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Indian Standard

CODE OF PRACTICE FOR DESIGN, INSTALLATION AND MAINTENANCE OF OVERHEAD POWER LINES

PART 2 LINES ABOVE 11 kV AND UP TO AND INCLUDING 220 kV

Section 2 Installation and Maintenance

(First Revision)

First Reprint DECEMBER 1990

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

November 1985
AMENDMENT NO.1 SEPTEMBER 2007
TO
IS 5613 (PART 2/SEC 2) : 1985 CODE OF
PRACTICE FOR DESIGN, INSTALLATION
AND MAINTENANCE OF OVERHEAD
POWER LINES

PART 2 LINES ABOVE 11 kV AND UP TO AND
INCLUDING 220 kV

Section 2 Installation and Maintenance

(Page 6, clause 5.3.2, informal table) --- Add the following note:

'NOTE - Lower values of Right-of-Way may be adopted by power utilities by use of V-strings or
adopting smaller spans in the forest areas, based on the Line Clearance (Right-of-Way) Requirement
in accordance with Fig. 1.'

(ET 37)
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(First Revision)

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(Continued on page 2)

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Section 2 Installation and Maintenance

(Page 6, clause 5.3.2, informal table) --- Add the following note:

'NOTE - Lower values of Right-of-Way may be adopted by power utilities by use of V-strings or adopting smaller spans in the forest areas, based on the Line Clearance (Right-of-Way) Requirement in accordance with Fig. 1.'
AMENDMENT NO. 3 AUGUST 2010
TO
5613 (PART 2/SEC 2) : 1985 CODE OF PRACTICE FOR DESIGN, INSTALLATION AND MAINTENANCE OF OVERHEAD POWER LINES
PART 2 LINES ABOVE 11 kV AND UP TO AND INCLUDING 220 kV
Section 2 Installation and Maintenance
( First Revision )

(Please see Amendment No. 1, September 2007) — Substitute ‘AMENDMENT NO. 2’ for ‘AMENDMENT NO. 1’ in the title.
Indian Standard

CODE OF PRACTICE FOR DESIGN, INSTALLATION AND MAINTENANCE OF OVERHEAD POWER LINES

PART 2 LINES ABOVE 11 kV AND UP TO AND INCLUDING 220 kV

Section 2 Installation and Maintenance

(First Revision)

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 23 January 1985, after the draft finalized by the Conductors and Accessories for Overhead Lines Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The design, installation and maintenance practices of overhead power lines vary widely from state to state and organization to organization. This variation leads to uneconomic designs and higher installation and maintenance cost. The necessity was, therefore, felt to prepare a standard on this subject which should result in unification of designs of overhead lines and also in saving of cost.

0.3 This standard was first published in 1976. The revision of this standard has been done to take into account the developments that have taken place since the first publication of the standard.

0.4 This standard is being prepared in the following three parts:

Part 1 Lines up to and including 11 kV;
Part 2 Lines above 11 kV and up to and including 220 kV; and
Part 3 Lines above 220 kV.

Each part has been further divided in two sections. Section 1 of each part covers design aspects while Section 2 covers installation and maintenance of overhead power lines.
0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This code (Part 2/Sec 2) covers installation and maintenance of overhead power lines above 11 kV and up to and including 220 kV.

1.2 This code does not cover installation and maintenance of service lines.

Note — For details of installation and maintenance of overhead power lines supported on poles, reference shall be made to IS : 5613 (Part I/Sec 2)-1985†.

2. TERMINOLOGY

2.1 For the purpose of this code, the definitions given in IS : 1885 (Part 32)-1981‡ and the Indian Electricity Rules, 1956 shall apply.

3. EXCHANGE OF INFORMATION

3.1 General — A proper design of transmission line and its supporting structures, insulators, conductors, etc, should be finalized on the basis of IS : 5613 (Part 2/Sec 1)-1985§ and other relevant Indian Standards. Detailed specifications shall be worked out before ordering the materials.

3.2 Transport Facilities — Information about transportation particularly for line supporting structures should be obtained from rail, road or navigation authorities where required. This may involve procurement of special trailers, or alternatively reduced lengths of various members in uneven terrains where head-loading is more often resorted to.

3.3 Terrain and Weather Conditions — Information on this is necessary in order to procure right type of installation tools and material handling equipment. Facilities locally available for maintenance of equipment shall also be known.

*Rules for rounding off numerical values (revised).
†Code of practice for design, installation and maintenance of overhead power lines: Part 1 Lines up to and including 11 kV, Section 2 Installation and maintenance (first revision).
‡Electrotechnical vocabulary: Part 32 Cables, conductors and accessories for electricity supply.
§Code of practice for design, installation and maintenance of overhead power lines: Part 2 Lines above 11 kV and up to and including 220 kV, Section 1 Design (first revision).
3.4 Vegetation, Right-of-Way (ROW) and Access Requirements — Information on vegetation should be obtained along with a true assessment of problems facing procurement of right-of-way and way-leaves for access, and compensation required to be paid.

3.5 Local Laws — The information about the local laws should be obtained in advance in order that there is no infringement of prevailing local laws and to ensure smooth installation, operation and maintenance work.

3.6 Before ordering supporting structures, insulators, conductors, etc, of the transmission line, the provisions of 3.2 to 3.5 shall be considered.

4. GENERAL REQUIREMENTS

4.1 Materials and Equipment — All materials, fittings, etc, used in the installation and also the construction tools and equipment shall conform to the relevant Indian Standards wherever they exist. In cases where there is no Indian Standard available, the items shall conform to the specification of the purchaser/manufacturer or shall be approved by a competent authority.

4.2 Compliance with Indian Electricity Rules and Other Authorities' Regulations — All overhead lines shall comply with the requirements of the Indian Electricity Act and Rules made thereunder and the regulations or specifications as laid down by railways or railway electrification authorities, post and telegraphs department, roadways or navigation or aviation authorities, local governing bodies, defence authorities and power and telecommunications coordination committee, wherever applicable. Relevant matters requiring attention of such authorities should be referred to them before planning the layout and installation and during construction work. Such references, however, may be made by the owner of the installation and within appropriate time so as to ensure smooth progress.

4.3 Personnel — The electrical installations shall be carried out only by authorized and trained/experience personnel and supervised by technically qualified persons competent to undertake such work under the rules and regulations that may be in force in different states.

4.4 Scope of Work — Installation of overhead line includes walk-over survey; laying out the line (route alignment); detailed and check survey; clearing the work site and line route; making access roads; civil construction work of foundations, etc, erection of the line; all connected material, transport and handling till the line is ready for use; testing and commissioning or taking over.
5. SURVEY

5.1 Walk-Over Survey — Before starting the detailed survey, a walk-over survey of the line shall be made. The various feasible routes shall be ascertained and marked on the toposheet.

5.2 Routine-Alignment Map — On completion of walk-over survey, a route-alignment map may be prepared to a scale of 1:50,000. Route near the towns will be shown in greater details to a scale of 1:10,000. If considered necessary, a key map to a scale of 1:200,000 may be prepared showing the main sections of the line in addition to the above.

