BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Electrical and Electronic Engineering

Course No. : EEE 414
Course Title : Electrical Services Design Laboratory

Electrical Services Design Project

Submitted to:

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Objectives

The objective of this project is-

1. Grasping the layout: Understanding the typical floor plan of such buildings and how spaces are organized.
2. Equipping the spaces: Identifying the various electrical fittings and fixtures used in different rooms and their purposes.
3. Charting the electrical flow: Learning to systematically map out the conduit layout that channels electrical wiring throughout the building.
4. Connecting the power: Mastering the design and drawing of switchboard connections, including those for emergency situations.
5. Selecting the right components: Calculating and strategically placing essential elements like circuit breakers, transformers, and generators in the switchboard diagrams, ensuring they meet the specific requirements.
6. Shielding from the elements: Understanding and designing the electrical components of a lightning protection system to safeguard the building.

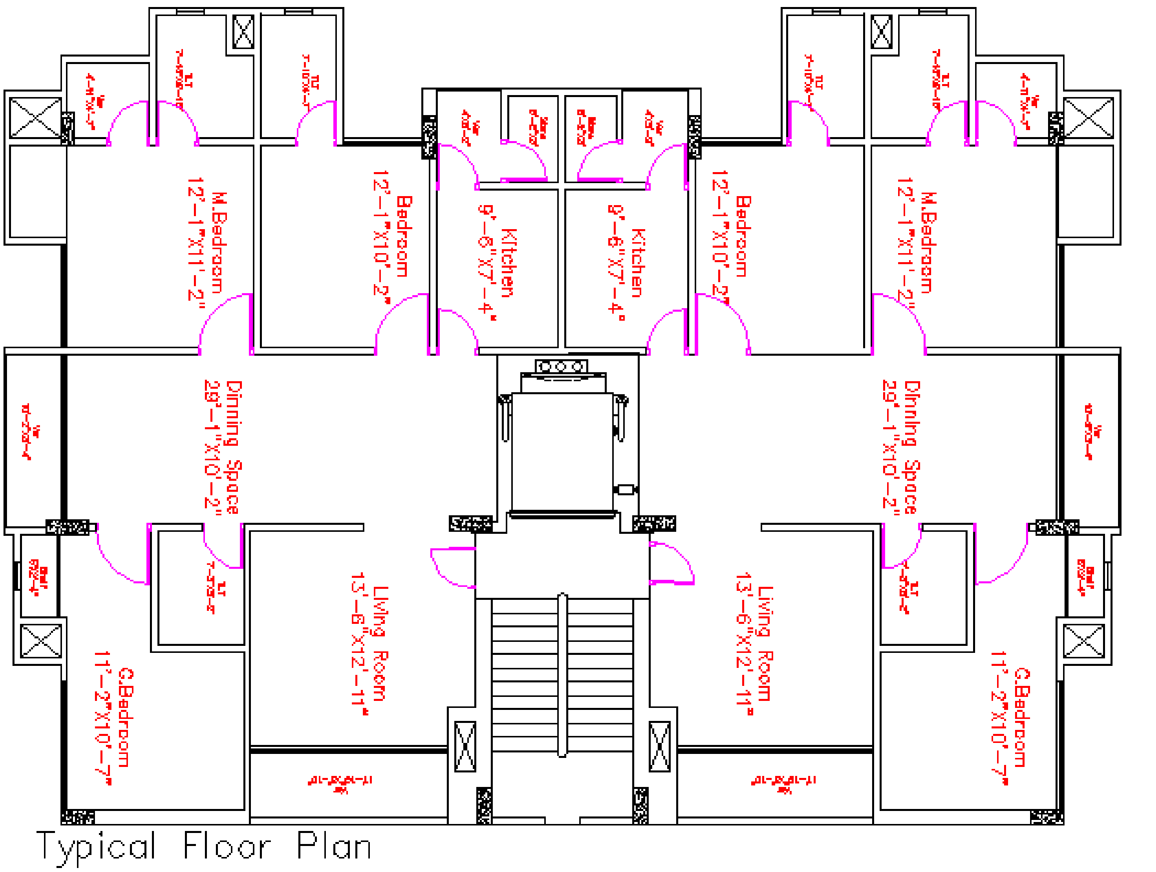
In essence, this project equips you with the knowledge and skills to navigate the electrical design process for multi-story residential buildings, from understanding the layout to ensuring its safe and efficient operation.

Design Steps

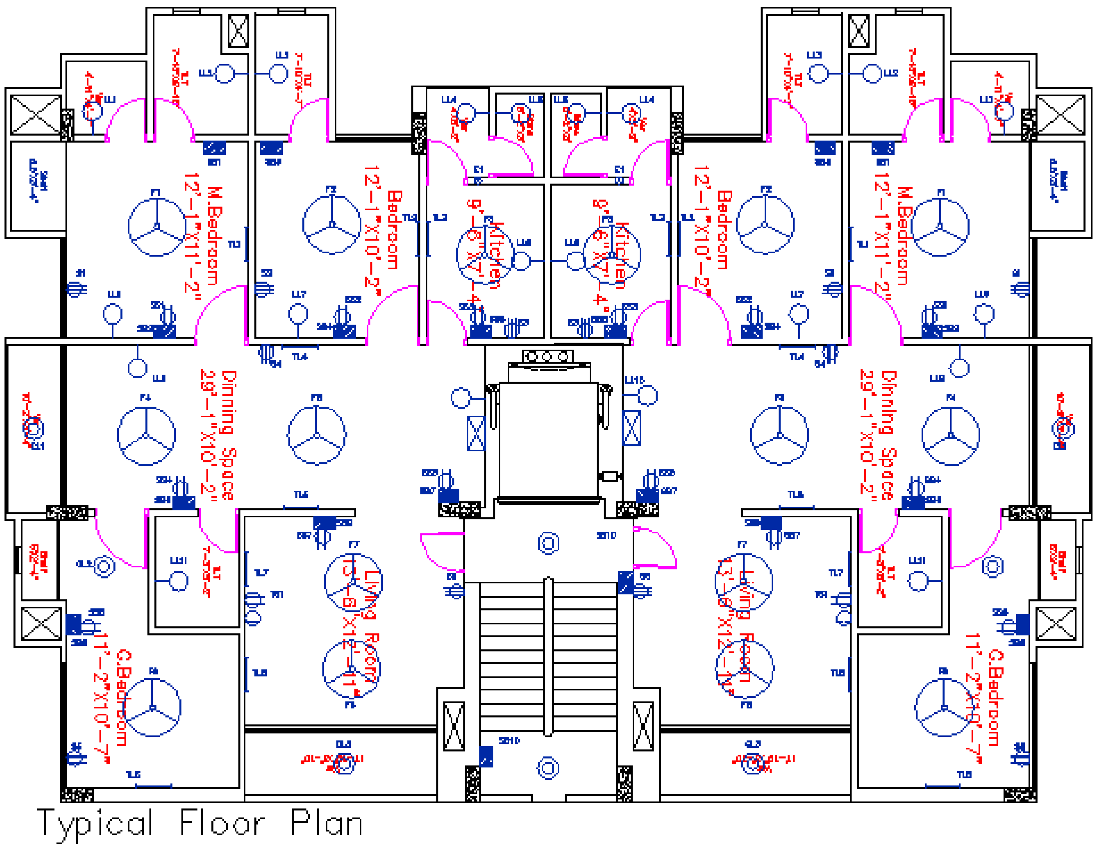
The project was carried out according to the following design steps:

1. Mapping the floors: Layout of the ground floor and one typical floor, showing where rooms are and how they connect.
2. Filling the rooms: The different electrical things used in each room, like lights, switches, and outlets.
3. Planning the wiring: How the electrical cables run through the building, hidden in walls and ceilings.
4. Connecting the power: Design of the main electrical panel and sub-panels that distribute power throughout the building.
5. Keeping it safe: How to protect the building from lightning strikes with a special lightning protection system.

