Unit No:- 02

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Estimating and Conductor Size Calculations

* Estimating meaning -
- Estimating means to determine the quantities of various items required to excute a job and to assess the cost of the execution.
- The estimator keeping in view the requirements arrived at during initial planning, chalk out a list of items and quantities.
- The cost is determined by him by consulting the price catalogue and schedule of labour rates.

* Various steps to form an estimate :-
- The various steps to form an estimate are;

i) Chalk out a list of items and quantities required.

ii) Consult the rate catalogues for pricing the various items.

iii) Assess the exact number of workmen required to complete the job and after consulting the schedule of labour rates add the labour cost to estimate under preparation. It should be noted that number of workmen required ~~as~~ is dependent upon the time limit fixed to complete the service.

iv) Add supervision charges and executor's profit.

v) In a case of Govt. organisaⁿ, where the work is to be executed by the contractor, the tenders are floated only after correctly specifying the description of each item, to avoid misunderstanding,

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* price catalogue :-
- It is in the form of booklet in which rates of various terms are indicated. The price catalogue is required to be amended as and when there is variation in the market. A specimen of price catalogue is given in Appendix

* Schedule of labour rates :-
- It is also in the form of booklet indicating the labour rates and sometime lump sum labour charge as 20% of material cost are added. This is usually done in case of big works costing over one lakh.

* Schedule of rates and estimating data :-
- Almost all govt departments have published schedule of rates or estimating data to facilitate the process of estimating.
- In these schedule or data, the estimated cost including labour charges for per metre run of wiring over-head lines etc. with various size of wire, aluminimum conductor, pole etc. are given.
- With the help of such a document, only overhead charges viz. supervision, departmental charges etc are required

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to be added after working the cost of the any services

* Determination of conductor size :-
- Before making an estimate it is necessary to find out the size of wire, cable or aluminium conductor.
- The following essential points are to be considered while calculating the size,

a) current carrying capacity.
b) voltage drop.
c) Minimum permissible size.

* current carrying capacity :-
- In any circuit the value of the current will be more as compared to sub-circuits.
- In sub-circuits as the load decreases the current is also reduced.
- Thus, it is very necessary to ~~det~~ divide the services into groups in accordance with the amount of current which will flow through them.
- Afterwords, the size of wire in ~~each~~ each group is determined.

* voltage drop :-
- The voltage drop is there as when the current flows through the wiring and the same should be as low as permissible

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and economical.

- The voltage drop can be determined by ohm's law. As the resistance is inversaly proportional to area, so the voltage drop will be less if the area of wire is more.

* Minimum permissible size :-

- Due to mechanical reason, the minimum permissible size of wires U/G cables and conductors should be as follows;

a) wire :- The area of aluminium wire should not be less than 1.5 sq mm and it's single strand should not be less than 1.40 mm diameter.

b) U/G cable :- The area of conductor for two core cable should not be less than 6 sq. mm and for ~~less~~ three and four cores, it should not be less than 25 sq. mm. The area of conductor for three and half cores cable should be 50 sq. mm or more.

c) A.C.S.R :- The size of A.C.S.R should not be less than 6/0.083 inch or 6/1 x 0.211 mm having total area of cross section as 20.71 sq. mm.

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* Conductor size calculation for Internal Domestic wiring -

- The important point to be considered is the current carrying capacity, the voltage drop is usually of very small magnitude and will not have much effect for small domestic wiring. For multistoreyed buildings, factories and industries, the voltage drop is required to be ascertained.
- If the voltage drop is much, the house-hold appliance and motors will not work.
- It should be noted that the maximum voltage drop should not be more than as given below :

a) Lighting Circuit, In any circuit :

i) at 200 volt supply, voltage drop should not be more than 5V.

ii) at 210 volt supply, voltage drop should not be more than 5.1 V.

iii) at 220 volt supply, voltage drop should not be more than 5.4 V.

iv) at 230 volt supply, voltage drop should not be more than 5.6 V.

v) at 240 volt supply, voltage drop should not be more than 5.8V.

vi) at 250 volt supply, voltage drop should not be more than 6.0 volts.