5.2.1 For convenient handling in the field, the maps should be made on sheets of 297 x 189 mm, with 3 cm overlap shown on following sheet.

5.3 Clearing Right-of-Way (ROW) and Access Roads — It is essential that this work is undertaken prior to carrying out of detailed survey, to be followed by the latter. The clearing should be carried out both in legal and physical sense. If any compensation has to be made on crops it shall be accounted for the period till the installation work is to be over according to programme.

5.3.1 Clearing may be done in accordance with Fig 1.

5.3.2 Taking into consideration on theoretical requirement of right-of-way and transport requirements of maintenance the following right-of-way widths are recommended:

<table>
<thead>
<tr>
<th>Transmission Voltage</th>
<th>Recommended Width of Right-of-Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>kV</td>
<td>m</td>
</tr>
<tr>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>66</td>
<td>18</td>
</tr>
<tr>
<td>110</td>
<td>22</td>
</tr>
<tr>
<td>132</td>
<td>27</td>
</tr>
<tr>
<td>220</td>
<td>35</td>
</tr>
</tbody>
</table>

5.4 Detailed Survey — Detailed survey with survey instruments shall be conducted on the approved alignment. The choice of the method will be left to the surveying party and either chain survey or tachometric survey or theodolite or aerial survey may be adopted as considered convenient. In hilly region, level of ground at 8 m from centre line is also to be noted and marked in profiles so as to ensure required ground clearance underneath conductor and side clearances in swing conditions of conductor.
5.4.1 From the field book entries, the route plan and level profile, commonly referred to as 'survey chart', will be plotted and prepared to the scales of 1 = 2000 horizontal and 1 = 200 vertical on 1 mm/5 mm/1 cm square papers or formed drawing sheets made for the purpose.

5.4.2 If the difference in level is very high, the chart may be broken up according to requirements. A 1-cm overlap will be shown on each following section and on each following sheet. The chart will progress from left to right. For convenience in handling the sheet size may be limited to 420 \( \times \) 1189 mm or 594 \( \times \) 1189 mm depending on whether profile is for plains or hills respectively. Each section shall be started on a new sheet.

**Note** — Portion of tree falling within clearance zone to be lopped or trimmed.

**Fig. 1 Line Clearance (Right-of-Way) Requirements**

5.4.3 Hearing strength, density and angle or repose of the soil shall also be determined in accordance with the standard test methods at the time of detailed survey for different types of terrain through which line traverses.
5.5 Sag Template and Tower Spotting — A typical sag template is shown in Fig. 2 and the method of its preparation and application for tower spotting is given in Appendix A.

1 represents cold template or uplift curve
2 represents hot template or maximum sag curve
3 represents ground clearance curve
4 represents support foot curve
IMRT Central Line represents Right Offset Level
IMLT Central Line represents Left Offset Level

**Fig. 2 Sag Template**

5.5.1 While locating the towers on survey charts, the following shall be borne in mind:

a) Maximum length of a ‘section’ shall not exceed 15 spans or 5 km in plain terrain, and 10 spans or 3 km in hilly terrain.

   *Note* — A section means a number of consecutive spans between two tension points. The individual spans within the sections are called intermediate spans.

b) The intermediate spans shall be as near as possible the normal design span. In case an individual span becomes too short on account of undulations in ground profile, one or more line supports of the section may be extended by inserting standard body extensions designed for the purpose according to technical specifications to bring the intermediate span as near as possible to the design span.

c) There shall not be any upward force on suspension towers under normal working condition, and the suspensions towers shall support the minimum weight span as provided in the designs. In case uplift is unavoidable, it will be examined if the same may be
overcome by adding standard body extensions to the towers, fail­
ing which tension towers designed for the purpose shall be em­
ployed at such positions.

d) Tower spotting shall be further checked by means of tower capa­
city charts furnished by the designer.

e) Requisite clearances to foreign objects shall be maintained.

5.6 Check Survey — This will be conducted to make a rough check on
detailed survey and to locate and peg mark the tower positions on ground
conforming to the survey charts. In the process it is necessary to have the
pit centres marked according to the excavation marking charts. The levels,
up and down, of each pit centre with respect to the centre of the tower
location shall be noted and recorded for determining the amount of bench­
ing or earthwork required to meet design requirements of the foundations.

5.6.1 If the levels of the pit centres be in sharp contract with the level
of the tower centre ( say beyond a slope of 1 : 4 ), suitable ‘leg extensions’
may be deployed as required. In that case the amount of benching earth­
work required shall be measured accordingly.

5.6.2 For the sake of reference, the pits of a tower shall be designated
as shown in Fig. 3.

5.7 Tower Schedule — A water schedule shall be prepared for planning
of materials. The proforma shall be made on a convenient sheet size of
280 × 508 mm. Tower schedule shall further be checked by means of the
tower capacity charts furnished by the designers. If the limits are exceeded
anywhere, the spotting should be relocated by trials.

5.7.1 Along with the tower schedules, a line schedule should also be
prepared which should cover in details the total quantity of all line mate­
rials required and the quantity in which these are required at various
points on the line.

5.8 For pole lines, reference shall be made to IS : 5613 ( Part 1/Sec 2 )­
1985*.

6. MATERIAL TRANSPORT

6.1 All material transport shall be undertaken in vehicles suitable for the
purpose and free from the effects of any chemical substances. Tower mem­
bers shall be loaded and transported in such a manner that these are not
bent in transit and sharp-bent members are not opened up or damaged.
Conductor and earthwire reels shall be handled carefully so that the drums
and their contents are not damaged.

*Code of practice for design, installation and maintenance of overhead power lines:
Part 1 Lines up to and including 11 kV, Section 2 Installation and maintenance ( first
revision ).
7. FOUNDATION

7.1 The construction of tower foundation shall be in accordance with IS: 4091-1979.

7.1.1 Dimension — Excavation shall be made according to the excavation marking chart. The pit size in the case of open cut foundation shall be determined after allowing a margin of 150 mm all round. No margin is necessary in the case of undercut foundations. The depth of the excavation at the pit centre shall be measured with reference to the tower centre level.

*Code of practice for design and construction foundations for transmission line towers and poles (first revision).
7.1.2 Shoring and Strutting — In the excavation in sandy soil or water-bearing strata where there is every likelihood of pits collapsing, shoring and strutting shall be made out of timber blanks or steel frames of adequate strength to suit the requirements.

7.1.3 Dewatering — Dewatering shall be carried out either manually or by mechanical pumps or power driven pumps to facilitate excavation. The pumps shall be suitable for handling mud water. The pits shall also be kept dewatered till 24 hours of concreting the foundations. Dewatering is not necessary in case of bored foundations below water table, These are stabilized by drilling muds and concreted by displacing the drilling mud.

7.1.4 Excavations in Rock — For excavations in hard rock, blasting can be resorted to. Reference shall be made to statutory rules for blasting and use of explosives for this purpose. No blasting is permitted near permanent works or dwellings. Blasting shall be so made that pits are as near to the designed dimensions as practicable.