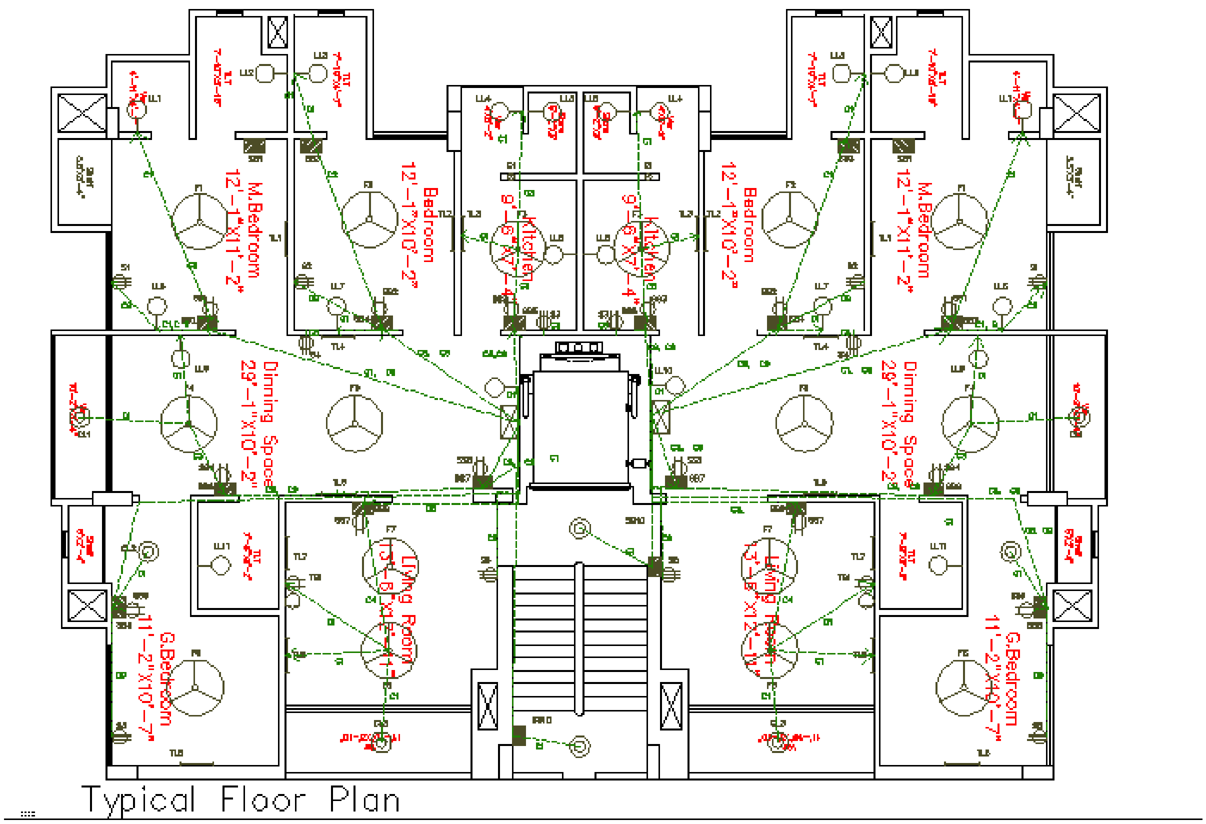
Typical Floor Plan



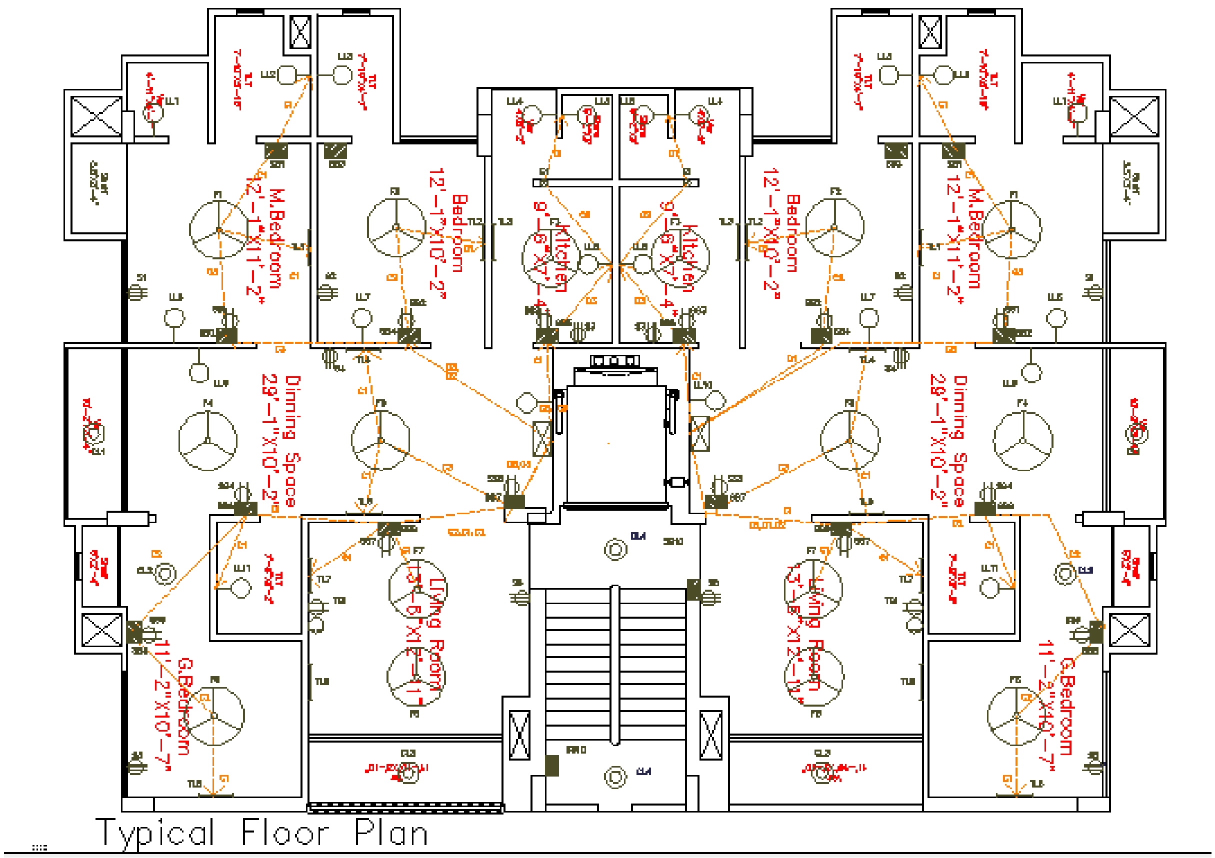
Typical Floor Plan with fixture



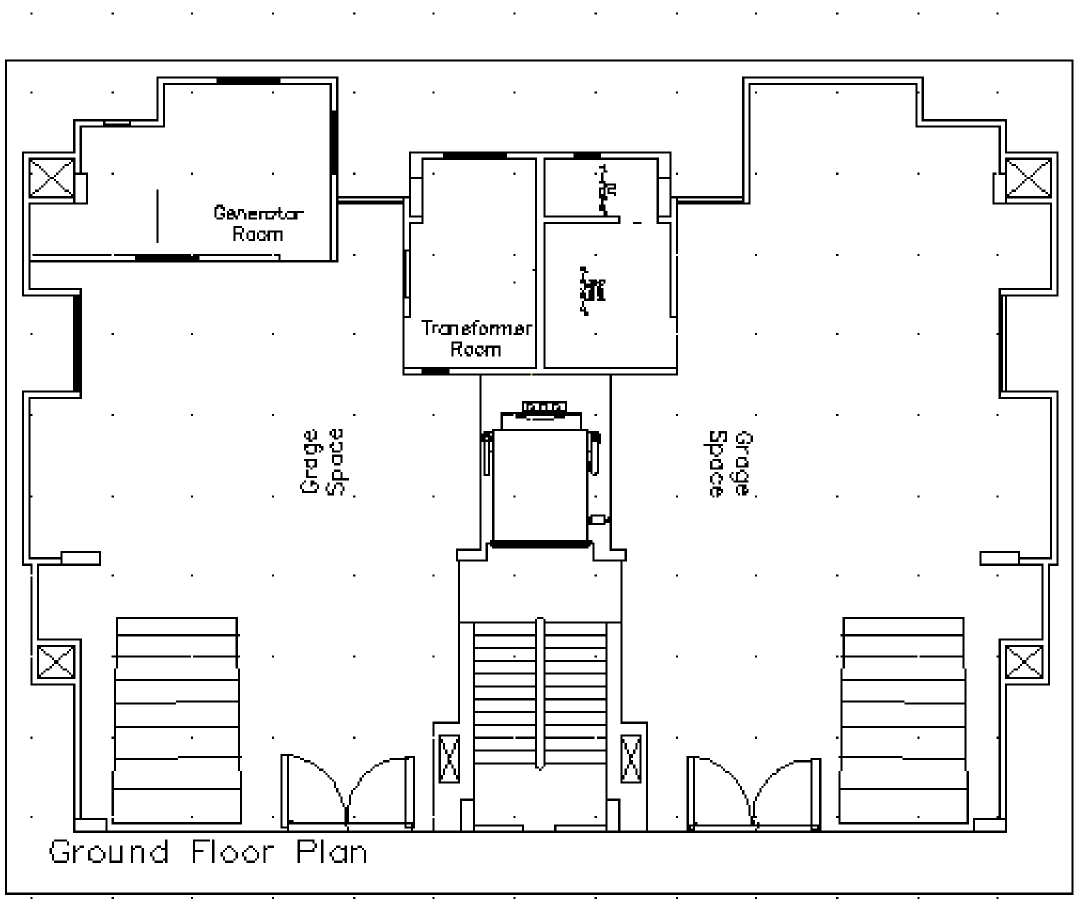
Typical Floor Plan with main line connection



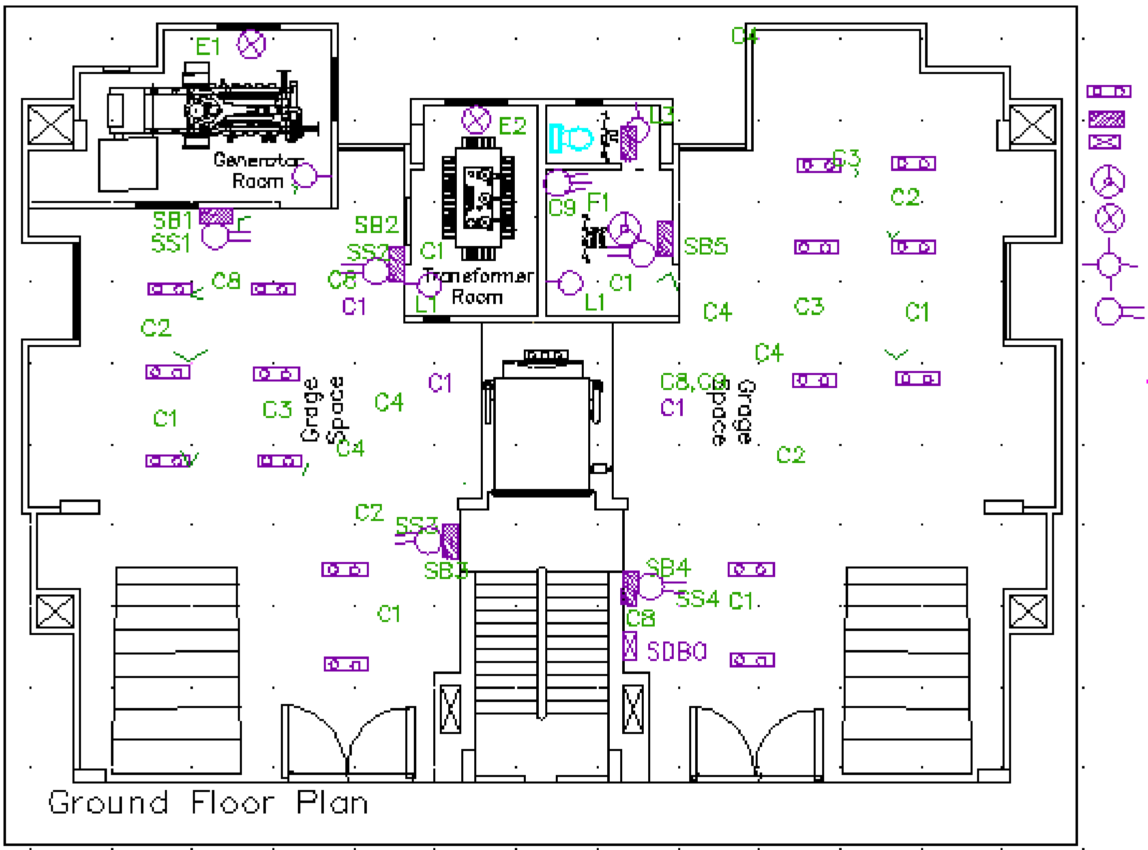
Typical Floor Plan with emergency connection



