CONSTRUCTION MANUAL FOR TRANSMISSION LINES
The Engineers experienced in the field of Transmission have made this effort to compile the experience gained over the past 40 years in the form of a Manual and make it available to the Engineers and Technical Supervisors of the Company. This is a step forward to disseminate knowledge so that uniform practices and procedures are followed in the construction activities in the Company.

This Manual covers all the activities related to the construction of Transmission lines.

I appreciate the work done by the members of the Committee in preparing and bringing out this Construction Manual for Transmission lines.

I hope that the Manual will be of immense use and reference to the Engineers of the Transmission & Construction Wing.

Shreemat Pandey  
Chairman & Managing Director  
July, 2007

Jaipur  
Rajasthan Rajya Vidyut Prasaran Nigam Ltd.
The construction practices in the transmission wing of RVPN have been built over the past 40 years and passed on from seniors to juniors. The new generation of Engineers, skilled Technical Supervisors and Workmen have, from time to time, constantly updated the construction practices according to the latest developments in the field of Transmission Engineering.

It was felt that the construction practices built over the years be compiled in the form of a Manual and made available to Engineers and Technical Supervisors engaged in the construction activities so that uniform practices and procedures are followed in the Company.

A Committee of the following Engineers experienced in the field of Transmission was assigned the task of preparing the Construction Manual:

Shri S. Dhawan, Chief Engineer (MM)
Shri B. N. Saini, Superintending Engineer (400 KV Design)
Shri Raghuvendra Singh, Executive Engineer (Prot. II)
Shri Mohan Singh Ruhela, Executive Engineer (C&M–400 KV GSS), Heerapura
Shri A. D. Sharma, Assistant Engineer (Civil – 400 KV Design)
Shri Atul Sharma, Assistant Engineer (TLPC)

I appreciate the work done by the members of the Committee in preparing and bringing out this Construction Manual for Transmission lines. I am confident that the Manual will be of great help to the Engineers posted in the Transmission & Construction Wing in discharging their duties.

Y. K. Raizada
Director (Technical)
July, 2007
Jaipur
Rajasthan Rajya Vidyut Prasaran Nigam Ltd.
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SECTION – I

PRELIMINARY WORKS
CHAPTER – 1

SELECTION OF ROUTE

1.0 CRITERIA FOR ROUTE SELECTION:

1.1 The route of a transmission line is decided from the following main considerations.

a) Shortest length, hence least capital cost.
b) Ease during construction and ease in maintenance of the line (route near roads for easy approach & accessibility).
c) Requirement of future loads (sub stations) near the proposed route so that the line can be easily connected.
d) Required separation distance from parallel communication lines (P&T, Railways, etc.) for meeting the conditions of induced voltage for obtaining PTCC approval.
e) Avoiding of forest areas as well as wild life sanctuaries.
f) Cost of securing and clearing right of way (ROW).
g) Maintaining statutory distances from Airports / Helipads.

1.2 The following areas are to be avoided as far as possible while selecting the route of the line.

a) Tough inaccessible areas where approach is difficult.
b) Towns and villages, leaving sufficient margin for their growth.
c) Areas subject to floods, gushing nalas during rainy seasons, tanks, ponds, lakes, etc. and natural hazards.
d) Wooded areas with high trees or fruit bearing trees involving payment of heavy compensations for cutting of the trees.
e) Swamps and shallow lands subject to flood, marshy areas, low lying lands, river beds, and earth slip zones, etc. involving risk to stability to foundations.
f) High hillocks / hilly areas / sand dunes and areas involving abrupt changes in levels and requiring too many long spans.
g) Series of irrigation wells.
h) Rifle shooting areas and other protected areas such as army / defence installations and ammunition depots.
i) Areas which involve risk to human life, damage to public & private properties, religious places, cremation grounds, quarry sites and underground mines, gardens, orchards and plantations.
j) Areas which will create problems of right of way and way leaves.
k) Buildings / Storage areas for explosives or inflammable materials, bulk oil storage tanks, oil or gas pipelines, etc.

1.3 The route of the transmission line shall, as far as possible, be the shortest length between the pre – determined sub stations.

1.4 The route of the transmission line is to be so located that, as far as possible, it is protected from high winds and falling trees & branches. In hilly tracks, the line is to be routed, as far as possible, along the side of the hills or through valleys rather than over high points. However, a route of the line very close to steep slopes of hills be avoided as far as possible as there may be difficulty in obtaining lateral (side) clearance to ground for conductors. Also, there may be overhanging / loose boulders which may roll down and damage the line.

1.5 It is desirable to take the line as near the paths and roads as practicable without unduly increasing the length of the line so as to facilitate transportation of material during construction and the patrolling / maintenance of the line. Where the line cannot be routed near paths / roads economically, care shall be taken to see that easy access is possible at every 5 to 8 km. It shall be ensured that all angle / tension points, particularly in the case of 400 kV
Construction Manual for Transmission Lines

lines, are approachable to facilitate easy transportation of stringing equipment during construction and for maintenance / breakdowns.

1.6 In hilly / mountainous type of terrain or in thickly populated areas, it is generally not advisable to attempt a direct route or try to locate towers in long spans. Small angles of a few degrees cost a little more and add little to the length of the line. Suspension towers (A – type) can be provided for line angles of upto 2 degrees and small angle towers (B – type) can be provided for angles upto 15 degrees.

1.7 In general, large angles in the line are to be avoided wherever possible. The magnitude of the angle be small as far as possible and should never be more than 60 degrees.

1.8 The line shall be aligned suitably so that it can be diverted / looped in looped out (LILO) to cater for possible future loads / sub stations along the route.

2.0 APPROVAL OF THE POWER & TELECOMMUNICATION CO-ORDINATION COMMITTEE (PTCC):

2.1 The line route shall be so selected that the voltage induced in parallel running telegraph / telephone / communication / signaling lines / circuits of the P&T Department/ Railways does not exceed the prescribed permissible values under fault conditions. The PTCC approval should be obtained before energizing the line.

3.0 APPROVAL OF THE AVIATION AUTHORITIES:

3.1 The line route shall be at a sufficient distance from the aerodromes / airports so that clearance from the aerodrome / airport authorities is not required or, otherwise, can be obtained easily.

4.0 CROSSING OF RAILWAY TRACKS:

4.1 The crossing of Railway tracks shall normally be outside the railway station limits.

5.0 CROSSING OF RIVERS / NALAS / ROADS:

5.1 Crossing of rivers / nalas is preferably done at points where the bed is of the smallest width and the banks on both sides of the rivers / nalas are high. The crossing is done at points of the river path where it is unlikely to cut the banks when it is flowing.

5.2 The route is selected such that multiple crossings of the same road are avoided.

5.3 Crossing of roads at very small angles is to be avoided.

6.0 CROSSING OF POWER LINES:

6.1 When crossing existing higher voltage power lines, the new line shall normally be below such existing lines except in extremely limiting circumstances.

6.2 When crossing existing lower voltage power lines, the new line shall normally be above such existing lines except in circumstances where it is not possible.

6.3 When crossing existing power lines of the same voltage, the new line may be above or below such existing lines as per site conditions.

7.0 APPROVAL OF FOREST DEPARTMENT:

7.1 Forest area is to be avoided as far as possible.

7.2 If forest area cannot be avoided, or if the line route is uneconomical in case forest area is avoided, then the approval of the Forest Department is required.
CHAPTER – 2
RECONNAISSANCE SURVEY

1.0 GENERAL:
1.1 Reconnaissance survey of the transmission line route is to be carried out for deciding upon the most economical line route and the most economical location of towers in view of the high cost per location.

1.2 The G. T. sheets of the Survey of India are the best available maps. The maps covering the complete proposed route of the line shall be obtained. The maps which also cover the topography of the land at an additional distance of 10 km on both sides of the proposed line are also to be obtained. The scale of these maps shall be 1:50,000, i.e., 1 cm. = 500 metres. These maps are also required for the purpose of obtaining various clearances for the line route. Sufficient number of copies of these maps is to be arranged as per requirement.

1.3 These maps give details of the location of villages, towns, cities, ponds, lakes, rivers, nalas, roads, kucha & packa rastas, orchards, plantations, religious places, hilly area, sand dunes, etc.

1.4 After a study of these maps, a tentative line route is selected based on the criteria described in Chapter – 1. This is marked on the maps.

1.5 A walkover reconnaissance and route alignment survey is first carried out. A vehicle may also be used wherever the terrain permits and where long distances can be seen without obstacles. This is essentially carried out to verify the physical features on the ground which may not be clearly available in the survey maps due to developments that might have taken place subsequent to the preparation of the maps.