7.1.5 All excavated material shall be dumped at least 1 to 2 m away from the pits, preferably in diagonal directions, keeping the space along the centre lines free for foundation work. Care shall be taken that no moving vehicles or heavy equipment are drawn too near the foundation excavations.

7.2 The foundation and erection of poles shall be in accordance with 5 and 6 of IS : 5613 (Part 1/Sec 2) 1985.

8. CLASSIFICATION OF SOIL

8.1 Classification of soil shall be made according to IS : 1200 (Part 1)-1974, for footings cast in open pits. It shall however be noted that for all the classifications listed therein the soil may be dry or wet.

8.2 Dry soil shall be that where sub-soil water is wet below the foundation base. In the ‘wet’ category, classifications shall be as under:

a) Wet — Where sub-soil water rises in the pit up to 1.5 m below ground level; or where there is water over the ground for long periods but does not penetrate beyond 1 m below ground such as paddy fields.

b) Partially submerged — Where water rises in the pit up to 0.75 m below ground level.

*Code of practice for design, installation and maintenance of overhead power lines: Part 1 Lines up to and including 11 kV, Section 2 Installation and maintenance (first revision).

†Method of measurement of building and civil engineering works: Part 1 Earthwork (third revision).
c) Submerged — Where sub-soil water rises in the pit within 0·75 m below ground level.

Note — In all the cases the water level shall be measured with respect to the tower centre level.

9. STUB SETTING (OR TOWER FOOTING)

9.1 For the purpose of setting, the top chord pieces of the template frames shall have centre punch or chisel markings on the flanges and heel at the centre line positions of standard height towers as well as heights extended with standard body extensions. The plumb strings shall be dropped from these reference points which shall be marked at the shops. The same template shall preferably be suitable for setting stub positions for various tower heights. If such adjustments are not available, a section of tower body may be used as template. For maintaining accuracy of setting, squaring and the slope, the plan diagonals and bracket pieces shall be fitted with the templates.

9.2 Assembly and Check — Assembly shall be made on adjustable screw jacks resting over ground. Initial levels shall be made with an accurate long bubble spirit level and template shall be centred properly bringing the side and diagonal measurements equal according to design drawings. Levels and alignment shall once again be checked after pouring slab/pyramid concrete and before pouring chimney concrete and adjusted for differences, if any.

9.2.1 The allowable tolerances on template setting shall be as given in Appendix B.

9.2.2 In case due to collapsed pits the template may not be fitted on jacks, the same shall be assembled with stubs resting over 1 : 2 : 4 plain cement concrete block in comparatively green condition cast at the site with a 300 or 450 mm square base and a depth equal to the designed concrete cover under stub. The sides of the blocks shall be rough cast while the top shall be smooth, and for this purpose these may be cast in wetted pits made in ground. These blocks shall remain in position and shall form integral part of foundation concrete. The templates should remain in position for less than 24 hours.

10. CONCRETE

10.1 Type — For reasons of economy and progress it is normal practice to use coarse and fine aggregates available along the line route and/or nearest locations to the route. As such, it is not practicable to design the concrete mix and use controlled concrete. Moreover, since the quantity of concrete involved is rather small, ordinary plain or reinforced cement concrete given in IS: 456-1978* shall be used in overhead line foundations.

*Code of practice for plain and reinforced (third revision).
10.2 Mixes — For main foundation, M 150 or 1 : 2 : 4 mix cement concrete shall be used. For lean concrete sub-bases or pads, M 100 or 1 : 3 : 6 mix cement concrete may be used. The properties of concrete and mix proportions shall be as given in IS : 456-1978*.

It shall be permissible to proportionate the concrete as follows:

a) Prepare a wooden measuring box of 35 litres capacity (that is equal to 1 bag or 50 kg of cement) with inside dimensions of (not exceeding) 30 × 30 cm alternatively 34 cm diameter and 39 cm height.

The mix quantities according to the measuring box shall be as follows:

<table>
<thead>
<tr>
<th></th>
<th>M 150</th>
<th>M 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1 bag</td>
<td>1 bag</td>
</tr>
<tr>
<td>Sand</td>
<td>2 boxes</td>
<td>3 boxes</td>
</tr>
<tr>
<td>Stone</td>
<td>4 boxes</td>
<td>6 boxes</td>
</tr>
<tr>
<td>Water</td>
<td>1 box less</td>
<td>1 box less</td>
</tr>
<tr>
<td></td>
<td>3 litres</td>
<td>1 litre</td>
</tr>
</tbody>
</table>

b) Measurement of water may be made with separate watertight drums of the above size or with 1 or 2 litre mugs.

Note — For concreting the bored foundations by displacing the drilling muds, 10 percent extra cement in the mix is required.

10.2.1 One bag of cement is taken to contain 50 kg or 35 litres of ordinary Portland cement.

10.3 Form Work

10.3.1 General — The form work shall conform to the shape, lines and dimensions as shown on the design drawings, and be so constructed as to be rigid during the placing and compacting of concrete, and shall be sufficiently tight to prevent loss of liquid from concrete. It shall be of light design easily removable without distortions and shall be of steel, hardwood or framed plywood. The inner surface coming in contact with concrete shall be smooth and free from projections. Window on one face shall be provided for pyramid forms to facilitate concreting in the lower parts which shall be fixed after concrete in the bottom parts is placed. In bored footings form work may be needed only towards the top for the portion above ground level.

*Code of practice for plain and reinforced concrete (third revision).
10.3.2 The form work for slabs and pyramids shall be made symmetrical about the base of the chimney to ensure interchangeable faces as illustrated in Fig. 4.

10.3.3 Clearing and Treatment of Forms — All rubbish, particularly chippings, shavings and sawdust, and traces of concrete, if any, shall be removed from the interior of the forms before the concrete is placed. The surface in contact with the concrete shall be wetted and sprayed with fine sand, or treated with an approved composition before use every time.

![Fig. 4 FORM WORK FOR SLABS/PYRAMIDS](image)

10.3.4 Stripping Time — Under fair weather conditions (generally where average daily temperature is 20°C or above), and where ordinary cement is used, forms may be struck after 24 hours of the placing of concrete. In dull weather (such as rainy periods) and very cold temperature, the forms shall be struck after 48 hours of the placing of concrete.

10.3.5 Procedure when Removing Form Work — All form work shall be removed without such shock or vibration as would damage the concrete or the forms.

10.4 Reinforcement — All reinforcements shall be properly placed according to design drawing with a minimum concrete cover of 50 mm. The bars shall, however, be placed clear of stubs and cleats where interfering. For binding, iron wire of not less than 0.9 mm shall be employed, and the bars may be bound at alternate crossing points. The work shall conform to IS : 2502-1963* wherever applicable. For bored footings, stub angles shall be used as reinforcement.

10.5 Sizes of Aggregates — The coarse aggregates (stone) to be used shall be single size aggregates of 40 mm nominal size for slab/pyramid concrete and 20-mm nominal size for chimney concrete conforming to IS : 2502-1963* wherever applicable. For bored footings, stub angle should be used as reinforcement.