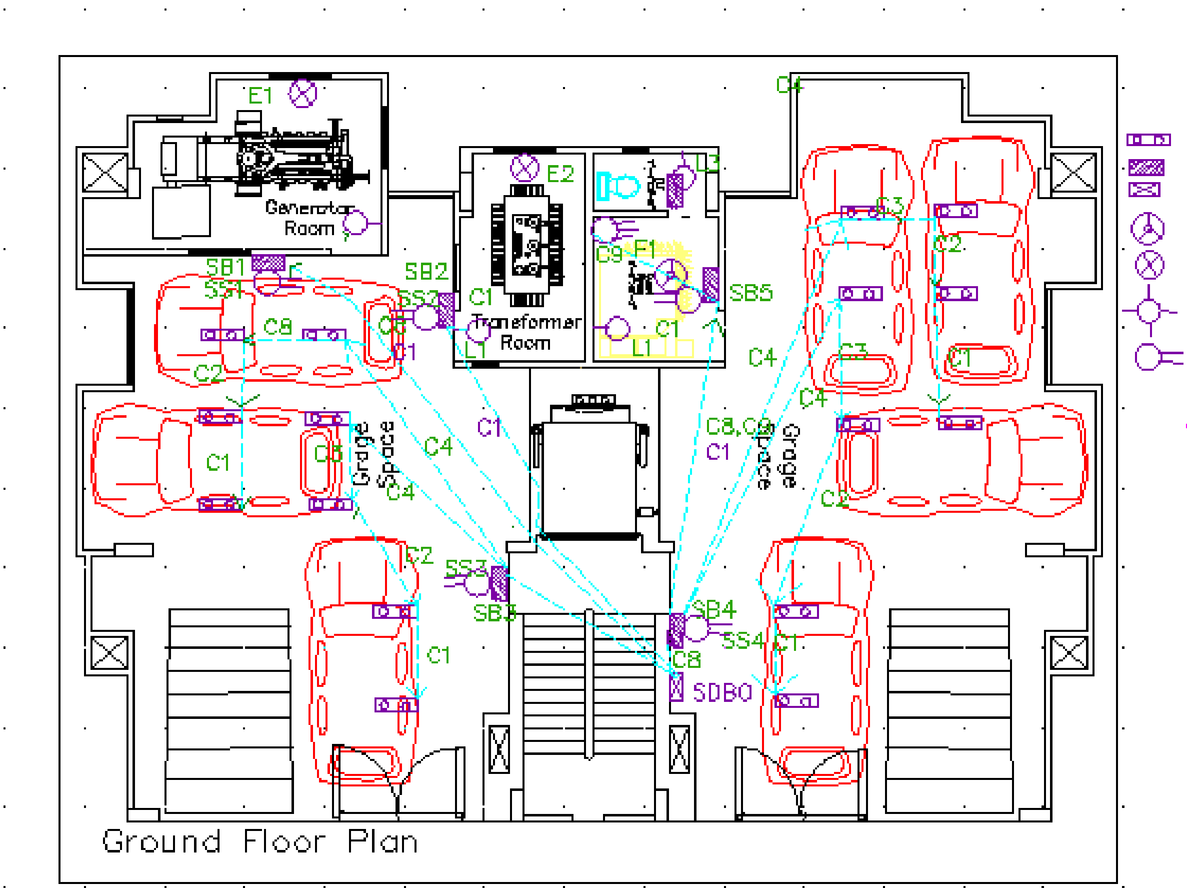
Ground Floor Plan



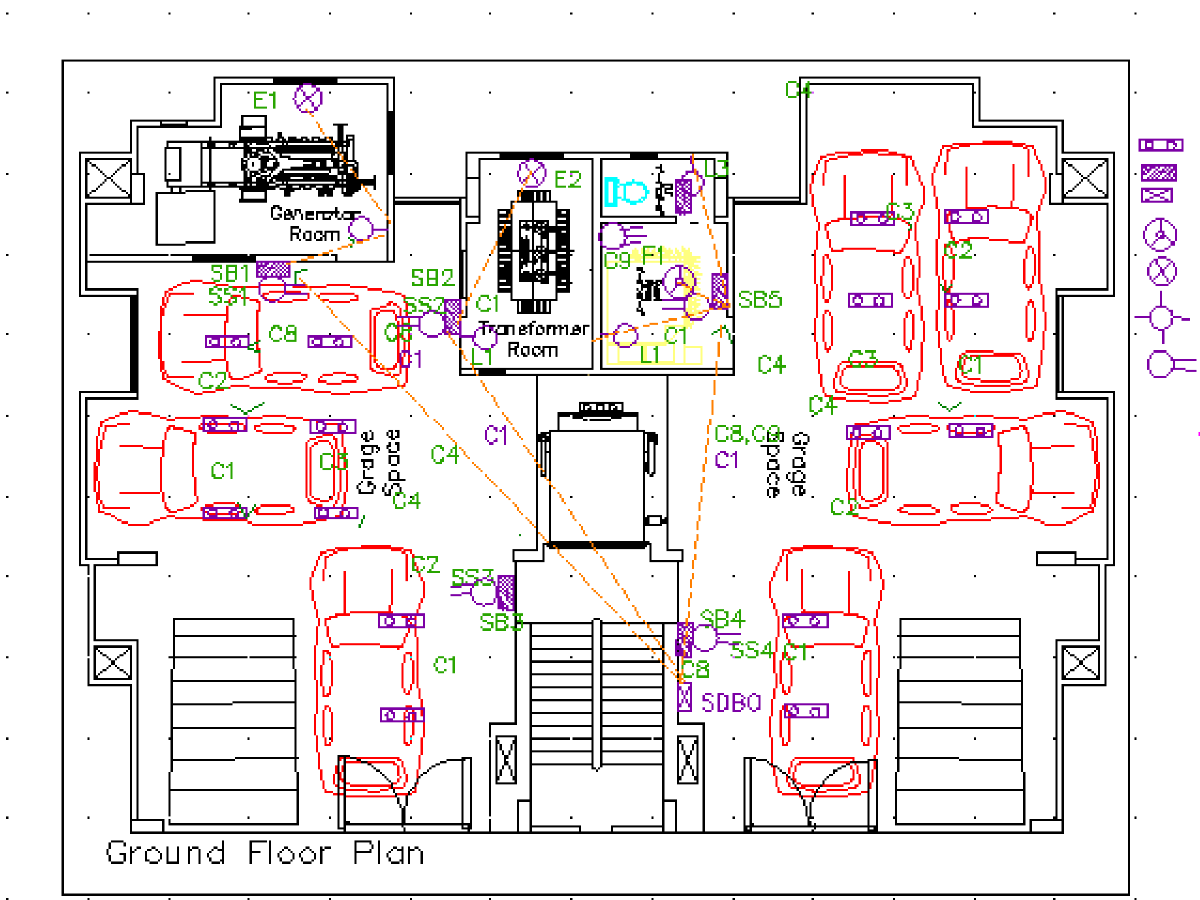
Ground Floor Plan with fixture



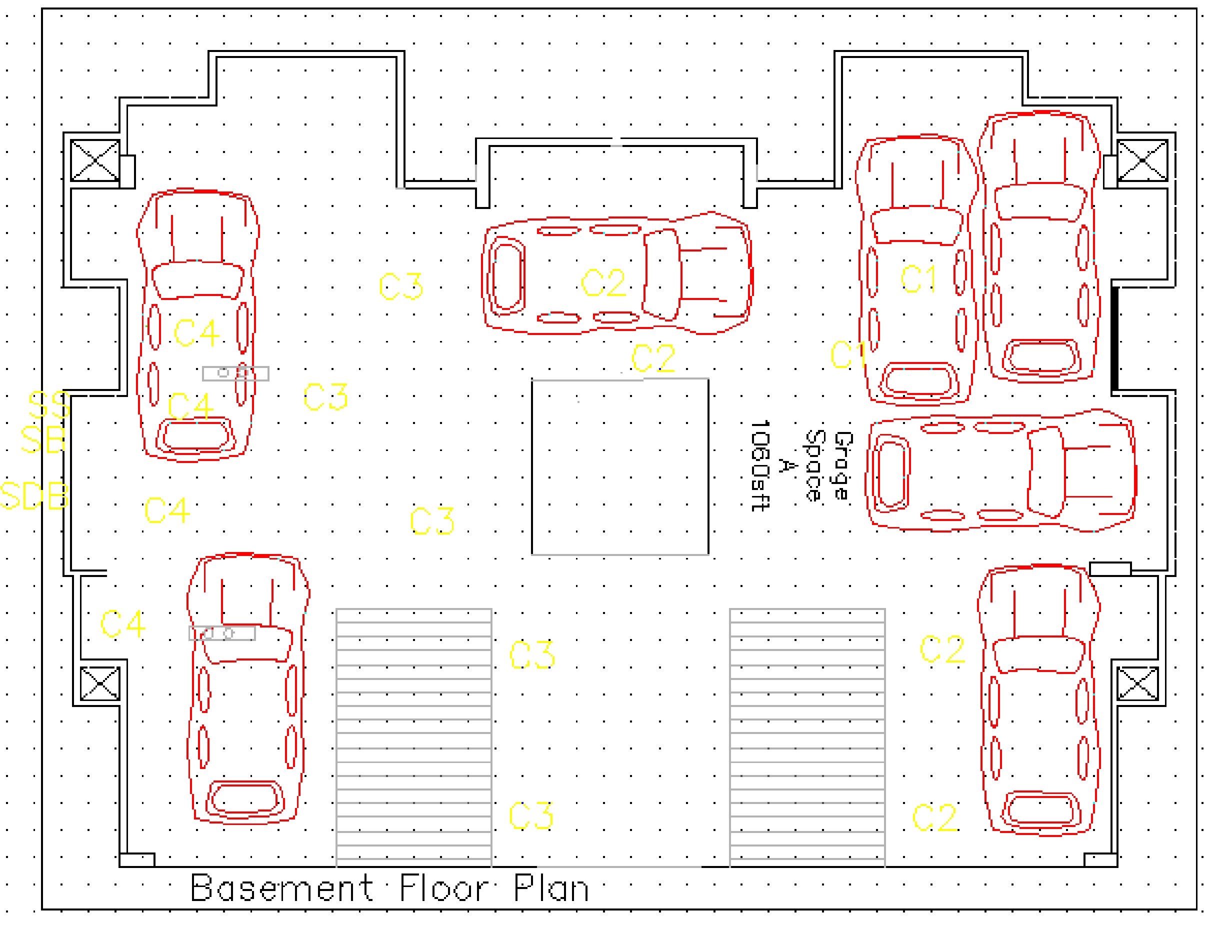
Ground Floor Plan with main lines



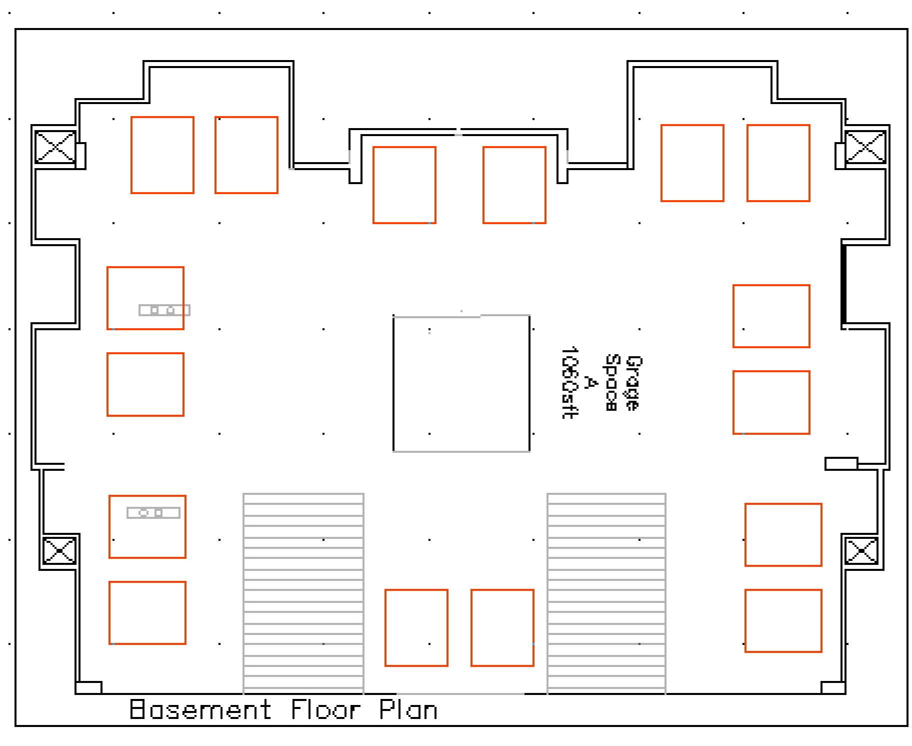
Ground Floor Plan with Emergency lines



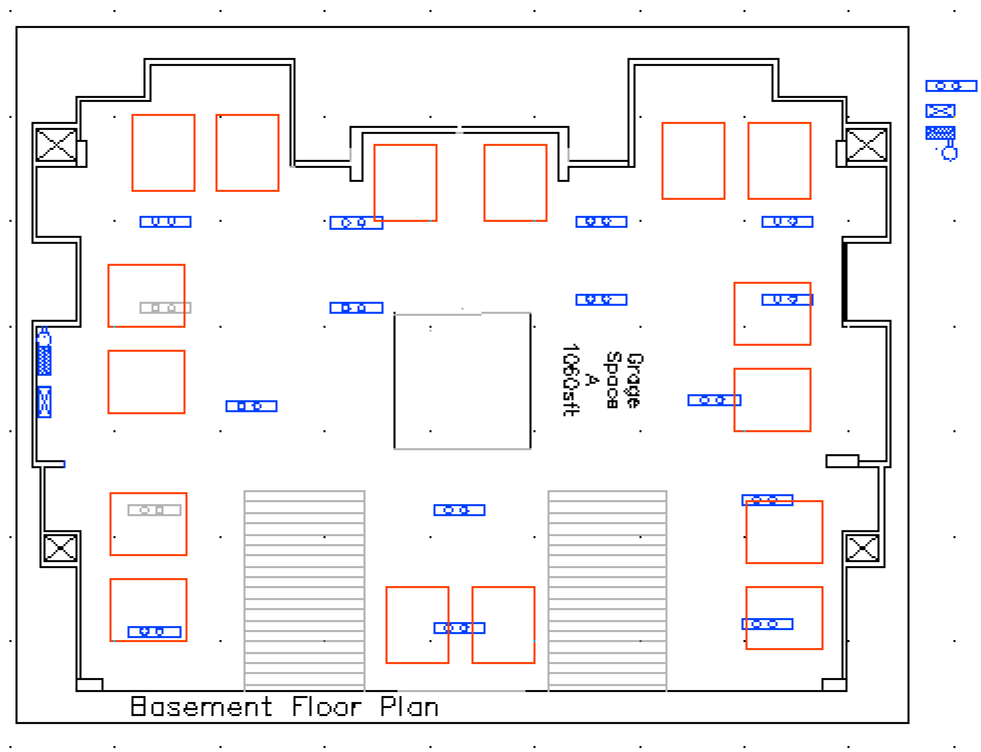
Basement Floor Plan



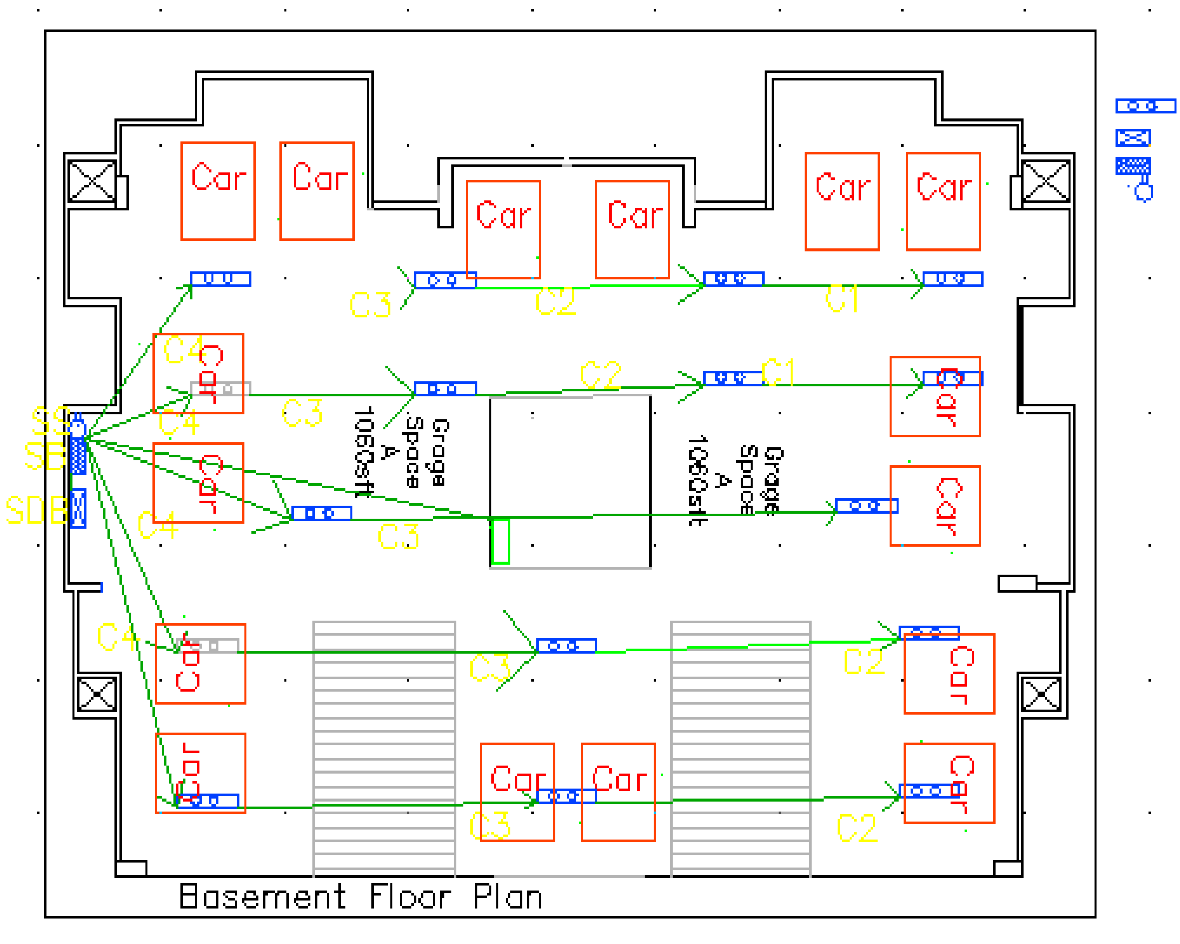
Basement Floor Plan with fixture



Basement Floor Plan with Fixture

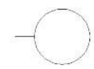
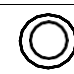
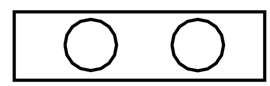
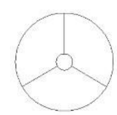
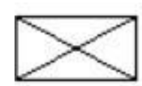
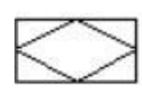


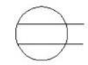
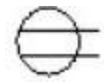
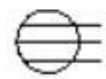
Basement Floor Plan with Connection



Fittings and Fixtures

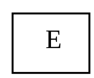
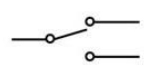
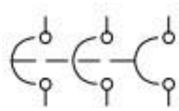
The types of different fixtures used along with their placement and symbol are presented below:

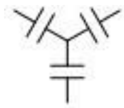
Description	Height	Caption	Symbol
Wall Mounted Light	Lintel	LL	
Ceiling Light	Ceiling	CL	
Wall Mounted Tube Light	Lintel	TL	
Ceiling Mounted Tube Light	Ceiling		
Fan (56” diameter)	Ceiling	F	
Switch Board	Mid wall	SB	
Sub Distribution Board	Mid wall	SDB	
Main Distribution Board	Mid wall	MDB	
Exhaust Fan (8” diameter)	Lintel	E	

2 Pin Socket	Mid wall	SS	
2 Pin TV Socket	Lower	TS	
Antenna Socket	Skirting	T	
3 Pin Socket 20A	Lintel	S	

Switchboard Legends

The types of different components used in switchboard diagrams along with their symbol are presented below:

Description	Symbol
Switch	
Energy Meter	
SPDT Two Way Switch for Automatic Transfer	
Fan Regulator	
Single Pole Circuit Breaker (SP MCCB)	
Triple Pole Circuit Breaker (TP MCCB)	

Delta to Wye Transformer	
Power Factor Improvement (PFI) Plant	
Generator	G

Calculation

Master bedroom

L = 12’ 1” = 3.683 meters

W = 11’ 2” = 3.4036 meters

Room index = 0.9672 (taken as 1)

UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 70 lux

F = 1250 lumen (wall light, ceiling light and fluorescent tube-light)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{70 * 3.683 * 3.4036}{1250 * 0.61 * 0.8} = 1.43$$

So, the number of lights is taken as 2.

Number of fans,

$$M = \frac{L(in\ ft) * W(in\ ft)}{100} = \frac{(12.0833) * (11.1667)}{100} = 1.349$$

So, the number of fans is taken as 1.

Summary of number of required lights and fans for all the bed-rooms and kitchen are provided below:

Room	E (lux)	Height (ft)	Width (ft)	Area (m^2)	Index	UF	N	M
M. Bedroom1	100	12’1”	11’2”	12.5	0.97	0.61	1.43 (2)	1.34 (1)

Bedroom	70	12’1”	10’2”	11.4	0.92	0.61	1.3 (2)	1.22 (1)
M. Bedroom2	70	11’2”	10’7”	11.0	0.91	0.61	1.26 (2)	1.18 (1)
Kitchen	200	9’6”	7’4”	6.5	0.69	0.61	2.12 (2)	0.70 (1)

Dining Room

L = 29’ 1” = 8.8646 meters

W = 10’ 2” = 3.0988 meters

Room index = 1.26 (taken as 1.25)

UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.65

MF = 0.8

E = 100 lux

F = 1250 lumen (wall light and fluorescent tubelight)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{100 * 8.8646 * 3.0988}{1250 * 0.65 * 0.8} = 4.226$$

So, the number of lights is taken as 4.

Number of fans,

$$M = \frac{L(in\ ft) * \mathrm{W}(in\ ft)}{100} = \frac{(29.08333) * (10.1667)}{100} = 2.956$$

So, the number of fans is taken as 2 because there is a lot of empty space close to the entrance gate where no fan is required.

Living Room

L = 13’ 6” = 4.114 meters
W = 12’ 11” = 3.937 meters
Room index = 1.1 (taken as 1)
UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 70 lux

F = 1250 lumen (fluorescent tubelight)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{70 * 4.114 * 3.937}{1250 * 0.61 * 0.8} = 1.858$$

So, the number of lights is taken as 2.

Number of fans,

$$M = \frac{L(in\ ft) * W(in\ ft)}{100} = \frac{(13.5) * (12.916)}{100} = 1.74$$

So, the number of fans is taken as 2.

Veranda Attached to Living Room

L = 11’ 10” = 3.6068 meters
W = 3’ 10” = 1.1684 meters
Room index = .746 (taken as 1)
UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 50 lux