1.6 The work of reconnaissance survey is essential for the purpose of establishing control points and collection of first hand information of various important field data required for transmission line works. These are as below:
   a) Crossing points of major EHV lines (66 kV and above) & details of the lines.
   b) Crossing points of Railway Tracks & details of such points.
   c) Crossing points of major rivers & details of such points.
   d) Type of terrain and nature of soil strata along the line route.
   e) Names of major towns.
   f) Important villages or towns coming enroute.

1.7 The tentative line route is continuously examined and evaluated with reference to the criteria described in Chapter – 1. Changes are proposed / made in the line route wherever required. If necessary, alternative line routes are to be studied / surveyed keeping in view the fundamental considerations for selection of line route.

1.8 The best route, modified or alternate, is then provisionally marked on the maps. This route shall form the basis for the detailed survey of the line.

2.0 MEASUREMENT OF EARTH RESISTIVITY:
2.1 Measurements of earth resistivity shall be made at every 2 to 3 km along the tentative route of the transmission line. In case soil characteristics change within 2 to 3 km, the earth resistivity shall also be measured at intermediate locations wherever such characteristics change. The megger reading and soil characteristics shall also be indicated in the earth resistivity results.

2.2 Earth resistivity along the route alignment shall be measured in dry weather by the four electrode method keeping inter – electrode spacing of 50 metres.
2.3 Test Procedure:
Four electrodes are driven into the earth at equal intervals $s$ along a straight line in the chosen direction. The depth of the electrodes in the ground shall be of the order of 30 to 50 cm. The earth resistance Megger is placed on a steady and approximately level base and the four electrodes are connected to the instrument terminals as shown in the figure. An appropriate range on the instrument, avoiding the two ends of the scale as far as possible, is then selected to obtain clear readings.

\[ \rho = 2 \pi s R \]

where
\[ \rho = \text{resistivity of soil in ohm – metre}, \]
\[ s = \text{distance between two successive electrodes (50 metres)}, \]
\[ R = \text{Megger reading in ohms}. \]

3.0 PRELIMINARY CHECKING FOR COMPLIANCE TO THE REQUIREMENTS OF THE POWER & TELECOMMUNICATION CO – ORDINATION COMMITTEE (PTCC):
3.1 A copy of the map of the line route is prepared in which the points where earth resistivity has been measured are indicated along with the values of the earth resistivity at such points.
3.2 The alignments of the railway lines and telephone / telegraph lines near the route of the line are also marked on the map.
3.3 This map is sent to the Executive Engineer (PTCC) in the office of the Chief Engineer (T&C), Jaipur for preliminary calculation of the induced voltages in the parallel running telecommunication / signal circuits.
3.4 If the induced voltages as per above preliminary calculations are within the prescribed permissible limits, then the route of the line can be considered to be final in this respect.
3.5 If the induced voltages as per above preliminary calculations are not within the prescribed permissible limits, then the proposed route of the line shall be got re-surveysed for maintaining sufficient separation distance from the parallel running telecommunication / signal circuits so that the induced voltages are within permissible limits. The approximate safe separation distances can be indicated by the Executive Engineer (PTCC). The map of the revised route, alongwith revised earth resistivity readings if required, is again sent to the Executive Engineer (PTCC) for confirmatory calculations. The new route of the line can be considered to be final in this respect if the induced voltages as per these confirmatory calculations are within the prescribed permissible limits.

3.6 If however it is not possible to maintain the safe separation distance from the parallel running telecommunication / signal circuits because of constraints which do not permit the required realignment, then the Executive Engineer (PTCC) may be requested to confirm that the induced voltages are within such limits for which protective devices can be provided by the telecommunication / railway authorities. The concerned department installs these protective devices after their cost is deposited by RVPN.

4.0 CROSSING OF RAILWAY TRACKS:
4.1 The crossing of Railway tracks shall not be located over a booster transformer, traction switching station, traction sub – station or a track cabin location in an electrified area.

5.0 CROSSING OF RIVERS / NALAS:
5.1 Crossing of rivers / nalas is preferably done at points where the bed is of the smallest width. High banks on both sides of the rivers / nalas are preferred at crossings so that higher height of towers is not required.

6.0 CROSSING OF ROADS:
6.1 The Ministry of Road Transport & Highways, Govt. of India, issues instructions / guidelines from time to time for regulating crossing of National Highways. Therefore, prior consultation be made with National Highway authorities in locating the line crossing keeping in view the likely development / improvements of the National Highways.

6.2 Crossings shall not be too near the existing structures on the National Highways, the minimum distance being 15 metres, or as specified by the Highway Authority.

6.3 The crossing points of roads are selected where there are no problems of right of way on the roadsides, e.g., dhabas, intersection of other roads, dense roadside plantation by the Forest Department / PWD, etc.

7.0 CROSSING OF POWER LINES:
7.1 The crossing of existing higher voltage power lines shall normally be below the higher voltage lines except in extremely limiting circumstances. Such crossing shall be done at a location where adequate ground clearance for the new line and the specified clearance from the existing power line (under maximum sag conditions) are available.

8.0 APPROVAL OF THE LINE ROUTE:
8.1 The map showing the route of the line complying with the requirements of PTCC approval is submitted to the Circle Superintending Engineer for according approval of the line route.

8.2 In the case of line route as per 3.6 above, the specific approval of the Circle Superintending Engineer shall be obtained for adopting the route of the line in which installation of protective devices by the concerned department is required for obtaining the PTCC approval.

8.3 If any changes are suggested by the Circle Superintending Engineer, the line route is to be got resurveyed accordingly and corrected route resubmitted for approval.
9.0 **RIGHT OF WAY:**

9.1 The authority for Right of Way is conferred by the issue of a Notification by the Chief Engineer in exercise of powers conferred by the Govt. of Rajasthan under Section 164 of the Electricity Act, 2003 (earlier, Indian Electricity Act, 1910). The powers are the same as conferred on the Telegraph Authority under Section 10 of The Indian Telegraph Act, 1885. Generally, Right of Way is not purchased. As per sub-section 10 (b) of The Indian Telegraph Act, 1885, RVPN does not acquire any right other than that of user only in the property under, over, along, across, in or upon which any line or tower is placed for construction, operation & maintenance of the line while the owner retains the ownership and use of the land. These powers shall not be exercised in respect of property vested in or under the control or management of any local authority without the permission of that authority.

9.2 The proposal for the issue of the Right of Way notification is submitted to the Chief Engineer (T&C). The names of all the villages / dhanies along the route of the line as well as villages adjacent to the route are mentioned in the proposal.

9.3 The Notification of Right of Way is to be got published in the State Gazette for which the required fees is deposited in the Government Press, Jaipur.

9.4 A copy of the Notification of Right of Way is also to be got published in the local newspapers of the areas in which the transmission line will be passing. This is important as proof of circulation of information to the general public when contesting court cases which local landowners may file. The Courts may not accept the publication of the Notification of Right of Way in the State Gazette as sufficient circulation of information.

9.5 A sample notification is enclosed at Appendix – A.

10.0 **COMPENSATION:**

10.1 In exercise of the powers vested under sub-section 10 (c) of The Indian Telegraph Act, 1885, RVPN shall do as little damage as possible, and, when it has exercised these powers in respect of any property (other than that vested in or under the control or management of any local authority), shall pay full compensation to all persons interested for any damage sustained by them by reason of exercise of those powers.

10.2 In case damage has been caused to standing crops or fruit bearing trees which are accepted by the Revenue Authorities as eligible for payment of compensation, the crop compensation sheet, indicating the following, is prepared with the assistance of the local Patwari of the area.

   a) The details of the tower(s) and/or section of the line.
   b) The name(s) of the property owner, Khasra no., name of village, etc.
   c) Dimensions and area of the property in which damage has been caused.
   d) The details, type and quality of the crop damaged.
   e) The expected yield(s) of the crop(s), rate(s) and total cost(s).

10.3 The crop compensation sheet is signed by the Junior Engineer / Supervisor & Assistant Engineer on behalf of RVPN, and the Patwari. The verification is done/award is given by a Revenue authority not below the rank of Naib Tehsildar. The competent authority, as per the currently applicable RVPN Delegation of Powers, issues the sanction for compensation for crops destroyed or property damaged during the execution of the works on the above basis.