*Code of practice for bending and fixing of bars for concrete reinforcement.
to IS : 383 - 1970*. These sizes are applicable to ordinary plain cement concrete; for RCC the aggregates shall preferably be of 20-mm nominal size. The fine aggregate (sand) shall be of Zone I Grade to IS: 383-1970* which is the coarse variety with maximum particle size of 4.75 mm. Zone II grade of fine aggregates may also be used.

10.6 Gravel Sub-base — In case the foundation happens to be over fine sand, an 80-mm thick gravel sub-base may be provided, if considered necessary, under the foundation. The maximum size of gravel or stone to be used shall be 80 mm.

10.7 Lean Concrete Sub-base or Pad — In case of foundations placed over ordinary wet soil, a lean concrete sub-base shall be provided in a thickness of 75 or 150 mm according to requirements. If water flow is observed with running in sand or soil, laying of the sub-base shall be taken up simultaneously with removal of mud and water proceeding from one end to the other. Semi-wet mix may also be used, if considered necessary. Placing of foundation concrete shall start after the sub-base has hardened sufficiently, or after about 12 hours. The size of the sub-base shall be considered to be the same as pit size.

10.8 Measurement of Concrete — Except where actual pit size concrete is required (such as in a rock foundation), the volume of concrete shall be calculated from design drawings. All volumes shall be expressed to the nearest cubic metre. The heights used for calculating concrete volumes shall be the projected heights and not those following the tower slope; the top of the pyramid concrete shall be considered to be the same as the chimney cross-section for the purpose of calculating the volumes, even though it is greater on account of the chimney slope.

10.8.1 The method of measurement of concrete for pile foundations is given as below.

10.8.1.1 Approximate volume of short bored under-reamed piles is calculated by the following formula:

\[
\text{Volume in cubic metre} = \frac{\pi}{4} \left[ L d^2 + 0.4 n (d_u - d) (d_u^2 - d^2) \right]
\]

(see Fig. 5).

where

- \( L \) = total length of pile in metres;
- \( d \) = diameter of pile shaft in metres;
- \( d_u \) = diameter of under-ream in metres (2 or 3 times \( d \)), normally 2.5 \( d \); and
- \( n \) = number of under-reames.

*Specification for coarse and fine aggregates from natural sources for concrete (second revision).
Distance between two under-reams = 1.25 to 1.5 $d_u$;
Spacing between piles = 2.0 $d_u$; 1.5 $d_u$ with 10 percent reduction in capacity.

10.9 Mixing, Placing and Compacting of Concrete — This shall be carried out according to the procedure laid down in Appendix C.

10.10 Opening Stub-Template and Backfilling — Following opening of framework and removal of shoring and strutting frames, if any, backfilling shall be started. Backfilling shall be done with the excavated soil. Care shall be taken that backfilled earth is started from inner ends of the pits, towards the outer ends. After the pits have been backfilled to half depth the stub-template may be struck and removed. All surplus soil shall be deposited around each of the tower legs uniformly over the pits including the residual sand and stone and concrete waste lying around, if any. Any shortfall in backfill-soil should be met with normal soil from suitable borrow pits.

10.11 Curing — The chimney tops shall be watered for a minimum period of 14 days after concreting both in morning and evening such that water is able to penetrate lower down the foundation keeping it wet.
10.12 Measurement of Backfilling — The volume of backfilling shall be considered equal to that of the excavation. In case, backfilling has to be done by earth from borrow areas, the same shall be measured separately together with the lead involved. This also applies to any earthwork/embankments to be provided over the foundation to the design drawings.

11. EARTHING

11.1 Each tower shall be earthed after the foundation has been cast. For this purpose, earth strips shall be fixed to the stub during concreting of the chimney and taken out horizontally below the ground level. In normal circumstances, the earth strip shall be provided on No. 1 stub leg as given in Fig. 3, that is, the leg with step bolts.

11.2 The resistance of tower to earth shall not exceed the values specified in IS: 3043.1966 after earthing and tower erection but before stringing of the overhead ground wire. In case the resistance exceeds the specified values, multiple pipe earthing or counterpoise earthing shall be adopted in accordance with the following procedure, but without interfering with the foundation concrete even though the earth strip/counterpoise lead remains exposed at the tower end. The connections in such case shall be made with the existing lattice member holes on the leg just above the chimney top.

11.3 Pipe Earth — The installation of the pipe earth shall be in accordance with IS: 3043.1966*. A typical example of earthing equipment (pipe type) is given in Fig. 6.

11.4 Counterpoise Earth — Counterpoise earth consists of four lengths of galvanized steel stranded wires, each fitted with a lug for connection to the tower leg at one end. The wires are connected to each of the legs and taken radially away from the tower end embedded horizontally 450 mm below ground level. The length of each wire is normally limited to 15 m, but may be increased if the resistance requirements are met. The size of the galvanized steel stranded wire may be taken equal to the sizes of the earth conductor. A typical example of counterpoise type earthing of tower is given in Fig. 7.

12. TOWER ERECTION

12.1 General — Towers shall be erected after the concrete is at least 14 days old, but a gap of 28 days shall be preferred.

12.2 Inspection and Sorting Out — The members shall be examined for defects in protective surface finish, if any. If any defects are found in case of hot-dip galvanized members, the damage shall be repaired by applying two coats of zinc-rich paint conforming to relevant Indian

*Code of practice for earthing.
Standard after cleaning the surface and ensuring that the surface is dry before the application of the paint. Members bent in transit shall be straightened such that the protective surface finish is not damaged.

All the members shall be sorted out properly at the erection site to check that all items are available; and shall be placed in a manner such that they are easily located during erection.

---

**Material List**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Length</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 mm bore G.I. Pipe</td>
<td>3,000</td>
<td>11.88</td>
</tr>
<tr>
<td>1</td>
<td>25 x 6 mm M.S. Flat</td>
<td>5,000</td>
<td>15.50</td>
</tr>
<tr>
<td>2</td>
<td>16 mm bolts with nuts</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>16 mm bolts with nuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Plain washer for 16 mm bolts</td>
<td></td>
<td>0.16</td>
</tr>
</tbody>
</table>

**Notes**

1. All ferrous parts are hot-dip galvanized.
2. In case of difficult location horizontal or slant laying of pipe and laying within the tower base or foundation pit shall be permissible.

All dimensions in millimetres.

**Fig. 6 A Typical Example of Earthing Equipment**
12.3 Treatment of Joints — Before starting assembly, specially for the lines in coastal or highly polluted areas, the surfaces at connection points shall be applied a coat of aluminium or zinc-rich paint in case of galvanized members, and red oxide or zinc chromate paint in case of painted members.