F = 1250 lumen (ceiling light)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{50 * 3.6068 * 1.1684}{1250 * 0.61 * 0.8} = 0.345$$

So, the number of lights is taken as 1. There is no need of fans in the veranda. Similar procedure has been followed for all the remaining verandas and the results are summarized below:

Veranda Attachment	E (lux)	Height (ft)	Width (ft)	Area (m^2)	Index	UF	N
Living Room	50	11’10”	3’10”	4.214	1	0.61	0.345 (1)
Dining Space	50	10’2”	3’4”	3.117	1	0.61	.255 (1)
Kitchen	50	4’	5’2”	1.901	1	0.61	.155 (1)
Master Bedroom	50	4’11”	4’10”	2.186	1	0.61	.179 (1)

Bathroom attached to master bedroom

L = 7’ 10” = 2.387 meters

W = 5’ 10” = 1.777 meters

Room index = .861 (taken as 1)

UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 50 lux

F = 1250 lumen (ceiling light)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{50 * 2.387 * 1.777}{1250 * 0.61 * 0.8} = 0.347$$

So, the number of lights is taken as 1. There is no need of fans in the bathroom. Similar procedure has been followed for all the remaining bathrooms and the results are summarized below:

Bathroom Attachment	E (lux)	Height (ft)	Width (ft)	Area (m^2)	Index	UF	N
Master Bedroom	50	7'10"	5'10"	4.241	1	0.61	0.347 (1)
Bedroom	50	7'10"	4'7"	3.334	1	0.61	.273 (1)
Guest Bedroom	50	7'3"	5'2"	3.478	1	0.61	.285 (1)
Common	50	8'2"	5'	3.793	1	0.61	.310 (1)

Garage

Area = 108.9307 square meter

Room index = 1

UF = 0.61

MF = 0.9

E = 100 lux

F = 2500 lumen (ceiling mounted tubelights)

Then, number of lights,

$$N = \frac{E * Area}{F * UF * MF} = \frac{100 * 108.9307}{1250 * 0.61 * 0.9} = 16$$

So, the number of ceiling mounted tube lights is taken as 16. There is no need of fans in the garage.

Generator Room

L = 15’ 4.5” = 4.68 meters
W = 11’5.6” = 3.493 meters
Room index =1.01 (taken as 1)
UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 50 lux

F = 1250 lumen (ceiling light)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{50 * 4.68 * 3.493}{1250 * 0.61 * 0.8} = 1.13$$

So, the number of lights is taken as 1. There is no need for fans in the generator room.

Transformer Room

L = 13’ 8” = 4.17 meters
W = 8’7” = 2.62 meters

Room index = .547 (taken as 1)
UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 50 lux

F = 1250 lumen (ceiling light)

Then, number of lights

$$N = \frac{E * L * W}{F * UF * MF} = \frac{50 * 4.17 * 2.62}{1250 * 0.61 * 0.8} = 0.89$$

So, the number of lights is taken as 1. There is no need for fans in the generator room.

Guard Room

L = 9’ 6” = 2.895 meters
W = 8’ 2” = 2.489 meters
Room index = 1.126 (taken as 1)
UF (from table for C=0.7, W = 0.5, F = 0.2) = 0.61

MF = 0.8

E = 50 lux

F = 1250 lumen (ceiling light)

Then, number of lights,

$$N = \frac{E * L * W}{F * UF * MF} = \frac{70 * 2.895 * 2.489}{1250 * 0.61 * 0.8} = 0.826$$

So, the number of lights is taken as 1.

Number of fans,

$$M = \frac{L(in\ ft) * W(in\ ft)}{100} = \frac{(9.5) * (8.166)}{100} = 0.775$$

So, the number of fans is taken as 1.

Basement

Area = 108.9307 square meter
Room index = 1
UF = 0.61

MF = 0.9

E = 100 lux

F = 2500 lumen (ceiling mounted tubelights)

Then, number of lights,

$$N = \frac{E * Area}{F * UF * MF} = \frac{100 * 108.9307}{1250 * 0.61 * 0.9} = 16$$

So, the number of ceiling mounted tube lights is taken as 16. There is no need of fans in the garage.

Conduit

The different types of conduits used in the layout along with their ratings andgeometry[2] are summarized below:

Schedule of Conduits

Symbol	Containing Power Cable + ECC	Conduit Size (Diameter)
C1	2 × 1.5rm BYM	¾"
C2	4 × 1.5rm BYM	¾"
C3	6 × 1.5rm BYM	¾"
C4	8 × 1.5rm BYM	1"
C5	10 × 1.5rm BYM	1"
C6	12 × 1.5rm BYM	1 ¼"
C7	14 × 1.5rm BYM	1 ¼"
C8	2 × 2.5rm BYM	¾"
C9	2 x 4rm BYM + 4rm BYA ECC	¾"
C10	4 x 4rm BYM + 2 x 4rm BYA ECC	1 ¼"
C11	2 x 1.5rm BYM + 1.5rm BYA ECC	¾"
C12	4 x 1.5rm BYM + 2 x 1.5rm BYA ECC	¾"
C13	2 x 2.5rm BYM + 2.5rm BYA ECC	¾"
C14	2 x 35rm BYM + 35rm BYA ECC	
C15	2 x 50rm BYM + 50rm BYA ECC	
C16	4 x 35rm BYM + 2 x 35rm BYA ECC	
C17	4 x 50rm BYM + 2 x 50rm BYA ECC	
C18	8 x 2.5rm BYM + 4 x 2.5rm BYA ECC	1 ½"

Switchboard

Example calculation for SDB-1

Dining room is under the sub distribution board as CKT-7. There are two switchboards in dining room, SB7 draws connection from the SDB, and SB6draws connection from SB7.

