EE 63001-ELECTRICAL INSTALLATIONS

Faculty of Engineering

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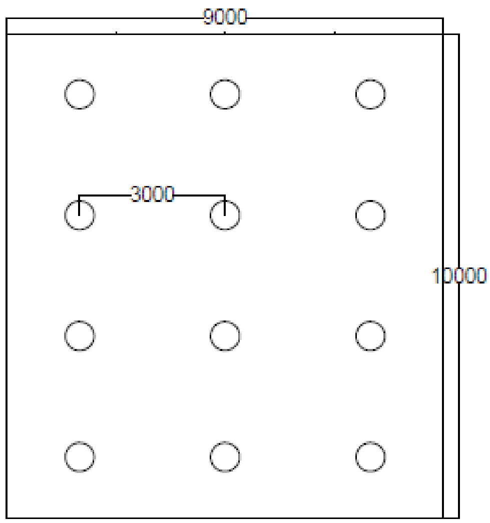
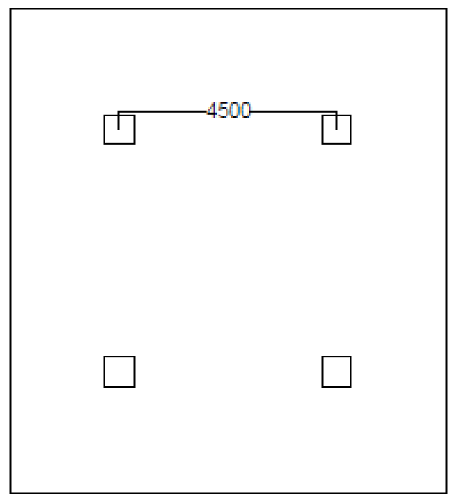
Sample design EE 63001

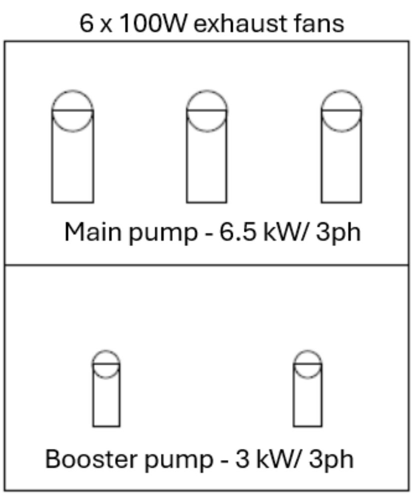
Lightning design



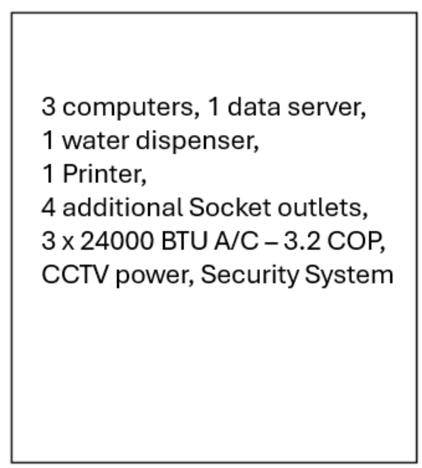
Ground floor



First floor



GF



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Calculations for the lightning

Ground floor

Total lumens required $= 600\times10\times9$

$= 54000$ lumens

Room index $= \dfrac{L\times W}{(H1-H0)\times(L+W)}$

$= \dfrac{10\times9}{(5-0.5)\times(10+9)}$

$= 1.053$

First floor

Total lumens required $= 250\times10\times9$

$= 22500$ lumens

Room index $= \dfrac{L\times W}{(H1-H0)\times(L+W)}$

$= \dfrac{10\times9}{(3-0.6)\times(10+9)}$

$= 1.974$

Table 1: Lighting Design Parameters for Ground Floor and First Floor

Parameters	Ground floor	First floor
Required lux level	600	250
Distance between luminaire and the working plane	4.8	2.4
Total lumens required	54000	22500
Reflectance	753	753
Maintenance factor	0.8	0.8
Utilization factor	0.54	0.68
Required lumens per luminaire	10417	10340

Demand calculation

Formulae for the current (3 ph.) $= \dfrac{\text{Real power given} \times \text{Number of units}}{\sqrt{3} \times 400 \text{ V} \times \text{PF}}$

Formulae for the current (single ph.) $= \dfrac{\text{Real power given} \times \text{Number of units}}{230 \text{ V} \times \text{PF}}$