10.4 The payment is to be made to the owner of the property through Account Payee Cheque and receipt obtained for the same. However, if the beneficiary requests in writing, payment up to Rs. 5000/- only can be made in cash subject to attestation of the acknowledgement by local Revenue Authority or the JEN / AEN of RVPN.
राजस्थान राज्य विद्युत प्रसारण नियम लियो
कार्यालय मुख्य अभियंता (प्रसारण एवं निर्माण), ........................
राराविप्र/मु.अ.(एवंनि)/अनु. /प ( )/ प्रे. दिनांक

अधिसूचना

विद्युत अधिनियम 2003 की धारा 164 के अन्तर्गत राजस्थान सरकार के मुख्य विभाग ने 28.2.2004 को अधिसूचना जारी की जो कि राजस्थान राज पत्र में S.O. 408 नं 393 (13) भाग 4 (GA) में दिनांक 3.3.2004 को प्रकाशित की गई।

उपरोक्त अधिसूचना में राजस्थान सरकार ने मुख्य अभियंता, राजस्थान राज्य विद्युत प्रसारण नियम को विद्युत लाइनों / कार्यालयों के निर्माण एवं विद्युत परियोजना हेतु या तत्त्वावधानी कार्यों के सम्बन्ध में लिए दुस्माषु अथवा संबंध के लिए तार के निर्माण हेतु विद्युत अधिनियम 2003 की धारा 184 के अन्तर्गत एवं भारतीय तार अधिनियम 1885 के तहत शक्तियों प्रदान की गयी है।

अतः उपरोक्त प्रदत्त शक्ति का उपयोग करते हुए, अभीजातुरकारलों द्वारा प्रस्तावित 220 केवल कई स्थलों हीरापुर द्वि परियोजना लाइन, जो कि 220 केवल जीएसएस इलेक्ट्रिक गठीनाग, जयपुर, जयपुर के लिए एंजनी के पथ अधिकार को विद्युत अपूर्ति हेतु स्वीकृति प्रदान की जाती है।

उपरोक्त लाइन निम्नलिखित रेखेखंड श्रमीं अन्दर से सुस्पिकी।

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<td>24</td>
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मुख्य अभियंता (एवं नि),
राराविप्र, ........................
प्रतिलिपि निम्न को शुरू एवं अंत संस्करण कार्यवाही हेतु प्रेषित हैं:
1. श्रीमान उप सचिव, उत्तर प्रदेश, राजस्थान सरकार, जयपुर।
2. श्रीमान सचिव (प्रशासन), रा. वा. वि. दि. फि. जयपुर।
3. श्रीमान रेडियो कॉलेज़, उदयपुर।
4. श्रीमान अधिकारी, केंद्रीय मुद्राशालय, जयपुर को अद्यावधि किया जाता है कि इस अभियंता को संस्थान सरकार के अंगीने अधिकारी राज निर्म द्वारा अंततः संस्करण में प्रकाशित करे तथा प्रतिलिपि उन्होंने राजस्थान, राजस्थान सरकार तथा इस कार्यक्षेत्र को प्रेषित करें।
5. श्रीमान अधिकारी अभियंता (डिजाइनिंग /400 केबल टीसेटिस), राजस्थान राज्य, सावधानितिक, (उदयपुर) को अद्यावधि किया जाता है कि मुख्य अभियंता (एच एवं फि), राजस्थान राज्य, जयपुर के प्रति क्रमांक प्र० 1251 विशेष 11.7.1991 के अनुसार अधिकारी केंद्रीय मुद्राशालय, जयपुर को उपरोक्त अभियंता को प्राप्त इंतेजू निर्धारित युक्त अन्वेषण करने।
6. श्रीमान अधिकारी अभियंता ( ), राजस्थान राज्य, सावधानितिक, उदयपुर।

मुख्य अभियंता (एच एवं फि),
राजस्थान, सावधानितिक,

CHAPTER – 3

PRELIMINARY SURVEY

1.0 FIXING OF ROUTE ALIGNMENT:

1.1 The alignment of the line route is carried out by survey using a theodolite.

1.2 The following positions are fixed during this survey.

a) Fixing of angle tower positions.
b) Finalizing of crossing points of major EHV lines (66 kV and above) & details of the lines.
c) Finalizing of crossing points of Railway Tracks & details of such points.
d) Finalizing of crossing points of major rivers & details of such points.

1.3 Measurements of the angles of deviation at all angle / section points are made. Resurvey of parts of the line route is done wherever it is possible to reduce the number of angle points and/or the magnitude of the angles of deviation.

1.4 For the purpose of guidance, the angles of deviation of the different types of towers are as below:

<table>
<thead>
<tr>
<th>Tower type</th>
<th>Used as</th>
<th>Angle of deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘A’</td>
<td>Suspension tower</td>
<td>upto 2 degrees</td>
</tr>
<tr>
<td>‘B’</td>
<td>Small angle tower</td>
<td>upto 15 degrees</td>
</tr>
<tr>
<td>‘C’</td>
<td>Medium angle tower</td>
<td>upto 30 degrees</td>
</tr>
<tr>
<td>‘D’</td>
<td>Large angle &amp; dead end tower</td>
<td>upto 60 degrees &amp; dead end</td>
</tr>
</tbody>
</table>

1.5 The length of the line route is also measured. This is done with the use of survey chains or with the theodolite.

1.6 When using survey chains for measuring the length of the line route, the chain should be kept horizontal in uneven or undulating land so that horizontal distances are measured and not the distances along the contours of the land.

1.7 A span is the part of the line between any two adjacent towers. A section is the portion of the line route with a single span or with a number of consecutive spans between two tension points with "B", "C", or "D" type towers, as applicable.

1.8 The number of consecutive spans between two angle / section points shall not exceed 15 (fifteen) in plain terrain and 10 (ten) spans in hilly terrain.

1.9 The length of any section of the line, i.e., between two angle / section points, shall not exceed 5 km in plain terrain and 3 km in hilly terrain. In case longer sections are available, then cut points / section points shall be provided by using “B” type tower.

1.10 If the terrain & line route permit, attempts can be made so that the section lengths are, as far as possible, in multiples of the basic span of the towers for the relevant voltage class.

1.11 The basic spans, which are the design spans for towers, as adopted for the various voltage levels are as below:

<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Basic Span</th>
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</thead>
<tbody>
<tr>
<td>400 kV</td>
<td>400 metres</td>
</tr>
<tr>
<td>220 kV</td>
<td>350 metres</td>
</tr>
<tr>
<td>132 kV</td>
<td>335 metres</td>
</tr>
</tbody>
</table>
2.0 CROSSING OF POWER LINES:

2.1 The crossing of existing power lines shall be at an angle as close to 90 degrees as possible.

2.2 The crossing of the new line over an existing power line is preferably done in the middle of the span between towers of existing power line where there is maximum sag of the conductor. When the line to be constructed is crossing another important EHV line for which shutdown may be difficult, suspension towers in combination with angle / dead-end towers, with extensions as required, may be used.

2.3 The crossing of the new line below an existing power line shall be done at locations where adequate ground clearance for the new line and the specified clearance from the existing power line are available. Such crossing shall preferably be in the mid span between towers / structures of the new power line, where there is maximum sag of the conductor, and near one of the towers of the crossing span of the existing line for taking advantage of the higher height of the conductors. These measures reduce the requirement of increasing the height of the existing line for obtaining the requisite clearance.

3.0 CROSSING OF THE TELECOMMUNICATION LINES:

3.1 The crossing of such lines should preferably be at 90 degrees, but an angle less than 60 degrees is not permissible.

4.0 CROSSING OF RAILWAY TRACKS:

4.1 The angle of crossing should preferably be 90 degrees, but an angle of up to 60 degrees may be permitted in special cases.

4.2 The crossing span shall be restricted to 300 metres or to 80% of the basic span of the towers of the relevant voltage class, whichever is less. Angle towers are to be provided on both sides.

4.3 The minimum distance of the towers of the crossing span from the center of the nearest railway track shall be equal to the height of the tower in metres above normal ground level plus 6 metres.

4.4 The crossing span over already electrified railway track shall be located at the middle of overhead equipment span supported by two adjacent traction masts / structures. The distance between any of the crossing conductors of the line and the nearest traction mast or structure under the most adverse conditions shall not be less than 6 metres.

4.5 As far as possible, higher levels of land on both sides of the railway track are preferred at crossings so that there is minimum requirement for increase in the height of the towers. One tower of the crossing span is located nearer to the Railway track for taking advantage of the higher height of the conductor on the tower.

4.6 The above paras give only the salient requirements prescribed in the Regulations for Power Line Crossings of Railway Tracks issued by the Railway Board. The latest issue of the above Regulations may be referred to for further details.

5.0 CROSSING OF ROADS:

5.1 Transmission line crossings across National Highways and major roads shall preferably be at right angles or as near to 90 degrees as possible.