For SB6 the power and current requirements are:
LL9 (lintel level light) = 20 watts 20W/(220*0.95)=0.09A

CL1 (ceiling level light) = 20 watts=220W/(220*0.95)=0.09A

F4 (ceiling fan) = 80 watts 80W/(220* 0.95)=0.38A
SS2 (2 pin socket without earth conductor) = 5A
Total current requirement for SB6 = (5+0.09+0.09+0.38) = 5.56A
Wire from SB7 to SB6 has to be rated higher than 5A, we use C8 wire here (2x4rm, 4rm ECC, 15A conduction capacity)

For SB7, the power requirements are:
SB6 5.56A
LL10 (lintel level light) = 20W 20W/(220*0.95)=0.09A

Total SB7 incoming current = (5. 56+ 0.09) =5.65A
Wire from SDB1 to SB7 has to be rated higher than 5A, we use C8 wire here (2x4rm, 4rm ECC, 15A conduction capacity)
Required circuit breaker for CKT-4 (Dining room) = 10A SP MCCB (singlepole mold case circuit breaker)

Switch Board Summary

Sub distribution board (SDB)-1 Fixtures							
Room Name	Circuit No	Switchboard	Fixture	Power (W)	Current Rating	Wire Rating	Breaker to SDB
M. Bedroom	CKT1	SB2	LL1(Light)	20	0.09	C1	5A
			LL6(Light)	20	0.09		
			Total	40	0.18		
Bedroom	CKT2	SB4	LL3(Light)	20	0.09	C8	10A
			LL7(Light)	20	0.09		
			SS2(2 pin socket	100	5		
			Total	140	5.18		
Kitchen	CKT3	SB5	LL4(Light)	20	0.09	C8	10A
			F3(Fan)	80	0.38		
			TL3(Light)	20	0.09		
			SS3(2 pin socket)	100	5		
			Total	220	5.56		
Dining	CKT4	SB6	LL9(Light)	20	0.09	C8	10A
			CL1(Light)	20	0.09		
			F4(Fan)	80	0.38		
			SS4(2 pin socket)	100	5		
		SB7	LL10(Light)	20	0.09		
			Total	240	5.65		
G. Bedroom	CKT5	SB8	CL2(Light)	20	0.09	C8	10A
			SS6(2 pin socket)	100	5		
			Total	120	5.09		
Living Room	CKT6	SB9	TS1(TV socket)	100	5	C8	10A
			TL8(Light)	20	0.09		
			CL3(Light)	20	0.09		
			F8(Fan)	80	0.38		
			Total	220	5.56		
Stairs	CKT7	SB10	CL7(Ceiling Mounted Light)	20	0.09	C1	5A

Sub distribution board (SDB)-1 Power Circuits			
Room Name	Power Socket	Current Rating (A)	Wire Rating
M. Bedroom	S1	20	2x6+6 ECC
Bedroom	S2	20	2x6+6 ECC
Kitchen	S3	15	2x4+4 ECC
Dining	S4	15	2x4+4 ECC
G. Bedroom	S5	20	2x6+6 ECC
Living Room	S6	20	2x6+6 ECC

Emergency sub distribution board (ESDB)-1 Fixtures							
Room Name	Circuit No	Switchboard	Fixture	Power Rating	Current Rating	Wire Rating	Breaker to ESDB
		SB1	LL2(Light)	20	0.09		
			F1(Fan)	80	0.38		
		SB2	TL1(Light)	20	0.09		
			SS1(2 pin socket)	100	5		
M. Bedroom	CKT1		Total	220	5.56	C8	10A
			TL2(Light)	20	0.09		
			F2(Fan)	80	0.38		
Bedroom	CKT2	SB4	Total	100	0.47	C1	5A
			LL5(Light)	20	0.09		
			E1(Exhaust Fan)	40	0.19		
			LL8(Light)	20	0.09		
Kitchen	CKT3	SB5	Total	80	0.37	C1	5A
		SB6	LL11(Light)	20	0.09		
			TL4(Light)	20	0.09		
			TL5(Light)	20	0.09		
			F5(Fan)	80	0.38		
		SB7	SS5(2 pin socket)	100	5		
Dining	CKT4		Total	240	5.65	C8	10A
			TL6(Light)	20	0.09		
			F6(Fan)	80	0.38		
G. Bedroom	CKT5	SB8	Total	100	0.47	C1	5A
			TL7(Light)	20	0.09		
			F7(Fan)	80	0.38		
			SS7(2 pin socket)	100	5		
Living Room	CKT6	SB9	Total	200	5.47	C8	10A

Emergency sub distribution board (ESDB)-0 Fixtures							
Room Name	Circuit No	Switchboard	Fixture	Power Rating	Current Rating	Wire Rating	Breaker to ESDB
Guard Room	CKT3	SB5	LL3(Light)	20	0.09	C8	10A
			F3(Fan)	80	0.38		
			SS3(2 pin socket) 100		5		
		SB6	LL4(Light)	20	0.09		
			Total	220	5.56		
Generator Room	CKT1	SB1	E1(Exhaust Fan)	80	0.38	C8	10A
			SS1(2 pin socket)	100	5		
			LL1(Light)	20	0.09		
			Total	200	5.47		
Transformer Room	CKT2	SB2	E2(Exhaust Fan)	80	0.38	C8	10A
			SS2(2 pin socket)	100	5		
			LL2(Light)	20	0.09		
			Total	200	5.47		

Sub distribution board (SDB)-0 Fixtures							
Room Name	Circuit No	Switchboard	Fixture	Power Rating	Current Rating	Wire Rating	Breaker to ESDB
Garage	CKT 3	SB3	CL1	20	0.09	C8	10
			CL2	20	0.09		
			CL3	20	0.09		
			CL4	20	0.09		
			CL5	20	0.09		
			CL6	20	0.09		
			CL7	20	0.09		
			CL8	20	0.09		
			SS3	100	5		
			Total	260	5.72		
	CKT4	SB4	CL9	20	0.09	C8	10
			CL10	20	0.09		
			CL11	20	0.09		
			CL12	20	0.09		

			CL13	20	0.09		
			CL14	20	0.09		
			CL15	20	0.09		
			CL16	20	0.09		
			SS4	100	5		
			Total	260	5.72		

Sub distribution board (SDB)-0 Power Circuits			
Room Name	Power Socket	Current Rating (A)	Wire Rating
Guard Room	S1	20	C9

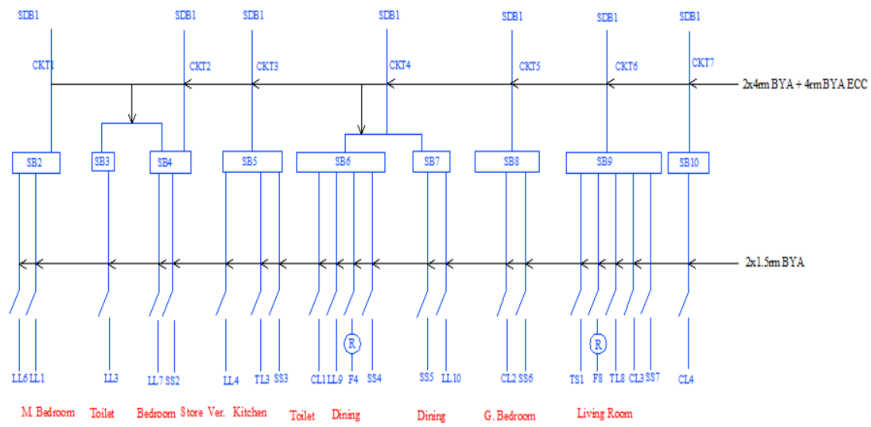
Sub distribution board (SDB)-2 Fixtures							
Room Name	Circuit No	Switchboard	Fixture	Power Rating	Current Rating	Wire Rating	Breaker to ESDB
Basement	CKT 1	SB3	CL1	20	0.09	C8	10
			CL2	20	0.09		
			CL3	20	0.09		
			CL4	20	0.09		
			CL5	20	0.09		
			CL6	20	0.09		
			CL7	20	0.09		
			CL8	20	0.09		
			CL9	20	0.09		
			CL10	20	0.09		
			CL11	20	0.09		
			CL12	20	0.09		
			CL13	20	0.09		
			CL14	20	0.09		
			CL15	20	0.09		
			CL16	20	0.09		
			SS1	100	5		
			Total	420	6.44		

Emergency sub distribution board (ESDB)-2 Fixtures						
Room Name	CircuitNo	Switchboard	Fixture	Power Rating	CurrentRating	Wire Rating
Lift	CKT 2	SB1		10.7kW	69.481A	C9

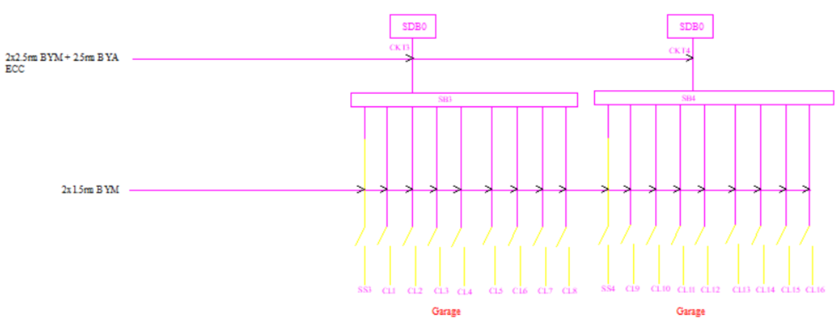
Circuit Diagram For MDB,SDB,SB,EMDB,ESDB

Switch Board	SB
Switch	
Fan Regulator	R
Single Pole Circuit Breaker (SP MCCB)	
Automatic Transfer Switch (ATS)	
Triple Pole Circuit Breaker (TP MCCB)	
Delta to Wye Transformer	
Power factor improvement (PFI) plant	
Generator	G
Energy Meter	EM

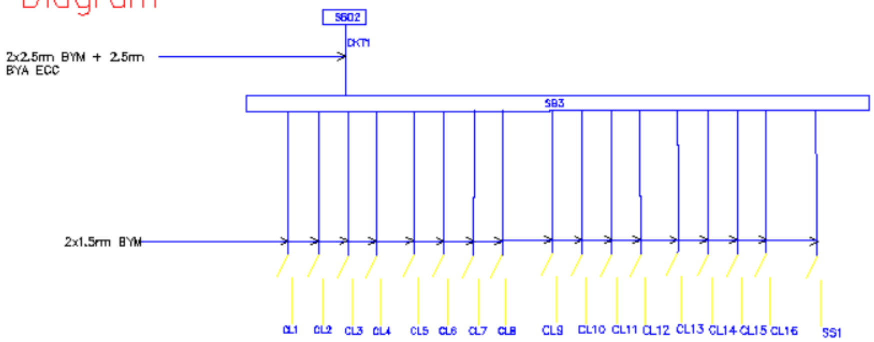
Switch Board Connection Diagram for Default Unit



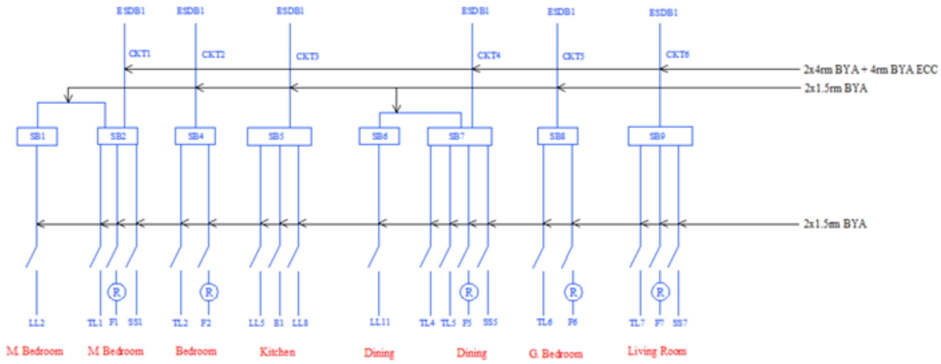
Ground Floor SDB0 Switch Board Connection Diagram



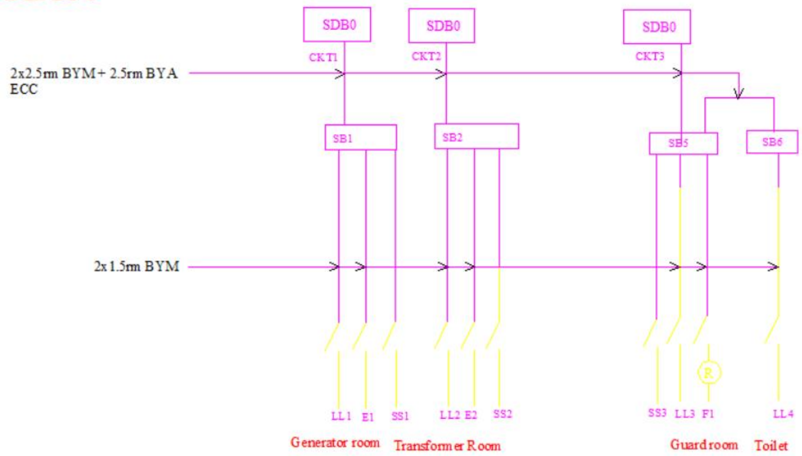
Basement SDB2 Switch Board Connection Diagram