12.4 Assembly — Irrespective of the method followed for the erection of towers, the points mentioned below shall be observed:

a) Straining of the members shall not be permitted for bringing them into position. It may, however, be necessary to match hole positions at joints and to facilitate this, tommy bars not more than 450 mm long may be used.
b) Before starting erection of an upper section the lower section shall be completely braced and all bolts fitted in accordance with approved drawings.

c) All plan diagonals relevant to a section of tower shall be placed in position before assembly of upper section is taken up.

d) All bolts shall have their nuts facing outside the tower for horizontal or nearly horizontal bolt connections and downwards for vertical bolt connections.

e) The cross-arms may be assembled on ground and the top cross-arm shall be lifted first, followed by the middle and bottom cross-arms. The tips shall be fully tightened before lifting them into position. Such bolts which are not accessible for tightening by ordinary tommy spanners, may be tightened with the help of box or ratchet ring spanners.

12.5 Tightening and Punching of Bolts and Nuts — All nuts shall be tightened properly using correct size spanners. Before tightening it will be seen that filler washers and plates are placed in relevant gaps between members, bolts of proper size and length are inserted, and one spring washer has been inserted under each nut. In case of step bolts, spring washer shall be placed under the outer nut. The tightening shall progressively be carried on from the top downwards, care being taken that all bolts at every level are tightened simultaneously. It may be better to employ four persons, each covering one leg and the face to his left.

12.5.1 The threads of bolts projecting outside nuts shall be punched at three positions on the diameter to ensure that the nuts are not loosened in course of time. If during tightening a nut is found to be slipping or running over the bolt threads, the bolt together with the nuts shall be changed outright. The bolts and nuts in all joints up to 3 m height above tower base shall be welded after final tightening.

12.6 Replacement — If any replacements are to be effected after stringing and tensioning or during maintenance, leg members and material bracings shall not be taken out without reducing the tension of the tower with proper guying or releasing the conductor. If the replacement of cross-arms becomes necessary after stringing, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

12.7 Painting (in Case of Painted Steelwork) — The steelwork fresh from the shops is usually supplied duly painted with one shop-coat of protective paints. One coat of protective paint (red lead or other primer) may be applied before the application of finishing coat. The specified number of finishing coats shall then be applied, one after the other, the latter coat being applied only after the earlier coat has completely dried.
up. Painting shall not be carried out on damp or wet surfaces; early morn­
ing painting shall be avoided. Work shall preferably be carried out in dry
and sufficiently warm weather, and shall progress from the top downwards.
If, for reasons of ensuring better workability, tinning of paints becomes
essential during hot and dry weather, the same shall be carried out in
accordance with recommendations of the parent manufacturers. The brush
shall be thoroughly worked into connections so that all gaps are filled in and
sealed from the effects of weather.

12.7.1 For fully painted towers, the portions which would be safe for
painting without shutdown should be specified for various ratings of
transmission lines. Before painting a live line, the engineer incharge
shall specify the safe zones up to which painting could be done without
shutdown.

12.7.2 For painting steelwork during maintenance period, the damaged
layers and loose rust shall be properly scrubbed with wire brushes and the
paints applied thereafter.

13. INSULATOR HOISTING

13.1 The strings shall be fixed on the towers just prior to the stringing of
conductors; but only after the towers (in case of painted steelwork) have
been duly painted according to the requirements of the technical specifi­
cations. This ensures insulators being clean and free of paint deposits. Dam­
ged insulators and fittings, if any, shall not be employed in the assemblies.
Before hoisting all insulators shall be cleaned in a manner that may not
spoil or injure or scratch the glaze of the procelain and in no case any oils
shall be used for the purpose. Security clips shall be in position for the
insulators before hoisting.

13.2 Arcing horns or guard rings, if required, shall be placed along the
line on suspension, and facing upwards on tension insulator string assem­
blies. The poke arrangements shall be horizontal for tension, and longitu­
dinal for suspension strings.

14. POWER AND EARTH CONDUCTOR ERECTION

14.1 General — The erection of conductors consists of four different oper­
ations as follows:

a) Delivery of conductors at site,
b) Running out (also called 'Paying out') and stringing,
c) Tensioning and sagging, and
d) Clipping-in.
14.2 Delivery of Conductors at Site — The standard length contained in all the drums supplied against the line requirements shall be noted down and the drums shall be batched in the following manner such that all the drums matched within a batches are of nearly equal lengths and that the midspan tension joints, where required to be made, fall preferably somewhere in the middle of the span in which they occur:

<table>
<thead>
<tr>
<th>Type of Line</th>
<th>Number of Drums in a Batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-phase, 1 circuit</td>
<td>3</td>
</tr>
<tr>
<td>3-phase, 2 circuits</td>
<td>6</td>
</tr>
<tr>
<td>1-phase, 1 circuit</td>
<td>2</td>
</tr>
<tr>
<td>1-phase, 2 circuits</td>
<td>4</td>
</tr>
</tbody>
</table>

14.2.1 At every dumping site, two such batches shall be dumped.

14.2.2 While deciding the place of dumping, due consideration shall be made of the particular standard length of the batch, extra length consumed on account of sag, damaged ends of the conductor in drum, inclined spans, etc. The points noted under 14.4.2 shall as well be borne in mind so that the planning for dumping of the drums would not be disturbed, once it is finalized.

14.2.3 All drums in dilapilated condition shall be discarded and the conductor shall be rewound on new drums before use. In case of the drums with only the laggings damaged, use may be made of turn tables holding the drums on a vertical rotational axis, for running out.

14.3 RUNNING OUT

14.3.1 Whatevery the method employed for running out conductors, care shall be taken that the conductors do not touch or rub against ground or objects which would cause scratches or damages to the strands. The conductors shall be run out of the drums from the top ( and not from the bottom ), in order to avoid damage due to chafing. The conductors shall be pulled out evenly in preference to pulling out a complete section of the wire. The conductor immediately after running out, shall be raised as the supports to a level as that of the clamp and placed into the running block or the aerial rollers.

14.3.2 The running blocks shall be of a diameter not less than the internal barrel diameter of the drum as given in IS : 1778-1980*. In case such blocks are not available, the blocks shall be provided with two small pulleys which shall enable the conductor to form a curve of minimum

*Specification for rolls and drums for bare conductors ( first revision ).
equivalent diameter. The groove of the pulley shall be of a design that the seat is semicircular and larger than the diameter of the conductor and it does not slip over or rub against the sides. The groove shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on well-oiled bearings.

14.3.3 The running blocks shall be suspended in a manner to suit the design of the cross-arms. All running blocks, especially those at the tensioning end, shall be fitted on the cross-arms with sacking wrapped over the steelwork and under the slings to avoid damage to the slings as well as to the protective surface finish of the steelwork. In case suspension, light angle or section towers are used for termination of stringing operations for longer periods, they shall be suitably guyed. Normally, suspension towers shall not be used even for temporary terminations, if this becomes necessary, these shall be well guyed and steps taken to avoid damage. The drums shall be provided with suitable breaking device to avoid loose running out and to prevent kinking of the conductors. The conductors shall continuously be observed for loose or broken strands or any other damage. When approaching the end of a drum length, at least three coils shall be left when the stringing operations are stopped. These coils shall be removed carefully and if another length is required to be run out, a joint shall be made according to the recommendation of the manufacturers. Normally, the joints shall be so made that these are not required to pass through the running blocks.