5.2 For crossing of National Highways and major roads in case of lines up to 220 kV, it is advisable to provide at least one angle / section tower in the crossing span for the purpose of ease during stringing. For 400 kV lines, angle / section towers are to be provided on both sides in such cases.
5.3 The towers supporting the crossing span shall be located outside the National Highway land.

6.0 RIGHT OF WAY:
6.1 The width of the right of way should be kept as per the provisions of the applicable part / section of the Indian Standard Code of Practice for Design, Installation and Maintenance of Overhead Power Lines (IS: 5613).

6.2 For lines upto 220 kV, IS 5613 (Part 2 / Sec 2) recommends the following right of way widths taking into consideration the theoretical requirement of right of way and transport requirements of maintenance:

<table>
<thead>
<tr>
<th>Transmission Voltage</th>
<th>Recommended Width of Right of Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>132 kV</td>
<td>27 metres</td>
</tr>
<tr>
<td>220 kV</td>
<td>35 metres</td>
</tr>
</tbody>
</table>

6.3 For 400 kV lines, the following right of way width, as per RVPN practice, shall be maintained taking into consideration the theoretical requirement of right of way and transport requirements of maintenance:

<table>
<thead>
<tr>
<th>Transmission Voltage</th>
<th>Recommended Width of Right of Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 kV</td>
<td>52 metres</td>
</tr>
</tbody>
</table>

7.0 MAINTAINING STATUTORY CLEARANCES:
7.1 Rule 80 of the Indian Electricity Rules, 1956 prescribes the horizontal clearance which is to be maintained from buildings / parts of buildings.

7.2 The horizontal clearance, on the basis of maximum deflection due to wind pressure, which should be maintained from buildings / parts of buildings, shall not be less than the values given below:

<table>
<thead>
<tr>
<th>Transmission Voltage</th>
<th>Minimum Horizontal Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>132 kV</td>
<td>2.9 metres</td>
</tr>
<tr>
<td>220 kV</td>
<td>3.8 metres</td>
</tr>
<tr>
<td>400 kV</td>
<td>5.6 metres</td>
</tr>
<tr>
<td>800 kV</td>
<td>9.2 metres</td>
</tr>
</tbody>
</table>

7.3 The maximum deflection of the conductors shall be calculated on the basis of the wind pressure as per Rule 83 of the Indian Electricity Rules, 1956.

8.0 APPROVAL OF FOREST DEPARTMENT:
8.1 While carrying out preliminary survey in forest areas, permission of the local forest authorities should be obtained for trimming / lopping of tree branches which obstruct the line of sight of the survey instrument. This is a mandatory requirement and any such above activity without permission can result in criminal proceedings.

8.2 The proposal for crossing of forest area is to be submitted in the prescribed forms / formats to the Forest Department for obtaining the requisite clearance.

9.0 ROUTE MARKING:
9.1 At the starting point of the commencement of route survey, at all angle / section points, at every 1.25 km. or part thereof, and at the end point of the route survey, concrete pillars 200 x 200 mm square and height 300 mm shall be buried firmly in the ground for easy identification. The concrete pillars shall have ‘RVPN’ marked on them. The top of these pillars shall be 50 mm below ground level and should not normally project above the ground level. A wooden peg of size 50 x 50 mm and length 150 mm is embedded in the center of the
concrete pillars when they are casted. Nails of 25 mm length shall be fixed on the top of these pegs to indicate the location of the center of the survey instrument.

9.2 Wooden pegs of size 50 x 50 mm and length 150 mm shall be driven in the ground between the angle points at prominent positions along the transmission line route surveyed at intervals of not more than 750 meters. These shall be driven into the ground at protected places such as field boundaries so that they are not removed or displaced by anybody. The pegs shall be driven firmly into the ground with the top at 50 mm below the ground level. Nails of 25 mm length shall be fixed on the top of these pegs to show the location of the center of the survey instrument.

10.0 MEASUREMENT OF EARTH RESISTIVITY:
10.1 Measurements of earth resistivity shall be done along the route of the transmission line as given in para 2.0 of Chapter – 2 of this section.

11.0 PLOTTING OF THE ROUTE ON THE MAP:
11.1 The line as surveyed is plotted on the G. T. sheet maps indicating all the angle points.

12.0 APPROVAL OF THE LINE ROUTE:
12.1 In case there are major deviations in the route as surveyed and the deviations are likely to affect the induced voltages in the telecommunication / railway signal calculated earlier, this route of the line is sent to the Executive Engineer (PTCC) for review and intimating acceptability.

12.2 In the above mentioned circumstances, this route of the line as surveyed is resubmitted to the Circle Superintending Engineer for according approval.
CHAPTER – 4

APPROVALS & CLEARANCES
FOR THE LINE ROUTE

1.0 APPROVAL OF THE POWER & TELECOMMUNICATION CO-ORDINATION COMMITTEE (PTCC):

1.1 A copy of the map of the final line route is prepared in which the points where earth resistivity has been measured are indicated along with the values of the earth resistivity at such points.

1.2 The questionnaire and other documents required for preparing the PTCC case are filled in and sent to the Executive Engineer (PTCC) in the office of the Chief Engineer (T&C), RVPN, Jaipur through the Circle Superintending Engineer.

1.3 The questionnaire for preparing the case for PTCC clearance is given in Appendix – A.

1.4 The line shall not be charged until the PTCC clearance is obtained.

2.0 APPROVAL OF THE AVIATION AUTHORITIES:

2.1 If the proposed route of the line is in the vicinity of civil or defence aerodromes / airports, an application shall be made to the aerodrome / airport authorities for issuing their approval with regard to sufficient distance from the aerodrome / airport.

2.2 This approval should be obtained in writing as per requirement of Rule 84 of the Indian Electricity Rules, 1956.

2.3 It is mandatory to obtain clearance from aerodromes / airports authorities in case of towers of height 45 metres and above irrespective of whether they are close to or far away from aerodromes / airports.

2.4 The form of application for obtaining such clearance as at para 2.3 is given in Appendix – B.

3.0 APPROVAL OF FOREST DEPARTMENT:

3.1 If the line route is proposed through forest area, the details of the area of the forest land affected in terms of length of line and width of right of way are to be prepared.

3.2 The proposal for permission for crossing of forest area is to be submitted in the prescribed forms / formats for obtaining the requisite clearance.

3.3 The proforma / forms for the above proposal are enclosed in Appendix – C.

3.4 The construction activities in the forest area cannot be started until the clearance is received.

4.0 APPROVAL OF RAILWAY AUTHORITIES:

4.1 A drawing showing the details of the crossing of the railway track is prepared as per requirements of the “Regulations for Power Line Crossings of Railway Tracks” issued by the Railway Board.

4.2 The form / questionnaire in the prescribed format is to be filled in.

4.3 The drawing, questionnaire and the agreement form alongwith the original receipt of inspection fee is to be submitted to the concerning Railway Authority through the Circle Superintending Engineer.
4.4 The proforma / forms for the above proposal are enclosed in Appendix – D.

4.5 The line shall not be charged until the clearance of the Railway Authority is obtained.

5.0 APPROVAL OF ELECTRICAL INSPECTOR:

5.1 The approval of the Chief Electrical Inspector of the State Government is required to be obtained as per Rule 63 of the Indian Electricity Rules, 1956 before energizing the line.

5.2 The application is made in the prescribed questionnaire and submitted along with required drawings and information.

5.3 The inspection fee, as prescribed from time to time, is to be deposited.

5.4 The proforma / questionnaire for the above application is enclosed in Appendix – E.
GOVERNMENT OF INDIA
POWER TELECOMMUNICATION CO-ORDINATION COMMITTEE QUESTIONNAIRE

1 Please supply data of the power system as per details below:
1.1 Key diagram (single line) of the Electrical layout of the relevant portion of the power system, indicating the number, voltage ratings, capacities, etc. of the various power apparatus. Indicate also by dotted line the extensions proposed, ultimately or through the current five year plan.
Note: - By relevant is meant all the power stations which under normal operating conditions will feed into a fault occurring within or outside the parallelism section as well as all lines on which such fault current would flow.

Enclosed Annexure - A (i) & A (ii).

1.2 Data on the characteristics of equipments, viz., Generators, Transformers, synchronous condensors, Earthing Transformers, etc. installed in the system as per the enclosed appendix (Transient reactance figures should be given for all rotating machines).

1.3 Please state if the neutral points of the power system are (i) Insulated (ii) earthed. If the latter, please indicate the type of earthing, e.g., solidly, earthed through Peterson coils, earthed through resistance or reactance. Give also full particulars.

Solidly Earthed by pipe earthing (Annexure – B).