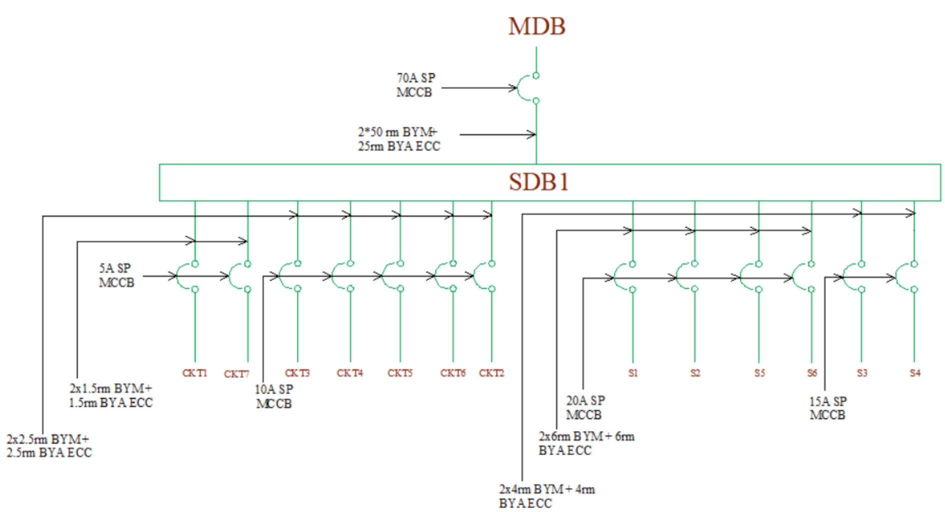
Emergency Switch Board Connection Diagram for Default Unit



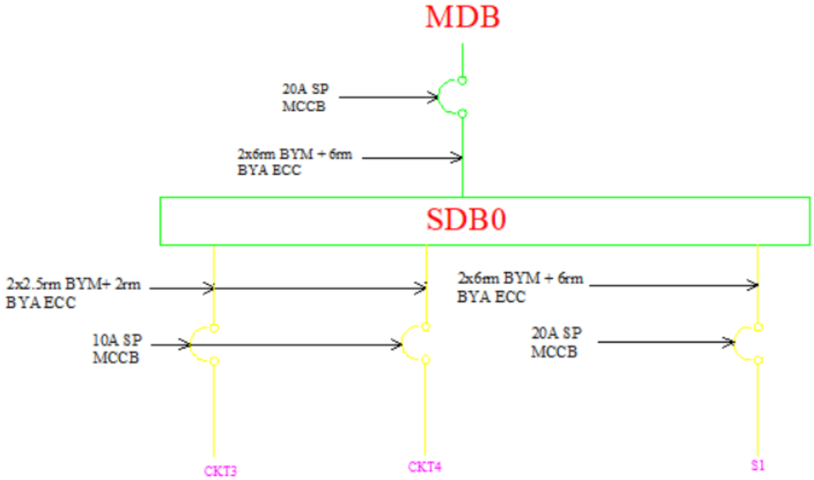
Emergency Switch Board Connection Diagram for ESDB0