14.3.4 Derricks shall be used where roads, rivers, canals, telephones or overhead power lines, railways, premises, fences or walls have to be crossed during stringing operations. It shall be ensured that normal services are not interrupted or damage caused to property. Shutdown shall be obtained when working at crossing of overhead power lines, and railways (electrified or otherwise).

14.3.5 The sequence of running out shall be from top downwards, that is, the earth conductor shall be run out first, followed by top, middle and bottom power conductors in succession. Unbalances of loads on towers shall be avoided as far as practicable.

14.4 Tensioning and Sagging of Conductors

14.4.1 The tension insulator sets, complete with clamped conductors, shall be hoisted at the ends remote from the tensioning points. The running blocks at the tensioning end shall be fitted on the cross-arms with sacking wrapped under the slings.

14.4.2 The mid-span tension joints shall be placed to ensure the following:
a) No joint shall be placed within 15 m of the conductor support;
b) There shall be no joints in important crossing spans, except where the spans are longer than the standard conductor length on the drum; and
c) There shall be not more than one joint per conductor in a span.

14.4.3 The tensioning and sagging shall be done in accordance with the approved stringing charts prepared from the data and relevant specifications of the line. Either 'initial' or 'final' stringing charts may be employed for the purpose, but the former shall be used in preference to the latter. Both sags and tensions may be checked if considered necessary, but checking on sag only shall also be considered sufficient. The sag shall preferably be checked in a span lying approximately in the middle of the relevant section, such span being as near the length of the ruling span for the section as practicable.

14.4.4 Tensioning and sagging operations shall be carried out in calm weather when rapid changes in temperature are not likely to occur.

14.5 Clipping-in

14.5.1 Clamping the conductors in position, armouring at supports, placing the dampers and spacers, etc, shall be done in accordance with the recommendations of the manufacturer or user or both.

14.5.2 The jumpers at the section and angle towers shall be formed to a curved shape to ensure minimum clearance requirements. Non-tension parallel-groove clamps in cases where bolted-type tension clamps are used for dead-ends shall be installed in place to ensure continuity of line. Pilot-suspension insulator strings with or without dead weights shall be used where necessary to restrict jumper swing.

14.5.3 Fasteners on all fittings and accessories shall be secured in position; the security clip also properly opened and sprung into position.

14.5.4 Repairs to conductors shall be carried out during the running out operations, with either repair sleeves or jointing sleeves in accordance with IS: 2121-( Part 2 ) 1981*. Preformed armour rods may also be used ( see IS : 2121 ( Part 1 )-1981†.

14.6 Safety Precautions

14.6.1 All conductors shall be temporarily earthed in an effective manner at every section point. Such temporary earth shall be removed after stringing of the entire line is over and before testing and commissioning of the line.

*Specification for conductors and earth wires accessories for overhead power lines:
Part 2 Mid span joints and repair sleeves ( first revision ).
†Specification for conductors and earth wires accessories for overhead power lines:
Part 1 Armour rods, binding wires and tapes ( first revision ).
15. TESTING AND COMMISSIONING

15.1 General

15.1.1 Before the line is energized, visual examination of the line shall be carried out to check that all nuts and bolts are tight and insulators are in position at each support. The earth and earth connections shall also be checked to verify that these are in order. The insulators of those sections of the line which fall in areas of heavy pollution shall be cleaned and washed before energization of the line.

15.2 Testing

15.2.1 Before commissioning of the lines, the following tests may be carried out:

a) Conductor continuity test — The objective of this test is to verify that each conductor of the overhead line is properly connected electrically (that is, the value of its electrical resistance does not vary abnormally from that of a continuous conductor of the same size and length). The electrical resistance of the conductor shall be measured with a Wheatstone bridge or other suitable instrument.

b) Insulation resistance test — This test may be carried out with the help of 5,000 volts megger preferably power driven to ascertain the insulation condition of line.

15.2.2 The line may be charged at a low value of power frequency voltage for the purposes of testing.

15.3 Statutory Requirements

15.3.1 The statutory authorities shall be informed before commissioning the lines and their approval obtained in accordance with Indian Electricity Act, 1910 and Indian Electricity Rules, 1956 (For details see Rules 63 to 69 of Indian Electricity Rules, 1956).

16. MAINTENANCE OF OVERHEAD LINES

16.0 General — The overhead lines shall be inspected periodically for maintenance purposes to detect any faults which may lead to breakdown of electric supply and necessary repairs should be done immediately using hot line maintenance techniques, if necessary and feasible.

16.1 Patrolling of Overhead Lines from the Ground — Patrolling of all overhead lines shall be done before and after the monsoon. The frequency of patrolling of the overhead lines for the rest of the period shall depend on the local conditions. The patrollers should write the inspection notes and pass them on to the maintenance gang for carrying out the necessary repairs. The patrollers should be equipped with inspection books, drawings, tape and binoculars. The main points to be noted while patrolling are as follows:
a) **Structures** — Seriously leaning structures; deformed members; buckled structures; missing fasteners and members; accessories removed; protective coatings, like galvanizing or paints disappeared; suspension and strain attachments for insulators damaged.

b) **Foundations** — Signs of external damage; settled and washed out soil below designed ground level over foundations within uplift frustum perimeters; tilted stubs; cracks or breaks in chimney top; slippage of stubs from encasing chimney concrete; uneven settlement of footings; disappearance of gravel blanket protection; backfills embankment and its covers (rip-rap or revetment); damage to retaining walls, abutments and breast walls and disappearance of external earth backing retaining walls below designed lines.

c) **Insulators and Fittings** — Damage to insulators; surface pollution of a bad nature; missing locking devices like nuts, washers and pins; burnt out fittings; deflected strings; damage to protective coatings. The cracked insulators, bird droppings, dense spider webs, kites with cord hanging on the insulators string may also be noted.

d) **Conductors and Jumpers** — Strands cut and opened up; loose jumpers gone out of shape and causing infringement of clearance of live wire to earthed metal parts. Dead birds, fallen branches or fallen trees on conductors may also be noted.

e) **Earthwire and Jumper** — In accordance with 16.1 (d) of this standard.

f) **Earthing Equipment** — Damaged, broken or missing earth strip.

g) **Right-of-Way and Clearance** — Shurbs and trees within right-of-way causing obstruction, and infringement of clearance of bottom conductor to ground; objects within line clearance excavation (see Fig. 1). In no circumstances, however, clearance measurements should be taken from live line, till hot line maintenance has been established.

h) **Foreign Objects** — Construction works near lines causing infringement in line safety or electrical clearance; bird nests on structures; use of structure for applying permanent support or pull to other objects; huts newly constructed underneath lines, also embankments/fencing.

**16.2 Inspection of Overhead Lines from Tower Tops** — Many breakdowns including slipping of conductor due to loose clamps, cracks in insulator porcelain, defects in insulator fittings, conductor, earthwire and their accessories and their attachment points on structures can only be
dispersed or seen by going on top of every structure. This inspection should be carried out by taking a shutdown of the line at least once in six years and should be done in the shortest time possible during seasons of comparatively light climate and power loading on the line. Along with such inspection, repairs should also be carried out. Any replacement as required should also be made.