Ground floor

Current for the main pump $= \dfrac{6500 \text{ W} \times 2}{\sqrt{3} \times 400 \text{ V} \times 0.85}$

$= 22.08$ A

Current for the booster pump $= \dfrac{3000 \text{ W} \times 2}{\sqrt{3} \times 400 \text{ V} \times 0.85}$

$= 10.19$ A

Current for the lamps $= \dfrac{60 \text{ W} \times 12}{3 \times 230 \text{ V} \times 0.9}$

$$= 1.16\ \text{A}$$

Current for the fans $= \dfrac{100\ \text{W} \times 4}{3{\times}230\ \text{V} \times 0.8}$

$$= 1.09\ \text{A}$$

Current for the socket outlets $= \dfrac{3000\ \text{W}}{3{\times}230\ \text{V} \times 0.85} \times \dfrac{4}{3}$

$$= 6.65\ \text{A}$$

Table 2: Electrical Load Analysis and Maximum Demand Currents for the Ground Floor

Electrical load	Current (A)	Power factor	Cluster	Demand/diversity factor	Currents at MD (A)
Main pumps (2 pumps working simultaneously)	22.08	0.85	1	1	22.08
Booster pumps (2 pumps working simultaneously)	10.19	0.85	2	1	10.19
Exhaust fans (4 working simultaneously)	1.09	0.8	3	0.67	0.73
Small power socket outlets (3000 W)	6.65	0.85	4	0.85	5.65
Lamps	1.16	0.9		1	1.16
Summation of the currents for the ground floor					**39.81**

First floor

Current for the computers $= \frac{300\ W \times 3}{230\ V \times 3 \times 0.9}$

$= 1.45\ A$

Current for the data center $= \frac{600\ W}{230\ V \times 0.9} \times \frac{1}{3}$

$= 0.97\ A$

Current for the printer $= \frac{500\ W}{230\ V \times 0.8} \times \frac{1}{3}$

$= 0.9\ A$

Current for the water dispenser $= \frac{500\ W}{230\ V \times 0.95} \times \frac{1}{3}$

$= 0.76\ A$

Current for the socket outlets $= \frac{500\ W}{230\ V \times 0.8 \times 3} \times \frac{4}{3}$

$= 1.2\ A$

BTU to kW $= \frac{BTU/hr}{COP}$

$= \frac{24000 \times 0.000293}{3.2}$

$= 2200\ W$

Current for the air condition $= \frac{2200W \times 3}{230\ V \times 3 \times 0.85}$

$= 11.25\ A$

Current for the cctv and security system $= \frac{500\ W}{230\ V \times 0.9} \times \frac{1}{3}$

$= 0.8\ A$

Current for the lamps $= \frac{40\ W}{230\ V \times 0.9 \times 3} \times \frac{4}{3}$

$= 0.09\ A$

Table 3: Maximum demand for various components of the first floor

Electrical load	Current (A)	Power factor	Demand and diversity factor	Currents at MD (A)
Computers	1.45	0.9	0.8	1.16
Data center	0.97	0.9	0.8	0.78
Printer	0.9	0.8	0.5	0.45
Water dispenser	0.76	0.95	0.6	0.46
Socket outlets	1.2	0.8	0.6	0.72
Air condition	11.25	0.85	0.9	10.13
Security system	0.8	0.9	1	0.8
Lamps	0.09	0.9	1	0.09
Summation of the currents for the first floor				**14.6**

Cable selection

Ground floor

Single phase loads

Lightning – $2C/1mm^2/Cu/PVC/PVC$

Exhaust fans – $2C/1mm^2/Cu/PVC/PVC$

Socket outlets – $2C/1.5mm^2/Cu/PVC/PVC$

Three phase loads

Main pump

Temperature derating factor (C_a) $= \sqrt{\frac{T_{max}-T_a}{T_{max}-T_0}}$

$= \sqrt{\frac{70-35}{70-30}}$

$= 0.94$

(Actual ambient temperature was taken as 30 °C)