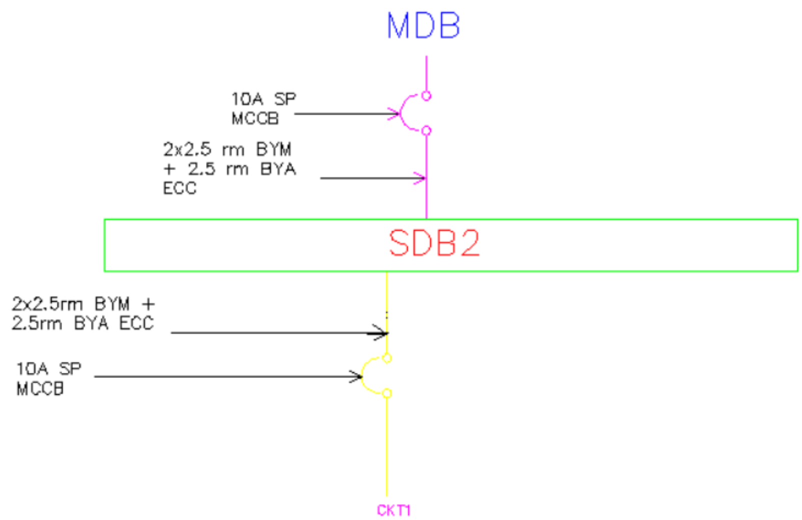
Typical Floor SDB1 Diagram



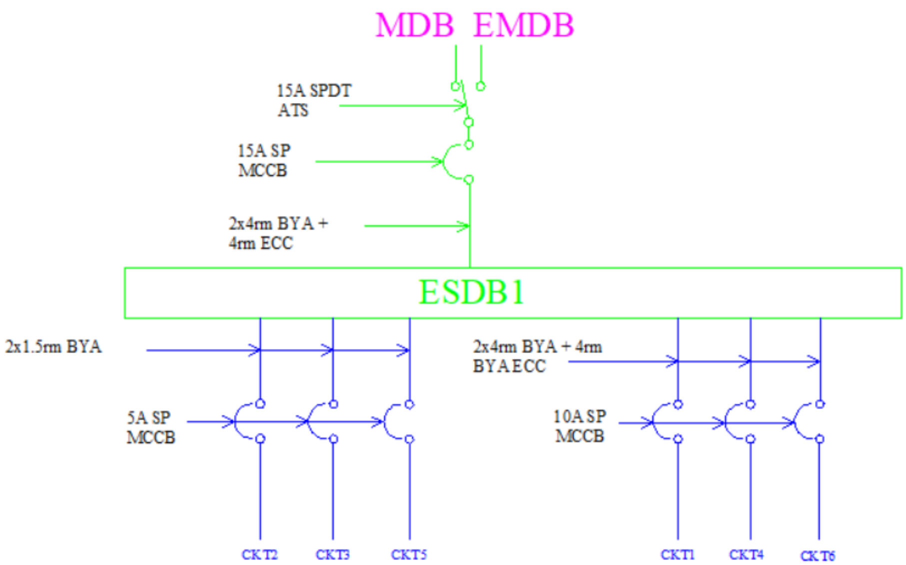
Ground Floor SDB0 Diagram



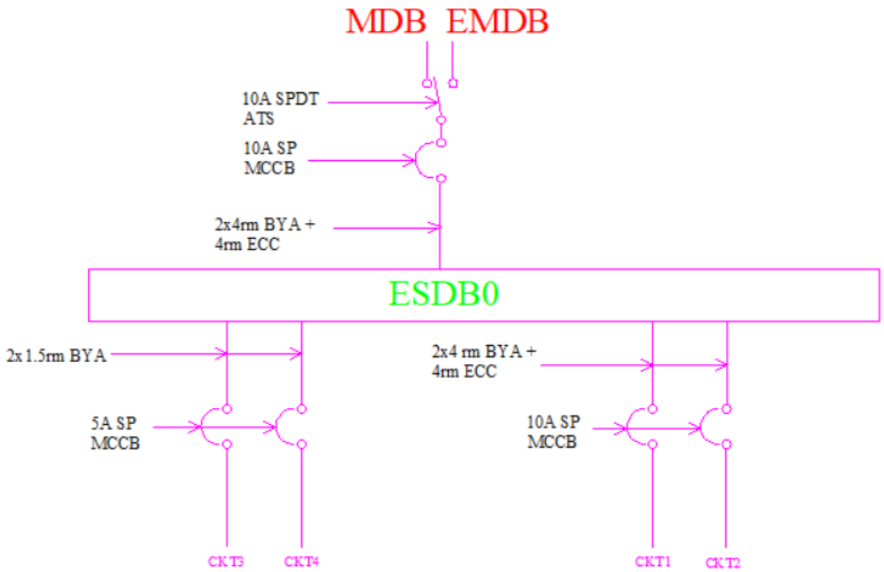
Basement SDB2 Diagram



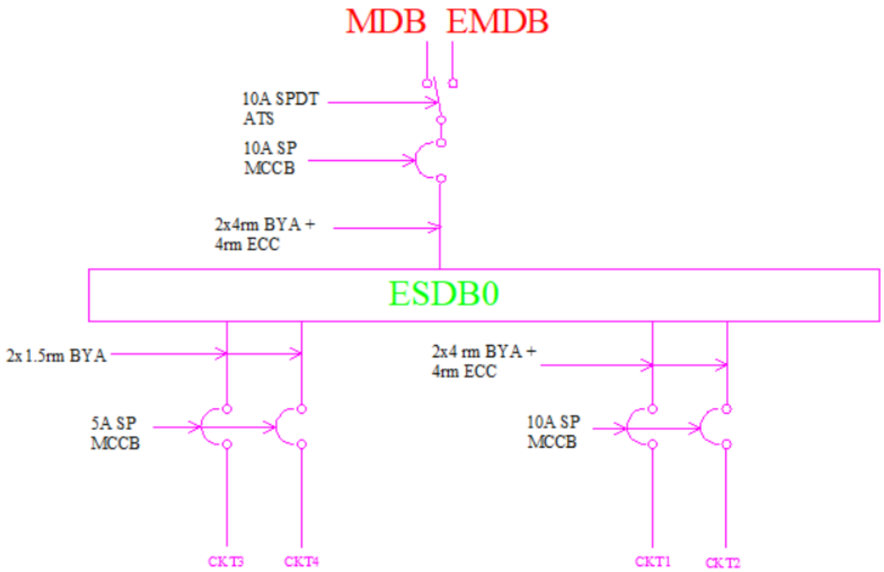
Default Unit ESDB1 Diagram



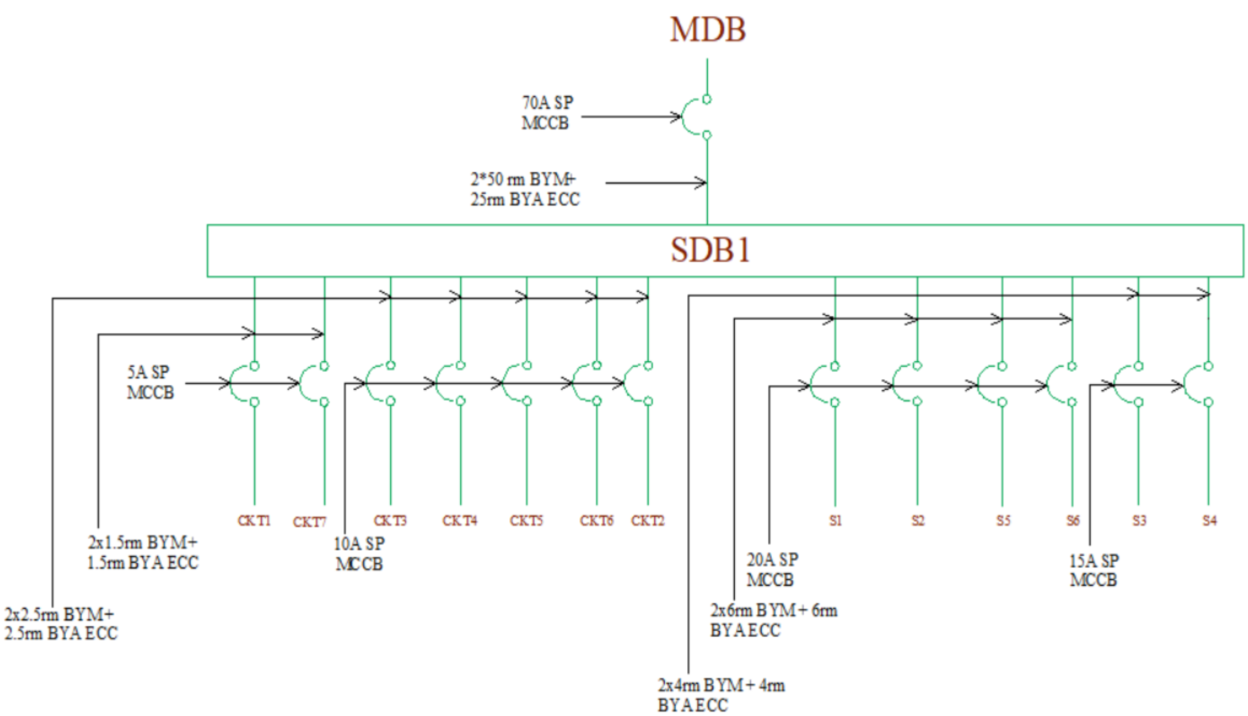
Ground Floor ESDB0 Diagram



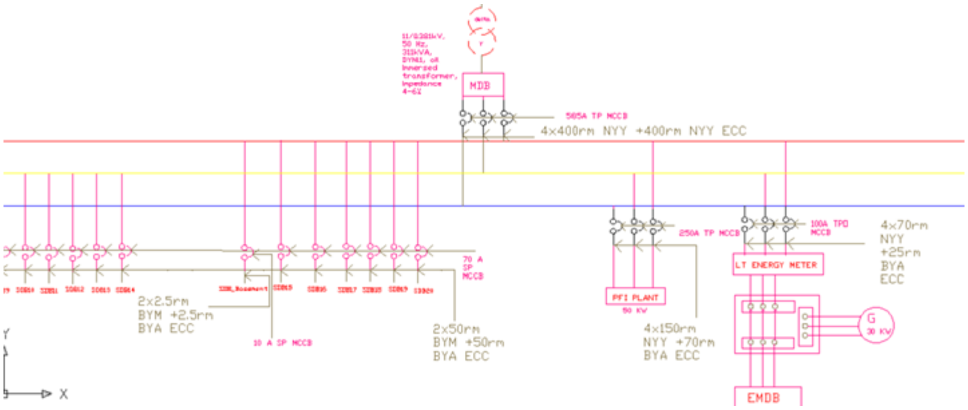
Ground Floor ESDB0 Diagram

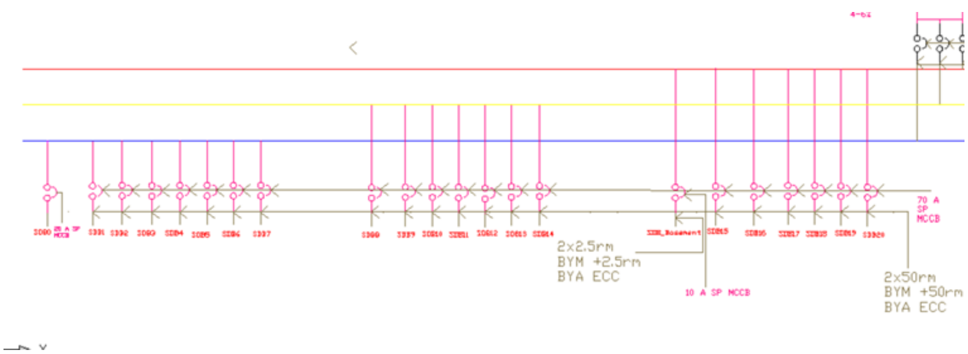


Typical Floor SDB1 Diagram

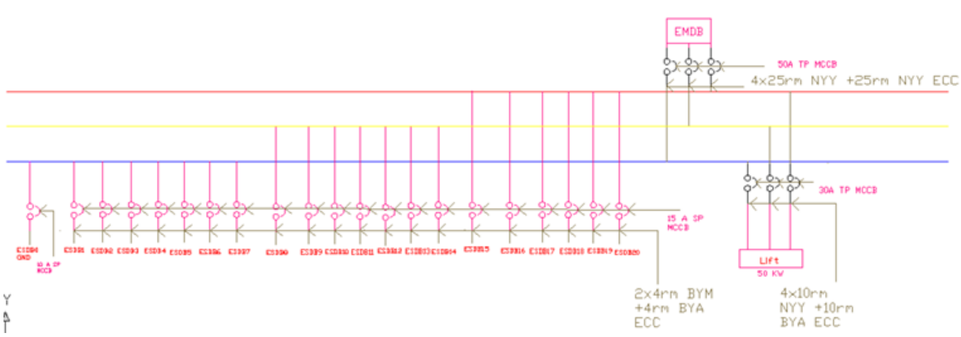


Main Distribution Board





Emergency Main Distribution Board



Sub-Distribution Board Calculations

Sub-distribution board 1

Total current rating in fixtures = (CKT1 + CKT2 + CKT3 + CKT4 + CKT5 + CKT6+ CKT7) = (0.18 + 5.18 + 5.56 + 5.65 + 5.09 + 5.56+ 0.09) A = 27.31 A

Total current rating in power circuits = (S1 + S2 + S3 + S4 + S5 + S6) = (20 + 20 + 15 + 15 + 20 + 20) = 110 A

Activity factor for fixtures = 0.8

Activity factor for power circuits = 0.4

Total current rating for SDB-1 to MDB = (0.8x27.31 + 0.4x110) = 65.848A

Thus,

breaker rating for SDB-1 = 70A SP MCCB

Wire rating for SDB-1 = 2x50rm BYM + 50 rm BYA ECC

Emergency Sub-distribution board 1

Total current rating in fixtures = (CKT1 + CKT2 + CKT3 + CKT4 + CKT5 + CKT6) = (5.54 + 0.47 + 0.37 + 5.65 + 0.47 + 5.47) A = 17.97A

Activity factor for fixtures = 0.8

Total current rating for ESDB-1 = 0.8x17.97 = 14.3A

Breaker rating for ESDB-1 = 15A; ATS rating for ESDB-1 = 15A

Wire rating for ESDB-1 = 2x4rm BYM + 4rm BYA ECC

Sub-distribution board 0

Total current rating in fixtures = (CKT3 + CKT4)

= (5.72 + 5.72) A = 11.44 A

Total current rating in power circuits = S1 = 20 A

Total current rating for SDB-0 to MDB = (0.8x11.44+ 0.4x20) = 17.152

Breaker rating for SDB-0 = 20A SP MCCB

Wire rating for SDB-0 = 2x6rm BYM + 6rm BYA ECC

Emergency Sub-distribution board 0

Total current rating in fixtures = (CKT1 + CKT2 + CKT5) = (5.56 + 5.56 + 5.47) A = 16.5 A

Activity factor for fixtures = 0.8

Total current rating for ESDB-0 = 0.8x16.5A = 13.2

A Breaker rating for ESDB-0 = 15 A MCCB

ATS rating for ESDB-0 = 15 A

Wire rating for ESDB-0 =2x4rm BYM + 4rm BYA ECC

Sub-distribution board 2

Total current rating in fixtures = CKT1 = 6.44 A

Breaker rating for SDB-2 = 10A MCCB

ATS rating for SDB-2 = 10A

Wire rating for SDB-2 = 2x2.5rm BYM

Emergency Sub-distribution board 2

Total current rating in fixtures = CKT2 = 69.481 A

Activity factor for fixtures = 0.8

breaker rating for ESDB-2 = 70A SP MCCB

ATS rating for ESDB-2 = 70A

Wire rating for ESDB-2 = 2x50rm BYM + 50 rm BYA ECC

Main and Emergency Distribution Board Calculations

Main bus bar

Sub Distribution Board

Total Current rating for SDB-1 to MDB = 65.848A
Sub-distribution boards per phase of MDB bus-bar = 8
Total maximum current rating for phase R/Y/B from Main lines
= 70% x (8 x 65.848) = 368.75A

Emergency Sub Distribution Board

Total Current rating for ESDB-1 to EMDB = 14.3
Lift Load = 18.5 kW
Lift rating , I = $\frac{18500}{\sqrt{3}\times\sqrt{3}\times 220\times 0.95}$ A = 29.51A . Therefore, 30 A TP MCCB required
Lift rating = 30A
Total maximum current rating for phase R/Y/B from Generator lines
(including Lift and Pump) = 70% x (8 x 14.3+30) = 101.08A

Total current from main bus bar to phase = 368.75+101.08 = 469.83 A
∴ 585 A TP MCCB is required.
Line rating from transformer to main bus bar = 4x400rm NYY + 400rm NYY ECC

Transformer, PFI Plant and Generator Calculations

Transformer

Total current from main bus bar to phase = 469.8288 A
Worst case pf = 0.9
Transformer rating = 3*phase voltage*line current
= 3*220*469.8288 VA
= 310.1 kVA
= 311 kVA
∵ 311 kVA > 200 kVA , ∴ Separate substation is required.

PFI Plant

For improving, pf from worst case 0.9 to best case 0.95:

Total apparent power draw, S = 3*V*I = 3* 220* 469.8288 VA = 311 kVA
Worst case reactive power for 0.9 pf,

Q_{worst} = S$\sqrt{\left(\frac{1}{0.9}\right)^2 - 1}$ = 150.19 kVAR

Best case reactive power for 0.95 pf,

Q_{best} = S$\sqrt{\left(\frac{1}{0.95}\right)^2 - 1}$ = 101.92 kVAR

PFI plant rating = Q_{worst} - Q_{best} = 48.27 kVAR

For PFI current value, I = $\frac{Q}{3 \times V \times \sin 18.19}$ = $\frac{48270}{3 \times 220 \times \sin 18.19}$ = 234.22 A

∴ PFI breaker rating = 250 TP MCCB

Line rating 2×185 rm NYY + 185 rm NYY ECC

Generator

Generator Sizing

Total EMDB load = (20*940+620)*0.7+18500*0.7 = 26544 W

EMDB LOAD =26544 W

Assumed pf = 0.95

Generator size= LOAD/pf = 28 KVA

30KVA Generator with ATS

Lightning Protection System

Risk Assessment [3]

Index	Parameter	Class	Value
A	Use of Structure	Houses and similar buildings	2
B	Type of Construction	Brick, plain concrete or masonry with nonmetal roof	4
C	Contents of Consequential Effects	Ordinary domestic of office building, factories and workshops not containing valuable materials	2
D	Degree of Isolation	Located in a large area having structures of similar or greater height	2
E	Type of Terrain	Flat terrain at any level	2
F	Height of Structure	9-15m	4
G	Lightning Prevalence	Over 21	21
Total			37

Recommendation: Risk assessment factor < 40, lightning protection system is not mandatory but can be used for increased safety.

LPS Design Parameters

Lightning Arrestor

Rod Height = 2m

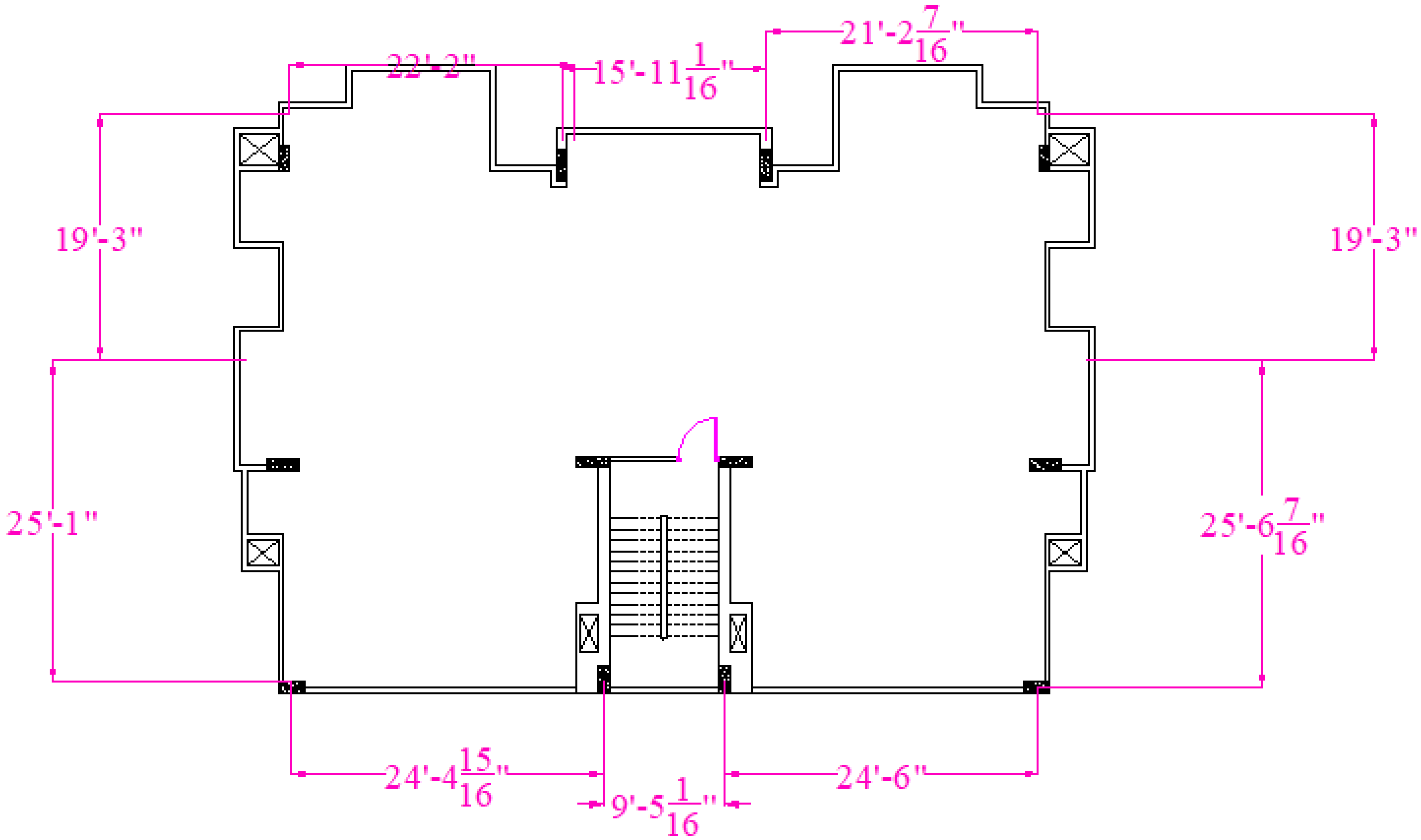
Roof perimeter = 2x(59’ 3 39/64” + 44’4”) = 207’ 3 7/32”