From the above, it will be seen that the permissible voltage drop in a lighting into circuit is 2% of the supply vtg. plus one volt.

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b) Industrial loads :-

- The maximum voltage drop at the end equipment or motor should not be more than 5% of the declared supply voltage.

Example No. 1

1) The main circuit wire in a house is required to carry a current of 45 amperes when connected to a single phase a.c. supply. Determine the size of wire if the length of the circuit is 40 meters.

→ Assuming, the declared voltage as 230V, the permissible voltage drop is 5.6V, which is taken from Table No. 1

2% of supply voltage + 1

$$\frac{230 \times 2}{100} + 1 = \underline{5.6\ V}$$

- The given current rating is 45 A;
so, from table no. 1; we are getting the size of conductor is 25 sq. mm which is held for 59 A; current rating.

- The voltage drop at 59 amperes rating will be;

$$\frac{\text{voltage drop at 59 amps}}{\text{current rating}} = \frac{\text{Length of wire}}{\text{Approx. length of run for volt drop in meters.}}$$

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$= \frac{40}{68}$ V

Voltage drop at 45 Amps $= \frac{\text{length of wire}}{\text{voltage drop}} \times \frac{\text{Minimum current rating}}{\text{Maximum current rating}}$

$= \frac{40}{68} \times \frac{45}{59}$

$= 4.486$ V

This Voltage drop is within permissible limit so, size of conductor selected is 25 sq.mm which is suitable.

- Example No.2

2) A room is to be wired for single phase a.c. supply directly taken from mains which has declared voltage of 200 volts. The length of the wire from the main switch to light and plug points is 30 ~~meter~~ metres. If the wire is to carry 5 amps, determine the size of conductor.

→ The permissible voltage drop $= 200 \times \frac{2}{100} + 1 = 5$ V

Reffering to Table no.1, minimum size of wire 1.5 sq mm (1/1.40) should be in a position to carry 5 amps safely.

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Now, it will be seen that there will be a drop 1 volt after every 2.3 metres for 10 amperes loading.

$$\therefore \text{Voltage drop at 10 amps} = \frac{\text{length of wire}}{\text{Voltage drop}}$$

$$= \frac{30}{2.3}$$

$$\text{Voltage drop at 5 amps} = \frac{\text{length of wire}}{\text{voltage drop}} \times \frac{\text{Minimum current rating}}{\text{Maximum current rating}}$$

$$= \frac{30}{2.3} \times \frac{5}{10}$$

$$= 6.52 \text{ V}$$

Hence, this is not suitable.

- Now, considering the next higher size 2.5 sq mm (1/1.80) wire and consulting Table no.1.

$$\text{Voltage drop at 15 amps} = \frac{\text{length of wire}}{\text{voltage drop}}$$

$$= \frac{30}{2.5}$$

$$\therefore \text{Voltage drop at 5 amp.} = \frac{\text{length of wire}}{\text{Voltage drop}} \times \frac{\text{Minimum current rating}}{\text{Maximum current rating}}$$

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$$= \frac{30}{2.5} \times \frac{5}{15}$$

$$= 4\ V$$

which is within permissible limit.

- Example No. 3.

3. A three-phase 3-wire connection is to be given to a promises in which an electric motor of 50 H.P. is to be installed. 40 metres of wire run from the main switch is required for this purpose. Determine the size of the wire to be used if the available voltage is 400 volts

→ length of wire = 40 m

If,

$$KW = \sqrt{3}\, V_L I_L \cos\phi$$

& $KVA = \sqrt{3}\, V_L I_L$.

so,

current drawn by the motor $= \dfrac{50 \times 746}{\sqrt{3} \times 400 \times 0.8}$

$= 67.90$ Amps. [1HP=746]

- If 3-core cable is used, then on referring Table No. 2, it will be ~~ta a~~ seen from Table No. 2, that 70 sq-mm (19/2.24) PVC cable will be in a position to carry the motor current safely.