Cable laying method (C_i) $= 1$

Grouping factor (C_g) $= \frac{1}{n^{\frac{1}{3}}}$

$= \frac{1}{3^{\frac{1}{3}}}$

$= 0.69$

Total derating $= C_a \times C_i \times C_g$

$= 0.94 \times 1 \times 0.69$

$= 0.65$

Main pump

Required minimum current capacity $= \frac{11.04\ A}{0.65}$

$= \underline{\underline{16.98\ A}}$

Booster pump

Temperature derating factor and cable laying method both are same

Grouping factor (C_g) $= \frac{1}{n^{\frac{1}{3}}}$

$= \frac{1}{2^{\frac{1}{3}}}$

$= 0.79$

Total derating $= C_a \times C_i \times C_g$

$= 0.94 \times 1 \times 0.79$

$= 0.74$

Required minimum current capacity $= \frac{5.10\text{ A}}{0.74}$

$= \underline{\underline{6.89\text{ A}}}$

Table 4: Electrical Load, Current Ratings, and Corresponding Cable Types for Various Equipment of the ground floor

Electrical load	**Current (A)**	**Cable type** (70°C multi core thermoplastic insulated cables)
Lightning	1.16	$2C/1mm^2/Cu/PVC/PVC$
Socket outlets	5.65	$2C/1mm^2/Cu/PVC/PVC$
Exhaust fans	0.73	$2C/1mm^2/Cu/PVC/PVC$
Main pump	16.98	$4C/2.5mm^2/Cu/PVC/PVC$
Booster pump	6.89	$4C/1mm^2/Cu/PVC/PVC$

Current capacity of the three-phase cable that distributes current to the single-phase loads $= 1.16A + 5.65A + 0.73A$

$= 7.54A$

Therefore, rated current $= \dfrac{7.54\text{ A}}{0.94}$

$= 8.02\text{A}$

Therefore, the applicable cable sizing is **4C/1.5mm²/Cu/PVC/PVC**

Table 5: Current Distribution Across Lines for Various Electrical Loads

Name of the load	Line 1	Line 2	Line 3
Lightning	3.49A		
Socket outlets	3.26A	3.26A	6.52A
Exhaust fans		1.47A	
Total Current	**6.75A**	**4.73A**	**6.52A**

Table 6: Electrical Loads and Corresponding Circuit Breaker Ratings for each line

Electrical load	Line 1
Lightning	6A/1P/MCB (type B)
Socket outlets	6A/1P/MCB (type B)

Electrical load	Line 2
Socket outlets	6A/1P/MCB (type B)
Exhaust fans	

Electrical load	Line 3
Socket outlets	10A/1P/MCB (type B)

Main pump breaker 20A/4P/MCB

Booster pump breaker 10A/4P/MCB

First floor

Table 7: Current Distribution Across Lines for Office Equipment and Electrical Loads for the first floor

Name of the load	Line 1	Line 2	Line 3
3 Computers	1.16A	1.16A	1.16A
1 Data center		2.34A	
1 Printer		1.35A	
1 Water dispenser			1.38A
4 Socket outlets	0.54A	0.54A	1.08A
3 Air condition	10.13A	10.13A	10.13A
1 Security system	2.4A		
4 Lamps			0.27A
Total Current	**14.23A**	**15.52**	**14.02A**

Maximum demand for a line in first floor is **15.52A**

Therefore, the total maximum demand = 39.81A + 15.52A

= **55.33A**

Cable sizing for this current

Hence the current capacity of the cable $= \frac{55.33A}{0.94}$

= 58.86A

Therefore, the appropriate cable = **4C/25mm^2/Cu/PVC/PVC**

This can be provided by CEB without transformer

If transformer requested then the rating of the transformer $= \sqrt{3}V_L I_L$

$= \sqrt{3} \times 400 \times 55.33$

$= \mathbf{38.33\ KVA}$

current capacity of the cable of the cable that supplies current for the main pumps and booster pumps $= \frac{39.81A}{0.94}$

$= 42.35A$

Applicable cable sizing is **4C/10mm²/Cu/PVC/PVC**

Cable selection for upper floor

C_a = 0.94

C_g = 1

C_i = 1

Total derating = 0.94

Hence the current capacity of the cable $= \frac{14.6A}{0.94}$

$= \mathbf{15.53A}$

4C/2.5mm²/Cu/PVC/PVC cable can be used.

For each phase **2C/2.5mm²/Cu/PVC/PVC** can be used.

