light fittings shall be supported by suitable **pipe/ conduits, brackets fabricated from structural steel, steel chains** or similar materials depending upon the type and **weight of the fittings**. Where a lighting fitting is to be supported by one or more flexible cords, the **maximum weight** to which the **twin flexible cords** may be subject are

shown in **Table 8.1.19**.

Table 8.1.19: Maximum Permissible Weight to which Twin Flexible Cords may be Subject

Nominal Cross-sectional Area of Twin Flexible Cord (mm²)	Number and Diameter (mm) of Wires	Maximum Permissible Weight (kg)
0.5	16/0.2	2
0.75	24/0.2	3
1.0	32/0.2	5
1.5	48/0.2	5.3
2.5	80/0.2	8.8
4	128/0.2	14

1.3.3.4 Light Fitting

(a) **Lighting Point** At each fixed lighting point one of the following accessories shall be used

- (i) 1 ceiling rose conforming BS 67
- (ii) 1 luminaire supporting coupler conforming BS 6972/7001
- (iii) 1 batten holder* conforming BS 7895, BS-EN6 0238/ 61184
- (iv) 1 luminaire connected directly to the circuit wiring
- (v) 1 suitable socket-outlet
- (vi) 1 connection unit conforming BS 5733/BS 1363-4.

Lighting installation shall be controlled e.g., by a switch to BS 3676/BS 5518, or by a suitable automatic control system, which where necessary shall be suitable for **discharge lighting** circuits.

1.3.3.4 Light Fitting

(b) Wires/cables used inside light fittings and any other fitting

Wires/cables used inside a light fitting or any other fittings are mostly flexible types. In some cases, single core PVC insulated wiring cables mostly 1.5 mm² are used. In such cases the cables must be of **high quality** in terms of **insulation** and must have **appropriate copper cross section**. Such cables are usually terminated in a ceiling rose.

1.3.3.5 Fans

(a) Ceiling Fan

Ceiling fans including their suspension shall conform to BDS 818.

With respect to the position of a lighting fitting, the **positioning of a fan shall be such so**

that it does not throw any shadow on the working plane is not acceptable. The unit module area shall be so chosen that the required number of fans could be suitably located, to **avoid creation of pockets receiving little or no air circulation.**

1.3.3.5 Fans

In general, fans in **large halls** (auditorium) may be spaced at **3 to 3.5 m** in both directions in the horizontal plane. If building modules do not lend themselves to proper positioning of the required number of ceiling fans, other types of fans, such as air circulators or wall mounted bracket fans shall have to be installed for the areas uncovered by the ceiling fans. In such cases, necessary electrical outlets shall have to be provided for the purpose.

1.3.3.5 Fans

Table 8.1.20 gives the recommended areas to be served by different sizes of ceiling fans where the height of fan blades is at 2.5 m above the finished floor level.

Wiring for a ceiling fan outlet from the switch board up to the ceiling fan outlet shall be done through pre-laid 18 mm dia PVC conduits using 1.5 mm² PVC insulated 2 cables of Brown and Blue insulation. A **high quality ceiling rose** is to be installed at the ceiling fan point for the termination of the wiring and the connection of the two wires of the Fan.

1.3.3.5 Fans

A fan **hook** is required to be placed during casting of the roof. The fan hook is to be made using a 12 mm dia MS rod having at least **600 mm** on both sides and shall be placed above the MS rod mesh of the roof slab.

Table 8.1.20: Recommended Fan Sizes in Rooms

Room Area (m²)	Fan Sweep
Up to 6	915 mm
Over 6 to 9	1220 mm
Over 9 to 12	1442 mm

1.3.3.5 Fans

(b) Wall mounted bracket fan

For wall mounted bracket fans shall be mounted on the wall using appropriate **rowel bolts**. Wiring from the switch board up to wall mounted bracket fan outlet shall be same as ceiling fan (i.e. conceal).

(c) Pedestal fans and table fans

These items are **movable** and no fixed connections are necessary. Sockets will be used to energize these fans [but use of extension plug is discouraged].

1.3.3.5 Fans

(d) Mounting of ventilating fans or exhaust fans

Exhaust fans are necessary for spaces, such as **toilets, kitchens, canteens and godowns** to provide the required air changes.

Since the exhaust fans are located generally on the **outer walls** of a room, appropriate openings in such walls shall be provided right from the **planning stage**. The sizes and the rpm of the exhaust fans will vary according to the application and the volume for which a fan used. In some applications (such as some **industries**, big size **gas generator room** etc.) high rpm fans are essential. In all cases appropriate types of fan need to be chosen and appropriate arrangement need to be made so that **rain water cannot get inside** the rooms.

1.3.3.5 Fans

(h) Cutout box/circuit breaker box

If the BDB or the SDB from which a 3-pin switched shuttered socket receives power is at a significant distance away and the load connected to the socket needs special care, an additional cutout/CB box may be placed adjacent to the socket. Such a Box shall be placed inside a 18 SWG Sheet Steel (coated with two coats of synthetic enamel paint) of appropriate size with appropriate Perspex cover plate. Such a box may be surface/concealed fitted. The box shall have a brass terminal for the termination of the ECC.

Q?

Thanks!