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The permissible voltage drop $= 400 \times \frac{5}{100} = 20V$

Voltage drop at 82 amp $= \frac{40}{14.7}$

Voltage drop at 67.30 $= \frac{40}{14.7} \times \frac{67.30}{82}$

$= 2.21 V$

- As the drop is within permissible limits, hence 3-core PVC cable size 70 sq.mm (19/2.24) is suitable.

* Conductor size calculation for underground cable:-

- While determining the size of underground cable, the following factors are to be considered.

i) current carrying capacity of the cable.

ii) The voltage drop which should not be more than 12.5% and 5% for transmission and distribution system respectively.

- This voltage drop should be for the complete system i.e. in case the transmission or distribution is done by both U/G cable and overhead lines then the maximum permissible drop at the tail end of the feeder should

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be same as the last point ~~te~~.

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Example No. ~~4~~ 4

4) ~~4~~ Determine the size of underground cable to be laid for transmitting electrical energy at 11 kV from the substation to the distribution substation at a distance of 600 metres of capacity 300 KVA.

→ V = 11 KV

KVA = 300

$$\text{Current} = \frac{300 \times 1000}{\sqrt{3} \times 11 \times 1000} = 15.82 \text{ Amp.}$$

Allowing 20% overload the current will be;

$$= 1.20 \times 15.82 = 18.984 \text{ amp.}$$

From Table No. 3, it will be seen that 3-core P.I.L.C (paper insulated lead covered) 25 sq.mm underground cable is suitable for the load. Again referring to table No.4 it will be seen that the resistance of this cable is 1.102 ohms per km.

∴ Resistance of 500 metre length $= 1.102 \times \frac{500}{1000}$

$= 0.551$ ohm

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voltage drop = $\sqrt{3} \times I \times R$

$= \sqrt{3} \times 18.984 \times 0.551$

$= 18.120$ volts.

which is within the permissible limits

- Hence, P.I.L.C. 3 core, 25 sq.mm and underground cable is suitable.

- Example No - 5.

5) A 33 KV substation is to be connected to a 11 KV stepdown substation which is at a distance of 1.5 km by a underground cable. If the size of the transformer in the stepdown substation is 500 KVA, determine the size of the cable.

→ voltage = 33 KV

KVA = 500

$$\text{current} = \frac{500 \times 1000}{\sqrt{3} \times 33 \times 1{,}000} = 8.75 \text{ amp.}$$

- Allowing 20% overload, the current will be;

$1.20 \times 8.75 = 10.5$ amp.

- Referring to table No. 5, P.I.L.C. 3-core, 33 KV, 70 sq-mm under ground cable is suitable. Again from table No. 4, it will be seen that this cable

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has a resistance of 0.4068 ohm per km.

$\therefore$ Resistance of 1.5 km length of cable $= 1.5 \times 0.4068$

$= 0.6102$ ohm.

Hence the voltage drop $= \sqrt{3} \times 0.6102 \times 10.5$

$= 11.09$ volts

which is within the permissible limits.

Hence P.I.L.C. 3-core, 33 KV, 70 sq.mm. underground cable is suitable.

Example No. 6

6) An underground cable is to be connected to a multistoreyed building with the feeding substation at a distance of 2 km. The connected load is 500 KW at 400 volts at a diversity factor of 0.7 and p.f. as 0.8. suggest if the building can be directly connected by a L.T. feeder from the substation.

→ $V = 400$ V

connected load = 500 KW

Actual load = diversity factor × connected load

$= 0.7 \times 500$

$= 350$ KW

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$$\text{current} = I = \frac{kW}{\sqrt{3}\, V \times \cos\phi}$$

$$= \frac{350 \times 1000}{\sqrt{3} \times 400 \times 0.8}$$

$$I = 631.7 \text{ Amp.}$$

- Refer to table No. 6, it will be seen that P.I.L.C. 1100V, single core cable of size 625 sq.mm. is suitable. Now, from table No. 4, the resistance of this table is 0.04645 ohm for a km.

Hence, resistance of 2 km length $= 2 \times 0.04645$

$= 0.0929$ ohm

further, voltage drop $= \sqrt{3} \times I \times R$

$= \sqrt{3} \times 631.7 \times 0.0929$

$= 101.6$ volts

which is much more than the permissible limits.