Table 8: Electrical Load, Current Ratings, and Corresponding Cable Types for Office Equipment

Electrical load	**Current (A)**	**Cable type** (70°C multi core thermoplastic insulated cables)
Computer	1.16	2C/1mm^2/Cu/PVC/PVC
1 Data center	2.34	2C/1mm^2/Cu/PVC/PVC
1 Printer	1.35	2C/1mm^2/Cu/PVC/PVC
1 Water dispenser	1.38	2C/1mm^2/Cu/PVC/PVC
Socket outlets	0.54	2C/1mm^2/Cu/PVC/PVC
3 Air condition	10.13	2C/2.5mm^2/Cu/PVC/PVC
1 Security system	2.4	2C/1mm^2/Cu/PVC/PVC
4 Lamps	0.27	2C/1mm^2/Cu/PVC/PVC

Table 9: Electrical Loads and Corresponding Circuit Breaker Ratings for each line

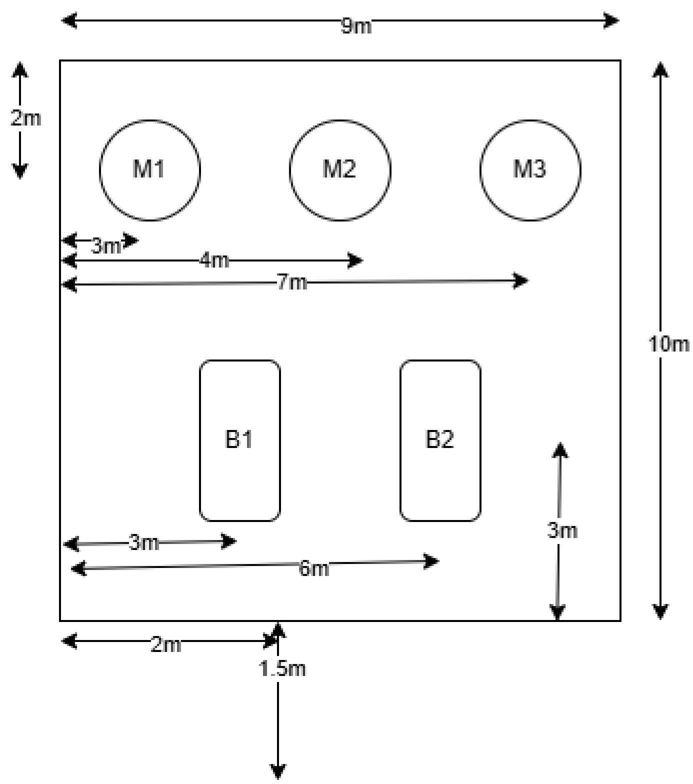
<table>
<tr><th>Electrical load</th><th>Line 1</th></tr>
<tr><td>Computer</td><td rowspan="2">6A/1P/MCB (type B)</td></tr>
<tr><td>1 Data center</td></tr>
<tr><td>Socket outlets</td><td>6A/1P/MCB (type B)</td></tr>
<tr><td>Air condition</td><td>10A/1P/MCB (type B)</td></tr>
</table>

<table>
<tr><th>Electrical load</th><th>Line 2</th></tr>
<tr><td>Computer</td><td rowspan="3">6A/1P/MCB (type B)</td></tr>
<tr><td>Printer</td></tr>
<tr><td>Water dispenser</td></tr>
<tr><td>Socket outlets</td><td>6A/1P/MCB (type B)</td></tr>
<tr><td>Air condition</td><td>10A/1P/MCB (type B)</td></tr>
<tr><td>Security system</td><td rowspan="2">6A/1P/MCB (type B)</td></tr>
<tr><td>Lamps</td></tr>
</table>

Electrical load	**Line 3**
Computer	6A/1P/MCB (type B)
Socket outlets	6A/1P/MCB (type B)
Air condition	10A/1P/MCB (type B)

Voltage drops

Ground floor cables



Maximum distance from the Distribution board to the main pumps	$= 1.5m + 2m + 8m + 7m$
	$= 18.5m$
Hence the voltage drop	$= \dfrac{15V/A/m \times 39.81A \times 18.5m}{1000}$
	$= 11.04V$
As a percentage	$= \dfrac{11.04}{400} \times 100\%$
	$= 2.76\%$

This is less than 5% hence this voltage drop is acceptable

First floor

maximum possible voltage drop $= \frac{15V/A/m \times 15.52A \times 13.5m}{1000} + \frac{18V/A/m \times 10.13A \times 7m}{1000}$

$= 4.42V$

$= \frac{4.42}{400} \times 100\%$

$= 1.1\%$

This is less than 5% drop hence this is acceptable

Single Line Diagrams