2 Please supply the following data in respect of particular power line for which approval is sought.

2.1.1 Name of power line. ____ kV ____ Circuit line from _______ to _________.

2.1.2 Operating Voltage and number of circuits. ____ kV, ____ Circuit.

2.1.3 a) Length of the line. ____ KM Approx.

b) Conductor / earthwire size and material.

i) Conductor: ACSR "_______", ____ / ____ mm Al & 7 / ____ mm Steel.

ii) Earthwire: 7 / ____ mm galvanised steel stranded wire, 110 kg / sq. mm quality.

2.1.4 If it is tap or spur line, the length of the tap and the distance of the tapping point from end of the sub - stations should be clearly indicated.

2.1.5 Is the power line bussed at any intermediate sub - station? If so, please give details.

2.1.6 Will the power line initially be charged at some lower voltage? If so, at what voltage?

2.1.7 Probable date of commencement of the work.

2.1.8 Probable date of commissioning.

2.1.9 Date by which the approval is desired.
2.2.1 Please supply a route map showing the proposed alignment of the power line and the prevailing telecommunication lines in the area, drawn to a scale of 1 CM = 0.5 KM. All topographical details including Railway Lines, Rivers, Canals and important Roads up to 8 KM on either side of the proposed power line may also be drawn to the scale. The Railway Stations should be located on the map and named.

Note: i) If the proposed line is an extension of the existing line which had not been referred to the committee previously, a similar route map of the existing line should also be supplied along with the route map of the proposed line.

ii) A copy of the route map with telecom circuits marked be also sent to local P&T authorities and Railway authorities requesting them to confirm the telecom circuits and also indicate the points of discontinuity in the telecom Circuits to both the Joint Secretaries of the committee.

2.2.2 Number and date of route map showing the proposed alignment.

2.3 Sketch or sketches of supports showing the conductor & ground wire arrangements of the transmission lines together with an indication of the size various wires.

2.4 Please also furnish the structural details of the supports indicating the factors of safety adopted under normal and broken wire conditions.

2.5 Please indicate the protective devices adopted for line. In respect of lines protected by circuit breaker, please furnish also the type of line relaying proposed and the total time (Breaker & Relay) for clearance of ground faults on the line with normal relay setting.

2.6 Please indicate the soil resistivity in the area covered by the line. The soil resistivity should be measured by the four electrode method with 50 Meters (150 Ft.) spacing. The measurements may be made at every 2 to 3 KM along the length of the line.

Route map enclosed vide Drg. No. 

____________________________
dt. ____________.

Attached. Drg. No. 

____________________________
dt. ____________.

Attached vide Annexure – C.

i) Under Normal Conditions = 2

ii) Under Broken Wire

Conditions = 1.5

The line will be protected by means of SF6 circuit breakers & IDMT fast acting relays and distance protection schemes having Tripping time of less than 0.1 Sec. from occurrence of fault.

Detailed statement is enclosed vide Annexure – D.
2.7 Please indicate the number of crossings between the proposed alignment and the Telecommunications lines involved and state if the crossing arrangements will be provided in accordance with the code of practice for crossings issued by the coordination committee.

There are ___ (______) Nos. only of P&T line crossings and the arrangement of the crossings will be provided in accordance with the code of practice for crossing issued by the PTCC.

Place: ____________
Date: ____________

Assistant Engineer (___________)  Executive Engineer (___________)
RVPN, ____________  RVPN, ____________.

Encl.  i) Route Map – 16 copies
       ii) Supporting sketches – 6 sets
AIRPORT AUTHORITY OF INDIA

APPLICATION FOR NO OBJECTION CERTIFICATE (NOC) FOR CONSTRUCTION OF BUILDING / STRUCTURES AROUND AIRPORTS.

(Please see reverse for guidelines for filling the application and the documents to be submitted)

1. Name of the applicant: Executive Engineer (_____________), Rajasthan Rajya Vidyut Prasaran Nigam Ltd., ________________.

2. Name of the airport for which NOC pertains to:

3. Address for communication:

4. Details of the site
   Tower No. _______ of ___ kV line from __________ to ____________.
   Plot No. / Survey No. / Name of Road:
   Village or Town / Taluk / Tehsil.:
   District / State.:

5. Type of structure proposed to be constructed. (House / Factory / Chimney / Overhead Water tank, etc):
   Transmission Line Tower.
   Height ______ Metres.

6. Location of the site
   (Distance and direction from the central point of runway, coordinates preferred).
   App. _____ KM N/S/E/W of ____________ Airport.
   App. Coordinates: __° __' __" E
                  __° __' __" N

7. Elevation (Reduced level AMSL of the ground level of the site, verified by the Survey of India):
   _____ Metres (approx.) Above Mean Sea Level.

8. If the structure proposed is a factory, type of Fuel proposed to be used in the furnace be given.
   : Not Applicable.

9. Elevation (reduced level AMSL) of the highest point of the building / structure proposed.
   : _____ Metres (approx.) Above Mean Sea Level.

10. Ownership of the site
    (Strike out whichever is not applicable)
    : Self owned / Leased / Corporate body / Society.
    : Not Applicable.

It is certified that the information given above is correct to the best of my knowledge. The required drawings / certificates / documents duly certified are enclosed.

Date __________
Executive Engineer (______________)
RRVPNL, ________________
GUIDELINES FOR FILLING THE APPLICATION FORM AND THE DOCUMENTS TO BE SUBMITTED

1. The application, completed in all respects, should be submitted to the In – charge of the airport, Airports Authority of India for which the NOC pertains (Nearest airport).

2. The location plan of scale 1: 8000 clearly highlighting the site of proposed structure with reference to the airport concerned and duly approved and authenticated by the municipal authorities / Urban Development Authority / any other authorized agency.

3. Architectural drawings of the plan and elevation including site plan with dimensions of the proposed structure or alterations indicating clearly the heights above the ground level / mean sea level.

4. A certificate authenticating the site elevation from the Municipal authorities / Corporation of the area or from the Central / State PWD or MES or concerned district authorities.

5. The following undertakings are to be submitted in the prescribed proforma on a non-judicial stamp paper of Rs.2/-.
   i) Undertaking for not installing any superstructures above the duly authenticated submitted drawing, not commencing construction on the proposed site before grant of NOC and for not making complaints / compensation demands against aircraft noise, vibrations, damages etc., due to aircraft operation at and in the vicinity of the airport (Form 1-A).
   ii) Undertaking for not causing smoke hazard, if the application is for industrial units / factory / chimneys (Form 1-B).

6. Under S.No. 9 of the application form,
   i) If the site belongs to Airports Authority of India and leased, the reference of AAI letter number to be indicated and enclose a copy of the AAI’s lease order.
   ii) If the site is leased from other parties, a copy of the lease agreement to be attached with the application.

7. If the application for NOC is for alternations / modifications of existing structure, a copy of earlier NOC for original structure is to be enclosed.

8. The sectional and elevation drawings should include all installations planned above the structure such as radio / television aerial / mast, lightning arrester, vent pipes, overhead water tanks and attachments on superstructure of any description.

9. Zoning maps for some of the AAI airports are available and can be obtained on payment.

10. Application form with all the above documents are to be submitted in quadruplicate (One Original and three copies).

(NOTE: Form 1-B is not applicable for RVPN)
FORM 1 – A

UN D E R T A K I N G

I, Executive Engineer (_____________), RRVPNL, _____________, for and on behalf of RRVPNL, the applicant for the proposed construction of ___ kV Transmission Line Tower at ________________, do hereby undertake:

1. Not to commence the proposed construction before grant of NOC by Airports Authority of India.

2. Not to complain / claim compensation against aircraft noise, vibrations, damages, etc., to me / us or to the occupants of the proposed construction due to aircraft operations at or in the vicinity of the airport.

3. That no radio / television aerial, mast, lightning arresters, vent pipes, overhead water tanks and attachments of any description will project on super structure, which are not indicated in the submitted drawings.

Signature of the applicant with date
Executive Engineer (______________)
RRVPNL, ________________
Dated ____________

Signature, Name and Address of witnesses:

1) ____________________________

Dated: __________________________

2) ____________________________

Dated: __________________________
FORM FOR SEEKING PRIOR APPROVAL UNDER SECTION – 2 OF THE FOREST (CONSERVATION) ACT, 1980 OF THE PROPOSAL BY THE STATE GOVERNMENT AND OTHER AUTHORITIES.