- Hence, it is not possible to connect the system with a L.T. underground ~~ea~~ feeder due to the reasons, i) high cost and ii) excess of voltage drop. It is advisable to go for 11 kV supply and a substation near the building.

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* Conductor size calculations for overhead lines with A.C.S.R. [Aluminium conductor steel reinforced]:-

- While determining the size of conductor for overhead lines, the following factor are to be considered :

i) Current rating of A.C.S.R. The current rating for various A.C.S.Rs is given in Table no.

ii) The voltage drop should not be more than 12.5% and 5% of the declared voltage for transmission and distribution overhead lines respectively.

- Example No.7.

7) A 6.6 KV feeder of length 1 km is to be erected to feed an industrial substation of 500 KVA capacity. Find out the suitable size of A.C.S.R. conductor to be used for the purpose.

→ KVA = 500

V = 6.6.

$$\text{Maximum current } I = \frac{KVA}{\sqrt{3} \times V}$$

$$= \frac{500 \times 1000}{\sqrt{3} \times 6.6 \times 1000}$$

$$= 43.75 \text{ amp.}$$

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- Now, referring to Table No.7 it will be squirrel (6/1 X 2·11) A·C·S·R. if used will be in a position to carry this load safely.

- Now, resistance of squirrel for 1 km length will be,

$R = 1.4$ ohms.

$\therefore$ Voltage drop $= \sqrt{3} \times I \times R$

$= \sqrt{3} \times 43.75 \times 1.4$

$= 106$ volts which is within permissible limits.

$$\text{Permissible voltage drop} = \frac{12.5 \times 6.6 \times 1000}{100}$$

$= 825$ volts.

- Hence, the overhead H.T. 6.6. kV line should be streched with squirrel (6/1 X 2·1) of A·C·S·R.

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Current ratings and voltage drop for vulcanised rubber PVC or polythene insulated or tough Rubber PVC lead sheathed single core aluminium wires or cables

Size of Conductor		2 Cables d.c. or Single-phase a.c.		3 or 4 cables of balanced 3-phase		4 Cables d.c.	
Normal area sq. mm.	Number and diameter of wire in mm.	Current rating in amperes	Approx. length of run for volt drop in metres	Current rating in amperes	Approx. length of run for 1 volt drop in metres	Current rating in amperes	Approx. length of run for 1 volt drop in metres
1.5	1/1.40	10	2.3	9	2.9	9	2.5
2.5	1/1.80	15	2.5	12	3.6	11	3.4
4.0	1/2.24	20	2.9	17	3.9	15	4.1
6.0	1/2.80	27	3.4	24	4.3	21	4.3
10.0	1/3.55	34	4.3	31	5.4	27	5.4
16.0	7/1.70	43	5.4	38	7.0	35	6.8
25.0	7/2.24	59	6.8	54	8.5	48	8.5
35.0	7/2.50	69	7.2	62	9.3	55	9.0
50.0	7/3.0] 19/1.80]	91	7.9	82	10.1	69	10.0

Table No. 2

Current ratings and voltage drop for vulcanised rubber, P.V.C. or polythene insulated or tough rubber, PVC lead sheathed twin, three or four cores aluminium wires or cables

Size of conductor		One twin core cable D. C. or single phase A. C.			One 3 core or 4 core cable balanced three phase	
Nominal area in sq. mm	Number and diameter of wires in mm	Current rating in Amperes	Approx. length of run of 1 volt drop D.C. metres	A.C. metres	Current rating in Amperes	Approx. length of run for one volt drop in metres
1.5	1/1.40	10	2.2	2.3	7	1.7
2.5	1/1.80	15	2.5	2.5	11	2.2
4.0	1/2.24	20	2.9	2.9	14	4.2
6.0	1/2.60	27	3.4	3.4	19	5.3
10.0	1/3.55	34	4.2	4.2	24	6.3
16.0	7/1.70	43	5.3	5.3	30	8.7
25.0	7/2.24	59	6.6	6.6	42	10.9
35.0	7/2.50	69	7.1	7.1	45	11.7
50.0	7/3.00 19/1.80	91	7.7	7.7	62	13.1
70.0	19/2.24	118	9.0			
95.0	19/2.50	136	8.8	8.8	82	14.7
120.0	37/2.06	162	10.8	9.8	94	15.7
				10.2	114	20.8