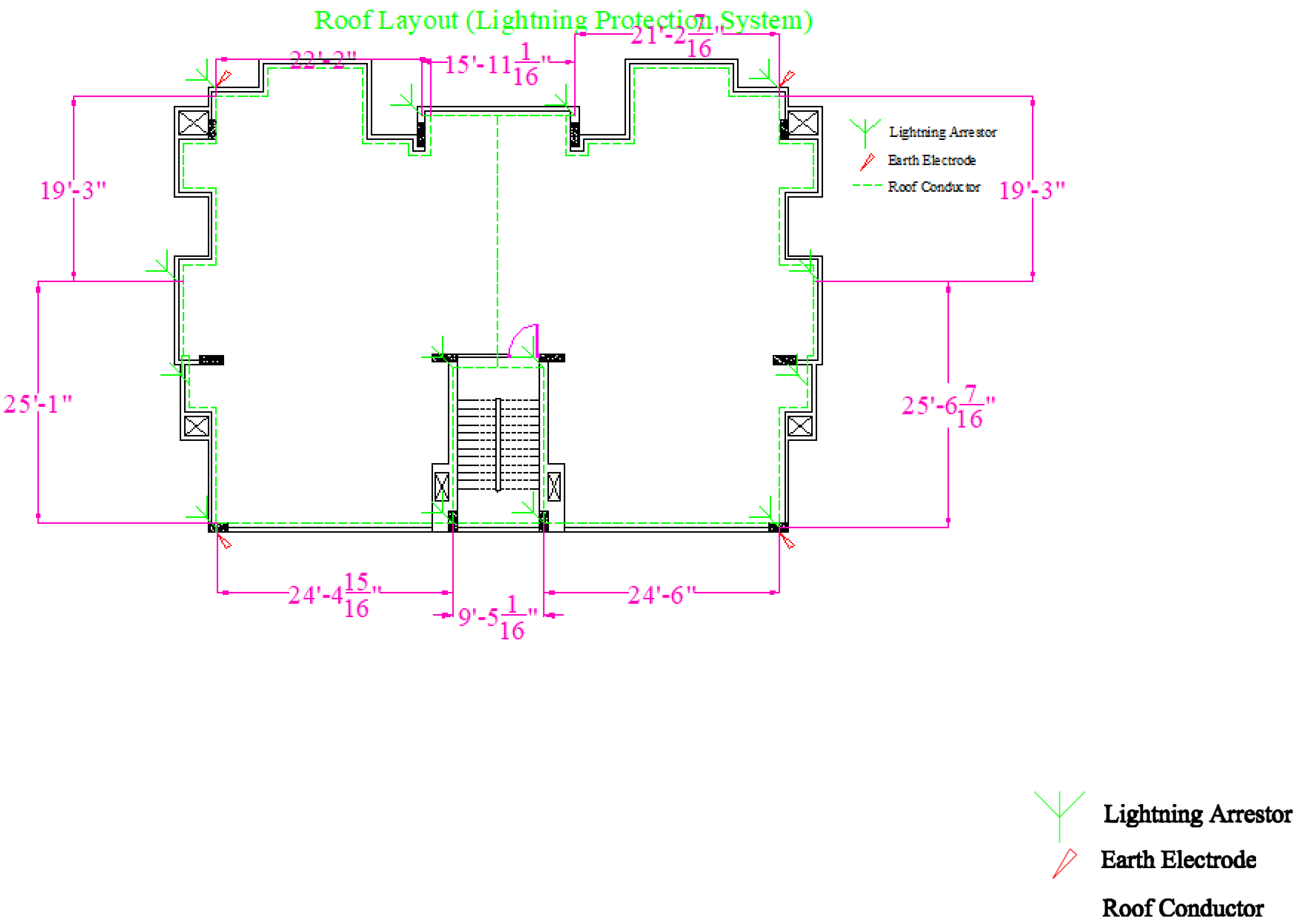
We place arrestors 25’ apart, requiring 4 arrestors along the length of the roof perimeter, 3 arrestors along the width, and 4 on the corners of the stair-room.

Roof Conductors

Roof conductors are placed 6” away from the roof railing connecting all the lightning arrestors to the down conductors.

Roof Layout (Lightning Protection System)





Roof Layout (Lightning Protection System)
22'-2"
15'-11 1/16"
21'-2 7/16"
19'-3"
19'-3"
Lightning Arrestor
Earth Electrode
Roof Conductor
25'-1"
25'-6 7/16"
24'-4 15/16"
9'-5 1/16"
24'-6"
Lightning Arrestor
Earth Electrode
Roof Conductor

Conclusion

In this project, we have performed the designing of a three-story building floor plan along with the electrical fixtures and conduit layout. Then, we have designed the switchboard connection diagram showing how the incoming electric power is distributed throughout the residential building. Along with the general connectivity, different wire schedules and protection equipment such as circuit breakers have been shown in the single line diagrams. To protect the building from electrical surges caused by lightning strike, we have planned the necessary lightning protection system. Thus, we have gained a hands-on experience on the electrical service design of a residential building.

Acknowledgments

We would like to thank Yeasir Arafat Sir, Mrinmoy Kundu Sir, Md. Rasel Mia Sir for their valuable guidance in this project.

References

[1] BNBC Table 8.1.5 (Recommended Values of Illumination for Residential Buildings

[2] Table for Cables, Conduits, ECC, EL, Voltage drop and Current ratings of different specifications as per Manual of Eastern Cables, BICC cables and Tables, Electrical Conductors (International Standard Sizes etc)

[3] BNBC Table 8.1.27 (Index Figures Associated with Lightning Protection Design)

References [1]

Table 8.1.5: Recommended Values of Illumination for Residential Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Dwelling Houses		**Hotels**	
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

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Basement Car Park	100	Kitchens	
Porches, Entrances	70	Food stores	100
Sewing and darning	600	Working areas	250
Reading (casual)	150	Goods and passenger lifts	70
Home work and sustained reading	300	Cloak-rooms and toilets	100
		Bathrooms	100
		Above mirror in bathrooms	300

References [2]

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Table for Cables, Conduits, ECC, EL, Voltage drop and Current ratings of different specifications as per Manual of Eastern Cables, BICC cables and Tables, Electrical Conductors (International Standard Sizes) etc. :

A	B	C	D	E	F		G	H	I		J	
					a'	b'			a''	b''	a'''	B'''
3/0.029	1.5	5	16	10	6	10		27	27	22	16	20
7/0.029	2.5	10	16	10	4	7		16	36	30	22	28
7/0.036	4	15	14	10	3	5	1	10	47	39	30	37
7/0.044	6	20	14	10	2	4	1	6.8	59	50	38	47
7/0.052	10	30	10	10	1	2	1.5	4	78	68	52	63
7/0.064	16	40	10	10		1	1.5	2.6	100	94	70	85
19/0.052	25	50	6	6		1	2	1.6	130	125	91	110
19/0.064	35	60	6	6			2	1.2	155	160	112	136
19/0.072	50	70	6	6			2	0.93	185	195	136	164
19/0.083	70	100	1/0	1/0			2	0.65	225	245	173	207
37/0.072	95	120	1/0	1/0			2.5	0.48	270	300	216	253
37/0.083	120	150	1/0	1/0			2.5	0.4	310	350	244	291
37/0.093	150	200	1/0	1/0			3	0.34	350	405		333
37/0.130	185	250	3/0	3/0			3.5	0.29	390	460		381
61/0.093	240	300	3/0	3/0			4	0.24	450	555		452
61/0.103	300	425	3/0	3/0			4	0.22	515	640		526
91/0.093	400	585	3/0	3/0			6	0.2	586	770		639
91/0.103	500	685	3/0	3/0			6	0.18	680	900		752
127/0.103	630	800	3/0	3/0			6	0.17	800	1030		855

A : *Single core cable construction diameter, inch .... as per Imperial Standard Size : B.S.S (old).*

B : *Single core cable construction area, mm² .... as per Metric Standard Size : VDE.*

C : *CB designed current rating amps.*

D : *ECC (Earth Continuity Conductor), SWG.*

E : *EL (Earthing Lead), SWG*

F : *No. of cables in*

a') 3/4" diameter conduit

b') 1" diameter conduit

G : *GI pipe diameter (for 4 – core cable), inch.*

H : *Volt drop /amp/meter, Vd in mV (For PVC insulated, non-armoured single core cable 600/1000 volts as per BICC Metric Supplement, page 20-22, September 1969).*

I : *Maximum Current rating (For Type : NYY to VDE 0271/3, 69)*

a") 30^0 C ambient temperature, underground, amps

b") 35^0 C ambient temperature in air, amps

J : *Maximum current carrying capacity (For Type : BYA to B.S. 6004 : 1975)*

a"') Bunched & Enclosed in conduit, two cables single phase at 35^0 C, amps

b"') Clipped to a surface or on a cable tray bunched and un-enclosed two cables single phase at 35^0 C, amps

NYY : *PVC insulated and PVC sheathed cable, rated voltage 600/1000 volts.*

BYA : *PVC insulated non-sheathed single core cable, rated voltage 450/750 volts.*

1.3.33 Lightning Protection of Buildings

Whether a building needs protection against lightning depends on the probability of a stroke and acceptable risk levels. Assessment of the risk and of the magnitude of the consequences needs to be made. As an aid to making a judgment, a set of indices is given in Table 8.1.27 below for the various factors involved.

Table 8.1.27 (a): Index Figures Associated with Lightning Protection Design

Index A: Use of Structure	Index	Index B: Type of Construction	Index
Houses and similar buildings	2	Steel framed encased with nonmetal roof[a]	1
Houses and similar buildings with outside aerial	4	Reinforced concrete with nonmetal roof	2
Small and medium size factories, workshops and laboratories	6	Brick, plain concrete, or masonry with nonmetal roof	4
Big industrial plants, telephone exchanges, office blocks, hotels, blocks of flats	7	Steel framed encased or reinforced concrete with metal roof	5
Places of assembly, for example, places of workshop, halls, theatres, museums, exhibitions, department stores, post offices, stations, airports, stadiums	8	Timber formed or clad with any roof other than metal or thatch	7
Schools, hospitals, children's homes and other such structures	10	Any building with a thatched roof	10

[a] A structure of exposed metal which is continuous down to ground level is excluded from the table as it requires no lightning protection beyond adequate earthing arrangements.

Table 8.1.27 (b): Index Figures Associated with Lightning Protection Design

Index C : Contents or Consequential Effects	Index	Index D : Degree of Isolation	Index
Ordinary domestic or office building, factories and workshops not containing valuable materials	2	Structure located in a large area having structures or trees of similar or greater height, e.g. a large town or forest	2
Industrial and agricultural buildings with specially susceptible [b] contents	5	Structure located in an area with a few other structures or trees of similar height	5
Power stations, gas works, telephone exchanges, radio stations	6	Structure completely isolated or exceeding at least twice the height of surrounding structures or trees	10
Industrial key plants, ancient monuments, historic buildings, museums, art galleries	8	**Index E : Type of Terrain**	**Index**
Schools, hospitals, children's and other homes, places of assembly	10	Flat terrain at any level	2
[b] This means specially valuable plant or materials vulnerable to fire or the results of fire.		Hilly terrain	6
		Mountainous terrain 300 m and above	8

Table 8.1.27 (c) : Index Figures Associated with Lightning Protection Design

Index F : Height of Structure	Index	Index G : Lightning Prevalence	Index
Up to 9 m	2	Number of thunderstorm days per year:	
9-15 m	4	Up to 3	2
15-18 m	5	4-6	5
18-24 m	8	7-9	8
24-30 m	11	10-12	11
30-38 m	16	13-15	14
38-46 m	22	16-18	17
46-53 m [c]	30	19-21	20
[c] Structures higher than 53 m require protection in all cases		Over 21	21