16.3 Special and Emergency Inspection — A special inspection of the overhead lines should be carried out after severe wind/hail storms, quakes, sabotages, snowfalls, forest fires, floods or heavy rains. The purpose of such inspection is to detect any damage or breakage on line and to affect necessary repairs.

16.3.1 When an overhead line trips on fault often, it should be inspected to ascertain the nature of fault, such as bridage, loose sag, tree branches touching the line, etc, and to find out the amount of repair involved with a view to avoid recurrence of such faults.

16.4 Maintenance Tests and Measurements — Insulation of line should be measured at convenient interval particularly at the time when the line is shutdown for repairs or maintenance. In regard to measurements of earth resistance of metal structures, it should normally be carried out annually, however, local circumstance in the light of the experience may justify increase or decrease in this interval but it should not be less than once in two years.

16.4.1 The clearance and shape of the jumpers should be checked at an interval not exceeding 3 years.

16.5 Line Repairs Tools — The following special tools, apart from tools required for maintenance of civil works of the lines, should be kept handy and in working order:

a) Conductor jointing tools,
b) Bolted come-alongs,
c) Winches,
d) Aerial trolleys,
e) Aerial rollers,
f) Thermometers,
g) Dynamometers,
h) Level and theodolite,
j) Measuring tapes,
k) Linesman’s ratchet,
m) Pull-lift device of adequate capacity,
n) Wire ropes, and
p) Spanners.
16.5.1 Drawings — Sets of tower schedules, structural, foundation, insulators and accessories or tower profile drawings including those for special constructions bound in folders should be available with partrollers as well as the maintenance crew.

16.5.2 Replacements — An inventory of spare line materials shall be maintained in the stores for effecting repairs. Such inventory should be based upon the experience of repairs required in the earlier periods on similar other lines.

16.5.3 Method of Repairs — Damage to aluminium strands of line conductors shall be repaired with repair sleeves provided not more than one-sixth of the strands in the outermost layer have been severed. For portions adjacent to armour rod ends affected by vibrations due to wind, and minor abrasions due to some rubbing objects, extra-long preformed armour rods may be used for such repairs.

APPENDIX A

(S Clause 5.5)

SAG TEMPLATE AND TOWER SPOTTING

A-1. SAG TEMPLATE

A-1.1 The location of structures on the profile with sag template is essential for both correct design and economy. Sag template may be prepared on transparent paper or cardboard or hard plastic sheet or on celluloid.

A-1.2 Method of Preparation

A-1.2.1 A typical sag template is shown in Fig. 2. It consists of the following curves:

a) ‘Cold template’ or ‘uplift curve’ — Corresponding to the vertical component of sag at worst load conditions of wind.

b) ‘Hot template’ or ‘maximum sag curve’ — Corresponding to the ‘maximum steel air final sag’ at maximum temperature (or at 0°C with ice load) including sag tolerance to be accounted for, if any.

c) ‘Ground clearance curve’ — Drawn at a distance equal to the minimum specified ground clearance, from and parallel to No. 2 curve.
d) ‘Support foot curve’ — Drawn at a distance equal to the bottom conductor height at tower, from and parallel to No. 2 curve. (If required, additional ‘Support foot’ curves may also be drawn incorporating standard tower body extensions to advantage).

A-1.2.2 Curves No. 1 and 3 are normally drawn through the origin ‘0’ at the centre line of the template. The ‘Cold’ and ‘Hot’ templates (curves 1 and 2) are plotted and cut as a parabola on the minimum and maximum sag of the ruling span (the normal design span is the theoretical ruling span) which is extended by computing the sag as proportional to the square of the span for spans both shorter and longer than the ruling span. Any particular span is considered spread-out by half of its value on either side of origin ‘0’.

A-1.2.3 The parabola is accurate to within about one half of 1 percent for sags up to 5 percent of the span which is well within the acceptable limits.

A-1.3 The actual ruling spans for various stringing sections of a line may differ from the normal design span which forms the basis for the sag template. It is, therefore, essential that the actual ruling spans be as near the normal design spans as practicable. In case of considerable amount of difference the following shall be points to be observed:

a) *The Actual Ruling Span Shorter Than the Normal Design Span* — In this case the maximum working and other tensions are comparatively less, and therefore the sags comparatively greater than those obtained for the normal design span. The sag template, therefore, needs to be modified. An easier method shall be to provide suitably greater ground clearance while carrying out tower spotting.

b) *The Actual Ruling Span Longer Than the Normal Design Span* — In this case the maximum working and other tensions are comparatively greater, and therefore the sags comparatively less, than those obtained for the same span from the values for the normal design span. Obviously, greater tensions cannot be allowed on towers; and therefore, by working back with maximum working tension for normal design span we may get different sags at the actual ruling spans. This shall be suitably accounted for while carrying out tower spotting.

A-1.4 The template shall be prepared to the same scale as the survey chart, that is, 1 = 2,000 for horizontal distances and 1 = 200 for vertical heights. The vertical centre line and the horizontal line passing through origin ‘0’ shall be drawn prominently. The curves shall be extended such that all slopes on the profiles may be scaled with ease.
A-2. APPLICATION FOR TOWER SPOTTING

A-2.1 The method of application of the sag template is shown in Fig. 2. The template is applied to the profile by moving the same horizontally as shown while always ensuring that the vertical axis or centre line is held vertical. The structure positions are marked where the ‘Support foot’ curve cuts the profile, while the ‘Ground clearance’ curve is just clear of and above the profile. The ‘Ground clearance’ curve shall not only clear the route-centre-line profile, but also the profile to the left and right of the centre line up to a distance equal to the maximum swing of conductor including cross-arm spread on either side.

A-2.2 The ‘weight span’ on either side of the tower for practical purposes is obtained by marking the low points of the sag in the two adjacent spans and sealing the same off.

A-2.2.1 On step inclined spans the low point may fall beyond the lower support; this indicated that the conductor in the uphill span exerts a negative or upward pull on the lower tower. The amount of this upward pull is equal to the weight of the conductor from the lower tower to the low point in the sag. Should the upward pull of the uphill span be greater than the downward load of the next adjacent span, actual uplift would be caused and the conductor would tend to swing clear of the tower upward.

A-2.2.2 For an easy check whether a tower is under uplift or not, the following method may be adopted. The template is applied horizontally until the tops of alternate supports coincide with the cold template (curve 1). If the curve is above the intermediate support, the support is under uplift and has to be extended until it touches the cold template and so culminates uplift. If requisite standard body extensions are not available for extending the tower to desired height, a tower designed for uplift shall have to be provided.

Nota — The suspension towers shall be checked for uplift under normal working condition only, that is, both adjacent spans intact. The section and angle towers shall be checked for uplift under both normal broken wire conditions.