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Table No.3

Current rating in amperes as per I.S.S. 692-1965 for Aluminium conductor paper insulated mass impregnated lead covered 11 kV. underground cable

25	7/2.24	100	90	96	78	110	86
35	7/2.50	119	109	104	94	136	104
50	19/1.80	147	134	126	116	170	132
70	19/2.24	182	165	151	142	213	162
95	19/2.50	214	194	176	170	255	192
120	37/2.06	244	218	198	192	288	224
150	37/2.24	275	249	222	219	326	258
185	37/2.50	308	284	248	245	372	294
240	37/3.00	365	341	290	285	470	368
300	61/2.50	394	360	310	305	507	400
400	61/3.00	475	440	370	340	640	610
500	91/2.80	575	–	400	–	705	–
625	91/3.00	580	–	435	–	820	–

Table No. 4

Table

Resistance of Insulated underground cables

Nominal area in sq. mm.	Number and nominal diameter of wires in mm	Maximum allowable resistance per km. at 20° C for single core cables in ohms	Maximum allowable resistance per km. at 20° C for twin and multi-core cables in ohms
6	1/2.80	4.759	4.851
10	1/3.55	2.960	3.018
16	7/1.70	1.876	1.912
25	7/2.24	1.090	1.102
35	7/2.50	0.8670	0.8843
50	19/1.80	0.6178	0.6290
70	19/2.24	0.2998	0.4068
95	19/2.50	0.3201	0.3263
120	37/2.06	0.2423	0.2470
150	37/2.24	0.2049	0.2088
185	37/2.50	0.1645	0.1677
225	37/2.80	0.1311	0.1337
240	37/3.00	0.1142	0.1165
300	61/2.50	0.09979	0.1070
400	61/3.00	0.06920	0.07069
500	91/2.65	0.05960	–
625	91/3.00	0.04645	–

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Table No. 5

Current rating in amperes as per I.S.S. 692-1965 for three-core screened Aluminium conductors, Lead Alloy Sheathed, Double Steel Tape/Single wire Armoured 33 kV Underground cable

Nominal area of conductor sq. mm.	Maximum Continuous Current Rating		
	In Ground amps	In Duct amps	In Air amps
70	150	130	125
95	170	150	140
120	200	180	165
150	240	220	200
185	265	245	215
240	320	275	255
300	360	320	290

Table No. 6

Table 13.6

Current Rating as per I.S.S. 692-1965 in amperes for aluminium conductor paper insulated mass impregnated lead covered 1100 V underground cable.

Nominal area in sq. mm.	Number and size of wires in mm	Current Rating for cables laid in ground			Current rating for cable laid in ducts			Current rating for cable laid in air.		
		Single core unarmoured	Twin core	Three and multi-core	Single core unarmoured	Twin core	Three and multi-core	Single core unarmoured	Twin core	Three and multi core
6	1/2.80	50	57	48	42	44	40	56	48	40
10	1/3.55	70	74	62	56	60	51	72	66	56
16	7/1.70	90	96	81	76	80	68	94	88	72
25	7/2.24	115	122	107	98	108	90	124	117	97
35	7/5.50	138	147	128	116	130	105	151	141	119
50	19/1.80	172	180	158	140	159	128	184	177	150
70	19/2.24	208	219	192	170	190	156	227	220	182
95	19/2.50	244	262	224	198	224	184	272	258	224
120	37/2.06	278	302	257	222	254	211	312	298	258
150	37/2.24	316	346	296	249	287	243	358	339	300
185	37/2.50	359	398	336	279	323	278	412	387	348
240	37/3.00	430	485	413	335	397	340	520	492	437
300	61/2.50	466	536	438	358	422	364	570	524	475
400	61/3.00	553	618	513	412	515	425	680	635	545
500	81/2.80	595	–	–	445	–	–	760	–	–
625	91/3.00	670	–	–	490	–	–	895	–	–