1. PROJECT DETAILS:
   i) Short narrative of the proposal and project / scheme for which the forest land is required.
      : Construction of ___ kV _____ Circuit transmission line from ___ kV GSS __________ to ___ kV GSS ______________.
   ii) Map showing the required forest area, boundary of adjoining forest and item wise break up of the required forest area for different purposes (to be authenticated by an officer not below the rank of Dy. Conservator of Forest).
   iii) Total cost of the project
      : Rs. ____ Lakhs.
   iv) Justification for locating the project in the forest area giving alternatives examined and reasons for their rejection.
      : Justification note enclosed as Annexure B.
   v) Financial and social benefits.
      : The project will improve the availability & quality of power in the urban, rural & industrial areas in _________________ Districts.
   vi) Total population benefitted
      : Approx. ___ lakhs
   vii) Employment generated
      : Approx _______ mandays.

2. LOCATION OF THE PROJECT / SCHEME:
   i) State
      : Rajasthan
   ii) District
      :
   iii) Forest Division, Forest Block, Compartment, etc.
      : _______ Division, __________.

3. Item wise break up of the total land required for the project / scheme along with its existing land use:
   i) Length of the line in forest land
      : _____ KM (Approx.)
   ii) Width of right of way
      : ___ Meters.
   iii) Forest land required
      : (i) KM x (ii) KM = _____ Hectare.
   iv) Forest land required for foundation of towers.
      : _______ Hectares
   (a) Total forest land required for foundation of _____Nos. of towers : ( included in total required forest area)
      : _______ Hectares
4. DETAILS OF FOREST LAND INVOLVED:
   i) Legal status of the forest (namely, reserve, protected/ unclassified, etc.): Reserve / Protected / Unclassified / __________ forest
   ii) Details of flora and fauna existing in the area:
   iii) Density of Vegetation:
   iv) Species wise and diameter class wise abstract of trees: Enclosed as Annexure – 3A
   v) Vulnerability of the Forest area to erosion, whether it forms a part of a seriously eroded area or not:
   vi) Whether it forms a part of national park, wild life sanctuary, nature reserve, bio -sphere reserve, etc. and if so, details of the area involved (specific comments of the Chief Wild Life Warden to be annexed):
   vii) Item wise break up of the forest land required for the project / scheme for different purposes: As per Annexure ‘D’.
   viii) Rare/endangered species of flora and fauna in the area:
   ix) Whether it is a habitat for migrating fauna or forms a breeding ground for them:
   x) Any other significance of the area relevant to the proposal: There are ___ Nos. of trees __________. The land involved along the route is total forest and there is no alternative route.

5. DETAILS OF DISPLACEMENT OF PEOPLE DUE TO THE PROJECT:
   i) Total number of families involved in displacement:
   ii) Number of scheduled castes / scheduled Tribes families involved in displacement:
   iii) Detailed rehabilitation plan:

6. **DETAILS OF COMPENSATORY AFFORESTATION SCHEME:**

i) Details of the non-forest area / degraded forest area identified for compensatory afforestation, its distance from adjoining forests, number of patches, size of each patch.

   : Enclosed as per Annexure C

ii) Map showing non-forest / degraded forest area identified for compensatory afforestation and adjoining forest boundaries.

   : Enclosed as per Annexure G

iii) Detailed compensatory afforestation scheme including species to be planted, implementing agency, time schedule, cost structure, etc.

   : Enclosed as per Annexure H

iv) Total financial outlay for compensatory afforestation scheme.

   \[(\text{Area}) \times 2 \times (\text{Rate}) = \text{________},\]

   Rs.________ only

   (As per rates for the year 20__ - 20__)

v) Certificate from competent authority regarding suitability of area identified for compensatory afforestation and from Management point of view.

   (To be signed by the Officer not below the rank of Deputy Conservator of Forest)

   : Enclosed as per Annexure C.

vi) Certificate from the Chief Secretary regarding non availability of the forest land for compensatory afforestation (if applicable)

7. **DETAILS REGARDING TRANSMISSION LINES (ONLY FOR TRANSMISSION LINE PROPOSALS):**

i) Total length of the transmission line : _____ KM

ii) Length passing through forest area : _____ KM

iii) Right of way : _____ KM

iv) Number of towers to be erected. : ___ Nos.

v) No. of towers to be erected in forest area. : ___ Nos.

vi) Height of transmission towers : _____ Metres
8. DETAILS OF IRRIGATION / HYDEL PROJECTS:

i) Total catchment : Not applicable

ii) Total command area : -do-

iii) Full reservoir level : -do-

iv) High Flood level : -do-

v) Minimum drawal level : -do-

vi) Break up of area falling in catchment area of the project (Forest land, cultivated land, pasture land, human cultivation and others) : -do-

vii) Area of submergence at High Flood Level : -do-

viii) Area of submergence: full reservoir level : -do-

ix) Area of submergence 2 Metres below full reservoir level. : -do-

x) Area of submergence at 4 meter below full reservoir level (for medium and major projects only) : -do-

xi) Area of submergence at minimum drawal level : -do-

xii) Detailed catchment area treatment plan. : -do-

xiii) Total financial outlay and details regarding availability of funds for catchment area treatment plant. : -do-

9. DETAILS REGARDING ROAD / RAILWAYS LINES:
(Only for Roads / Railway Lines Proposals)

i) Length and width of the strip required and forest area required. : Not Applicable.

ii) Total length of the road : -do-

iii) Length of the road already constructed. : -do-

iv) Length of the road passing through the forest. : -do-
10. **DETAILS REGARDING MINING PROPOSALS:**
(Only for Mining Proposals) : 

i) Total mining lease area and forest area required. : Not applicable

ii) Period of mining lease proposed. : -do-

iii) Estimated reserve of each mineral / ore in the forest area and the non-forest area. : -do-

iv) Annual estimated production of mineral ore. : -do-

v) Nature of mining operations (Open cast / underground) : -do-

vi) Phased reclamation plan. : -do-

vii) Gradient of the area where mining would be undertaken. : -do-

viii) Copy of the lease deed (to be attached only for renewal purpose). : -do-

ix) Number of labourers to be employed. : -do-

x) Area of forest land required for:
   a) Mining
   b) Storing Mineral / Ore
   c) Dumping of overburden
   d) Storing tools & machinery
   e) Constructions, workshop, etc. : -do-
   f) Township / housing colony.
   g) Construction of road / ropeway / railway lines.
   h) Full land use plan of forest area required.

xi) Reasons why any of the activities referred to in (a) to (h) above under the project for which forest land has been asked for cannot be undertaken / located outside forest. : -do-

xii) The extent of damage likely to be caused and the number of trees effected on account of mining and related activities. : -do-
xiii) Distance of the mining area from perennial water courses, National and State Highway, National Parks, Sanctuaries and biosphere reserves: Not applicable

xiv) Procedure for stoking of the bio – spill for reuse: -do-

 xv) Extent of subsidence expected in underground mining operations and its impact on water forest and other vegetation: -do-

11. Cost benefit analysis (Required if the forest area utilized is 20 Hec. or more) :

12. Whether clearance from environment angle is required (Yes / No). If yes, whether requisite details for the same have been furnished (Yes / No): - No -

13. Whether any work in violation of the Act has been carried out(Yes / No) If Yes:
   i) Details of the same including date of commencement: ---
   ii) Officers responsible for violation of the Act: ---
   iii) The effect of the proposal on Fuel wood supply to rural: 
   iv) Whether work in violation of the Act is still in progress: ---

14. Any other information :

15. Details of certificates / documents enclosed: Annexure A to H

16. Detailed opinion of the Chief Conservator of Forest / Head of the Forest Department concerned covering the following aspects, namely:
   i) Out – turn of timber, fuel wood and other forest produce from the forest land involved: 
   ii) Whether the district is self sufficient in timber and fuel wood, and
iii) The effect of the proposal on:

a) Fuel wood supply to rural population.: 

b) Economy and livelihood of the tribals and backward communities.: 

iv) Special recommendation of the Chief Conservator of Forest / Head of the Forest Department for acceptance or otherwise of the proposal with reasons thereof.

Certified that all other alternatives for the purpose have been explored and the demand for the required area is the minimum demand for forest land.

Assistant Engineer (________)
RRVPNL, ______________.

Executive Engineer (_______) Dy. Conservator of Forest (_______)
RRVPNL, __________. Govt. of Rajasthan

__________
ANNEXURE – B

Item No. 1(iv) of the application form: Justification for locating the project in the forest area giving alternative routes and reasons for their rejection.

Scheme: Construction of ___ kV _____ Circuit Line from ____________ to ___________.

Route No.1

The scheme envisages construction of ___ kV _____ Circuit Line from ____________ to ____________. The ___ kV transmission line is to be drawn between the ___ kV GSS _______________ and ___ kV GSS _______________.