A-2.2.3 The analytical method for calculating weight span is given below:

Distance of ‘Null point’ or ‘Low point’ of conductor from centre of span is given by the formula (see Fig. 8 and 9):

\[ x = \frac{T h}{w l} \]

where

\[ x = \text{distance of low point from centre of span in m,} \]
\[ T = \text{conductor tension in kgf} \]
\( h \) = difference between conductor support levels in m,
\( w \) = unit weight of conductor in kg/m, and
\( l \) = span length in m.

**Weight span:**

For tower A, right hand side only:

\[
a = \frac{1}{2} - x
\]

For tower B, left hand side only:

\[
b = \frac{1}{2} + x
\]

**FIG. 8 DISTANCE OF NULL POINT OR LOW POINT FROM CENTRE OF SPAN**

Similarly, weight span for the other side of the towers, can be calculated and total weight span obtained.

If the sum of \( a \) and \( b \) calculated for a particular tower is negative, the tower is under 'uplift'.

It is also evident that maximum weight spans are obtained by the worst condition of wind loading when \( T \) is maximum, which means the vertical component of worst load sag should be taken for 'cold curve' of sag template in order to assess uplift on towers.
APPENDIX B

(TO 9.2.1)

TOLERANCES IN OVERHEAD LINE CONSTRUCTION

B-1. SURVEY

B-1.1 The accuracy of survey work depends upon, the accuracy of surveying instruments, the prevailing temperatures, the accuracy of placing instruments and their reading. It shall be ensured, however, that no measurements should be missed during surveys and check surveys carried out where any doubt arises.

B-2. STUB SETTING (TOWER FOOTING)

B-2.1 All the stub angles for tower legs shall be set accurately to the grade and alignment shown on the drawings. The difference in elevation between identical parts of any two stub angles shall not exceed 1/1,000 of the horizontal distance between the stubs, allowance being made for the difference,
if any, in the lengths of legs and extensions. The actual elevation of any stub angle shall not differ from the computed elevation by more than 1/100 of foundation depth. Stub angles shall be located horizontally so that each is within 6 mm of its correct position, and the batter of the stub angles shall not differ from the correct batter by more than either 1/100 of exposed stub length, or by the amount of play as offered by the clearance between bolts and holes of the setting template. To ensure greater accuracy, the hole clearance shall not be greater than 1.5 mm of the punched side of the template members.

**B-2.2** If the actual elevation of stubs is beyond 6 cm as found after casting the foundation and on the plus side (that is, if the foundation is raised), equivalent depth of earthwork will be provided over the top of the foundation as per design requirements with particular reference to such location. By design requirements is meant the earth required to resist uplift forces.

**B-2.3** The following tolerances shall be applicable in case of position of foundation as a whole with reference to tower position as spotted on the survey chart:

<table>
<thead>
<tr>
<th>Type of Tower</th>
<th>Out of Alignment</th>
<th>From Centre Line of Route</th>
<th>From Trans. Centre Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension or intermediate</td>
<td>0.5°</td>
<td>± 25 mm</td>
<td>± 250 mm</td>
</tr>
<tr>
<td>Section or tension (set at bi-section of deviation angle)</td>
<td>0.5°</td>
<td>± 25 mm</td>
<td>± 25 mm</td>
</tr>
</tbody>
</table>

**B-3. CONCRETE AND FORM DIMENSIONS**

**B-3.1** The maximum tolerance on the dimensions shall be ± 5 mm. This shall not be accumulative on height for various parts of the foundation.

**B-4. TOWERS**

**B-4.1** No member of a tower shall be out of straightness by more than one in 1000. Members failing the requirement shall be straightened before erection in a manner that shall not damage their properties or the protective finish.

**B-4.2** The towers shall not be out of vertical by more than 1 in 360 before stringing is carried out.

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B-5. STRINGING

B-5.1 The maximum tolerance in final still air sag at maximum temperature shall be ± 4 percent of such sag, in any span as obtained from the sag tension chart. The sag of any conductor in a span shall not depart from the mean sag of all conductors in the same span by more than 3 percent.

Note - In order that the minimum required ground clearance is not interfered with by tolerance in sag template used for tower spotting shall be based upon a plus tolerance in sag of 4 percent, the 'Support Foot' curve being located according to tower design.

APPENDIX C

(Clause 10.9)

MIXING, PLACING AND COMPACTING OF CONCRETE

C-1. MIXING

C-1.1 Concrete shall preferably be mixed in a mechanical mixer, but hand mixing shall be permissible. In case of emergency (when mechanical mixers are in use) such as failure of the mixers, or where it is not practicable to haul the mixers up to the location, and also for lean concrete sub-base, hand mixing may be resorted to.

C-1.2 When hand mixing is adopted, it shall be carried out on water-tight platforms such as 1.8 mm galvanized iron plain sheets properly overlapped and placed upon level ground. The coarse aggregates shall first be evenly spread out in required quantity over the sheets. The fine aggregates shall then be thoroughly mixed together and levelled. The required amount of cement shall now be spread evenly over the mixed aggregates and wet mixing shall start from one end with required amount of water suing showels. The whole lot shall not be wetted; instead mixing shall proceed progressively. If the aggregates are wet or washed, cement shall not be spread out, but shall be put in progressively.

C-1.3 For mixing in mechanical mixers, the same order of placing ingredients in the leader/drum shall be adopted, that is, coarse aggregates shall be put in first followed by sand, cement and water.

C-1.4 Mixing shall be continued until there is a uniform distribution of material and the mass is uniform in colour and consistency but in no case shall mixing be done for less than 2 minutes.

C-1.5 If the aggregates are wet, the amount of water shall be reduced suitably.
C-2. TRANSPORTING

C-2.1 Normally mixing shall be done right at the foundation. In places where it is not possible, concrete may be mixed at the nearest convenient place. The concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any of the ingredients. If segregation does occur during transport, the concrete shall be remixed before being placed.

C-2.2 During hot or cold weather, concrete shall be transported in deep containers; the deep containers, on account of their lower ratio of surface area to mass, reduce the rate of loss of water by evaporation during hot weather and loss of heat during cold weather.

C-3. PLACING AND COMPACTING

C-3.1 The concrete shall be placed and compacted before setting commences and should not be subsequently disturbed. The placing should be such that no segregation takes place.

C-3.2 Concrete shall be thoroughly compacted during the placing operation, and thoroughly worked around the reinforcement, around embedded fixtures and into corners of form work by means of 16 mm diameter poking bars pointed at the ends. As a guide for compacting the poking bars be worked 100 times in an area of 200 mm square for 300 mm depth. Over-compacting causes the liquid to flow out upward causing segregation and should be avoided.

C-3.3 If, after the form work has been struck, the concrete surface is found to have defects, all the damaged surfaces shall be repaired with mortar application composed of cement and sand in the same proportion as the cement and sand in the concrete mix. Such repairs shall be carried out well before the foundation pits are backfilled.

C-3.4 For precautions to be taken on concrete work in extreme weather and under water, the provisions of IS : 456-1978* shall apply.

C-3.5 Field tests on workability of concrete and consistency may be carried out in the form of slump test in accordance with IS : 1199-1959†.

*Code of practice for plain and reinforced concrete (third revision).
†Methods of sampling and analysis of concrete.
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