The line has to compulsorily cross the forest area in its route alignment between ____________ and ____________.

There is no alternative route available for this transmission line since the crossing of the ______________ Reserve / Protected / Unclassified / ____________ forest block cannot be avoided.

The route of the proposed ___ kV _____ Circuit Line from ____________ to ____________ passes through the ______________ Reserve / Protected / Unclassified / ____________ forest block having _______ density of trees.

The line is passing through the _____ KM. of the ______________ Reserve / Protected / Unclassified / ____________ forest block between ____________ & ____________.

Therefore, this being the only route available, it is the most advantageous and feasible route and has been accordingly selected for the transmission line.

Assistant Engineer (_______)
RRVPN, ______________.

Executive Engineer (_______)                      Dy. Conservator of Forest (______)
RRVPN, __________.                             Govt. of Rajasthan

_________________________
ANNEXURE – C

CERTIFICATE IN REFERENCE TO ITEM – 6 (V) OF THE APPLICATION FORM:

It is certified that 2 × ____ Hec. degraded forest area of __________________________ (Double of Forest Area required for the construction of the line) identified for raising compensatory afforestation is suitable from the point of view of plantation and management. This is with reference to conveying of approval by the Central Government under Forest (Conservation) Act, 1980 for construction of ___ kV ______ Circuit Line from __________ to __________ in ____ Hec. forest land of Reserve / Protected / Unclassified / __________ forest block under ____ Division, ________.

Assistant Engineer (_______)
RRVPN, ________________.

Executive Engineer (_______)                      Dy. Conservator of Forest (_______)
RRVPN, ____________                      Govt. of Rajasthan

________
ANNEXURE – D

ITEMWISE BREAK UP OF THE TOTAL LAND REQUIRED FOR THE PROJECT / SCHEME

____ kV ______ Circuit Line from ____________ to ____________

Reserve / Protected / Unclassified / ____________ forest block under _____ Division, ________.

i) Length of line in the Forest Area : _____ KM

ii) Width of Right of way : _____ KM

iii) Forest Land required : (i) × (ii) = _____ Hectares.

iv) a) Forest land required for foundation of towers. : _____ Hectares

b) Forest Land required for Foundation of ___ Nos. Tower. : _____ Hectares

TOTAL FOREST Area

i) Length of line in Forest Area : _____ KM

ii) Width of Right of way : _____ KM

iii) Forest Land Required for Right of way. : _____ Hectares

iv) Forest Land required for Foundation of ___ Nos. Towers. : _____ Hectares

Assistant Engineer (_______)                     Executive Engineer (_______)
RRVPNRL, ______________.                       RRVPNRL, __________.
ANNEXURE – E

CERTIFICATE

The Rajasthan Rajya Vidyut Prasaran Nigam Ltd. is ready to make admissible payment for compensation, if it would be required, against compensatory afforestation in accordance with the Forest (Conservation) Act, 1980 and guidelines and circulars issued from time to time for construction of ___ kV ______ Circuit Line from ___________ to ___________ in the Reserve / Protected / Unclassified / ___________ forest block under _____ Division, _________.

Assistant Engineer (_______)                          Executive Engineer (_______)
RRVPN, ______________.                                       RRVPN, ____________.
ANNEXURE – F

DETAILS OF THE FOREST LAND INVOLVED AS PER REVENUE RECORDS

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Khasra No.</th>
<th>Type of land</th>
</tr>
</thead>
</table>

Village :  
Tehsil :  
District :  
Scheme : ___ kV ______ Circuit Line from ____________ to ____________

Assistant Engineer (________)  
RRVPNL, ______________.

Executive Engineer (________)  
RRVPNL, ____________.

Dy. Conservator of Forest (______)  
Govt. of Rajasthan
ANNEXURE – H

Item No. 6 (iii) of the Application Form:

Detailed compensatory afforestation scheme including species to be planted, implementing agency, time schedule, cost structure, etc.

Scheme: Construction of ___ kV ______ Circuit Line from ____________ to ___________.

1. Details of degraded forest area identified for compensatory afforestation, viz., location, area, etc. :

2. Details of species to be planted. :

3. Name of implementing agency :

4. Time schedule :

5. Cost structure :

6. Any other information of significance to the afforestation scheme. :

Dy. Conservator of Forest (______)  
Govt. of Rajasthan,  
______________
APPENDIX – D

QUESTIONNAIRE FOR CROSSING OF RAILWAY TRACKS
BY OVERHEAD TRANSMISSION LINE

1. Situation of the crossing, its distance from the Nearest Rly. Station and the distance from Telegraph posts on either side of the crossing indicating numbers marked on the telegraph posts.

___ kV ______ Circuit Transmission line over head crossing between ________ & ________. Rly. Stations, at _____ Km from ________ Rly. Station and _____ KM from ________ Rly. Station, between TP No. ___ / ____ & ___ / ___. at a distance of _____ M from TP No. ___ / ____ and at ______ M from TP ___ / ___. The crossing is outside the Railway Station limit.

2. Site plan showing location of crossing (with Rly. Boundary in reference to Rly. mileage and telegraph posts (to be supplied in quadruplicate).

Drg. No. _________________________ dt. __________ enclosed.

The transmission line is crossing the Railway track at an angle of ___° as indicated in the enclosed drawing.

3. Does the Transmission line cross the Rly. Track at Right angle? If not, illustrate the angle by means of a sketch. A minimum crossing angle of 60° between the track and overhead line may be permitted only as special case.

The transmission line is crossing the Railway track at an angle of ___° as indicated in the enclosed drawing.

4. The length of the span at the crossing and also those on either side of the crossing.

Crossing span: ______ M.
Span towards ______________ = ____ M
Span towards ______________ = ____ M
as indicated in the enclosed site plan.

5. In the event of transmission line deviating on any of the supports of the crossing necessitating one of the structures to be a corner structure, state angle of such deviation.

The towers are suitable for taking load on the above respective angles.

i) Conductor ACSR “_________”.
   Size: ___ / _____ mm Al + ___ / ____ mm steel.

ii) Earth wire: 7 / ____ mm dia., 110 Kg / sq. mm quality galvanised steel stranded wire.

Disposition is as per tower sketch in the enclosed drawing.

No Guard wires are required to be provided.

6. The No., size and material of the conductors & wires crossing the tracks.

Each wire under Phase, Neutral, earth, guard, bearer & guard cross wire should be separately described and their dispositions indicated by means of sketch.

7. Indicate whether the proposed guard is to be restricted to the crossing span or is to be continued over the adjacent span.

8. i) The deviation of the span on either sides of the crossing shall be illustrated in the sketch mentioned in clause 3 above.
   ii) System of supply, line voltage, Frequency, No. of phases, whether Neutral is earthed or not.

9. Height of structures above ground and below ground & give details of foundations.

Type of tower    Height above ground    Depth below ground
i) ______        _______ M          _______ M
ii) ______        _______ M          _______ M

Details of Foundations are given in the enclosed drawing.
Approvals & Clearances for the Line Route

10 Height above Ground level of:
   i) Lowest conductor on insulator &
   ii) Guard bearer wire on brackets.

11 Height of Rail level above ground level measured at the foot of structure.

12 To what limits (Minimum & Maximum) will sag on copper and steel wires on the crossing be maintained.

13 Clearances under maximum sag conditions between Rail level & the lowest line conductor, and between Rail level & lowest guard wire (State of which type guarding is provided in the case of adoption of unearthed neutral system.

14 Ultimate Tensile Stress of the steel wire used for Ground for guard or on earth wire.

15 Approximate distance of each of the structures to the nearest Rail of track measured at right angle to the track.

16 Distance of the nearest line conductor to any Railway structures under the maximum deflection (This clearance should not be less than 15 ft. unless clearance of the Electrical Inspector to Govt. / Chief Electrical Engineer of the Railway is obtained.)

17 Are the proposed structures in Railway boundary (i) Outside station limits, ii) Inside station limits? And this may be indicated in the Drawing.

18 Are approved anticlimbing devices and warning notice fitted within Rly. Boundary (Required only when voltage exceeds 650 volts).

19 State the Tensile strength and Dimensions of the steel used for construction of each member of the supporting structure, is to be noted, must be approved design in conformity with the I. S. code of practice for use of structure steel in General building constructions (IS : 800 - 1956).

20 Dimensions & type of brackets used for cross arms as well as for the guard wire.
21 To facilitate checking of the design of the structure, state the Data assumed for the following and also furnish complete Design calculations for the supporting structures, including foundations thereof:

a) Wind load in kg / sq. cm.
b) Wind load on conductors, guards, etc. on the crossing span.
c) Wind load in conductors, guard, etc. on the adjacent spans
d) Wind load on structures
e) Unbalanced pull due to guard wire.
f) Unbalanced pull due to guard wire.
g) Total load on each structure due to (b), (c) and (f) above.
h) Total load on each structures due to (b) above.

22 Is each structure of the crossing span independently earthed by means of earth plate?

Structures are solidly earthed by earth pipe independently.

23 Is each structure supported by the guys in 3 directions? Give the size of guy wires (the effect of the pull by guys will be neglected in calculating the strength of structures).

Guys are not required as each structure is self supporting.

24 If no guard is provided, is the transmission line protected by a device to ensure instantaneous interruption in the case breakage of any conductor occurs? Give details.

The system is protected by means of circuit breakers & quick and fast acting relays which ensure instantaneous isolation.

25 With the arrangement referred to in item 24 above, are the insulators in duplicate and straddled / bridled as required by the regulations.

Double Tension insulator string facing Railway tracks. It is certified that each Insulator string will have one additional Insulator than its number used on Normal span.

Disc Type insulator strings have been used.

26 Type of Insulator used.

27 State the method of maintenance to ensure the following protections.

i) From over hanging or decaying trees which might fall on the line.
ii) To reduce the hazard to life and property.
iii) Supporting structures including guys from the danger of being struck by the moving road vehicle.
iv) Interference with Rly. Communication lines & those erected by the Indian P&T departments.

i) Over hanging trees will be cut down.
ii) Anti – climbing devices & danger plates provided on each tower.
iii) The structures are located at safe positions and no road is near enough the structure so that moving vehicles can be expected to come & strike the structures.
iv) Interference is negligible due to large crossing angle.

28 Drawing showing details of crossing, disturbance to Rly. Road, ground for attachment that may be necessary (to be supplied in quadruplicate)

Drawing enclosed.
29 Whether the proposals confirm to the regulations governing the placing of over head Electric transmission line & under ground cables across Rly. Tracks publications Nos. P.B. 119 (n) 560 revised. If not, specify the deviations therefrom.

Yes

30 Additional remarks, if any.

Assistant Engineer (_______)  Executive Engineer (_______)
RVPN, ___________.  RVPN, ___________.
QUESTIONNAIRE UNDER RULE 63 OF INDIAN ELECTRICITY RULES, 1956

1. Name of the line. ___ kV Transmission line from _______________ to ________________.
2. Length of the line. ______ KM.
3. Operating Voltage. _____ kV.
4. No. of circuits. Single / Double Circuit
5. Route of the transmission line. From ___ kV GSS _____________ to ___ kV GSS __________ passing through or near the following towns / villages / dhanies: __________, __________, __________, __________, __________, __________, __________, __________, __________, __________, __________, __________, __________, __________.
6. Type & height of poles. Lattice type steel fabricated transmission line towers. Height of lowest conductor above ground level: ______ metres.
7. Type of cross arms. Lattice type steel fabricated.
8. Type of insulators used. Long Rod insulators / Strings of 11 kV B & S type disc insulators of ___ KN and ___ KN EMS for suspension & tension respectively. String consisting of:
   Suspension Tension
   Nos. Nos.
9. Type and size of line conductor and earth wire used. a) ACSR Conductor:
   Name Aluminium Steel
   __ / ____ mm __ / ____ mm
   b) Earth wire:
   __ / ____ mm GSS wire
10. Number of crossings, viz., railway line, P&T Line & canal, etc. a) Railway crossing: ____ nos. b) P&T line crossing: ____ nos. c) Canals: ____ nos.
11. Average soil resistivity of the region. ______ ohm metres.
12. Details of minimum clearances above the ground level. ______ metres.
13. Number of earth electrodes provided for earthing of the line. Towers have been earthed individually.
14. Drawing of transmission line and towers showing method of construction. Route map of line and sketch of towers used are enclosed.
15. Actual date of completion of works _______

Encl: As above
(i) Route map of line
(ii) Sketch of line towers

Assistant Engineer (__________)  Executive Engineer (__________)
RVPN, ____________  RVPN, _______________.
SECTION – II

CONSTRUCTION ACTIVITIES
1.0 **DETAILED SURVEY:**

1.1 The detailed survey is taken up on the line route approved by the Circle Superintending Engineer.

1.2 The line route worked out during the preliminary survey, with changes if any, is used as the reference.

1.3 The measurements of the angle points are again done. These angles are indicated as Right (R) or Left (L) as per the direction of deviation with reference to the starting point.

1.4 The levels of the ground profile along the route of the line are taken. The reduced level (R.L.) of the ground at the starting point of the line is taken as 100.00 metres. The levels are generally taken at intervals of 30 metres along plain and evenly sloping ground. The levels are taken at shorter intervals wherever there are sudden changes in the ground profile. All the levels are calculated with reference to the assumed R.L. The levels of high hillsides or sand dunes on the sides of the line route are also taken so that horizontal and vertical clearance of the conductors from these can be checked.

1.5 The method of taking level readings for preparation of longitudinal and cross section profile can be

   a) By chain and dumpy level.
      This method is generally used in all plain areas where chaining offers no problems.
      This also requires comparatively less skilled surveyors.

   b) By tachometric survey with theodolite.
      The tachometric method is employed in hilly regions and such other inaccessible places where chaining is not possible. This method needs skilled surveyors having good understanding of the use of theodolite.
      In this method, both traversing and levelling is done by means of a tachometric theodolite (theodolite having stadia cross hairs fitted in the eye piece). The horizontal and vertical distances are computed with the help of readings of the stadia wires taken on the levelling staff held at the reading station. For the theory of this method, reference may be made to any standard surveying text books.

1.6 Details of all crossings of kutcha and metalled roads, canals, rivers, forest area, ponds, railway lines, P&T lines and power lines along the line route shall be noted. The height above ground of the earthwire (in case of overhead crossing) and the lowest conductor (in case of crossing under existing lines) of the lines being crossed should be measured at a distance from the centre line of the route which is equal to the distance between the centre line of the tower and the end of the lower cross arm.

1.7 Places along the line route where towers cannot be located due to poor or bad ground conditions, such as low lying areas, marshy areas, highly sloping areas, etc. should also be noted.

1.8 All kutcha and metalled roads, trees, structures, buildings, huts, sheds, canals, wells, rivers, forest area, railway lines, P&T lines, power lines, ponds, hillsides, high sand dunes and other objects, etc. within 50 metres on both sides of line route should be noted.
1.9 Wherever there are changes in the route surveyed earlier, the concrete pillars placed during the preliminary survey shall be relocated. Similarly, the wooden pegs placed in the preliminary should be removed from their earlier positions wherever there are changes.

1.10 All readings of levels and observations are noted in the field book(s).

2.0 PLOTTING OF PROFILES:

2.1 From the field book entries, route plan and longitudinal profile, commonly referred to as ‘Route Profile’ or simply ‘Profile’, is prepared. The profile is prepared and plotted on 1mm / 5mm / 1cm square paper rolls of graphed tracing paper. The profile is plotted to a scale of 1 cm = 20 M horizontal and 1 cm = 2 M vertical.

2.2 The profile shall progress from left to right. The height of the sheet shall be taken so that the ground profile and the towers, including extensions can be fully shown. For hilly terrain, greater height of the sheet may be taken, or the sections may be plotted on separate sheets.

2.3 The length of each sheet may be taken so that approximately 5 km of the line route can be plotted. A gap of 5 to 10 cm shall be kept between sections.

2.4 The profile shall show the longitudinal profiles along the centre line of the transmission line route and also the cross section profile wherever appreciable difference in level exists with reference to the centre line level.

2.5 The angle of line deviation, duly marked left (L) or right (R) as the case may be, shall also be shown.

2.6 The profile shall show the route plan giving details of all objects lying within 50 metres on both sides of the centre line of the route.

2.7 Objects and their distances along the route within 50 metres on both sides of the centre line, nearby villages, important roads or rivers shall be marked on the route profile.

2.8 Crossing details of any other power or telecommunication lines, roads, railway lines, canals or rivers shall be marked as clearly as possible.

2.9 Readings shall be taken of the levels of roads, canal and river embankments, maximum water / flood levels, railway top levels and heights of supports / lines being crossed, and shall be shown in the offsets part of the profile. All trees coming within the zone of the right of way and which need to be cut / trimmed shall also be indicated.

2.10 A typical profile is enclosed at Appendix – A.
CHAPTER – 2
TOWER SPOTTING AND TOWER SCHEDULE

1.0 SAG TEMPLATE:
1.1 A Sag Template is a very important tool with the help of which the position of towers on the Profile is decided so that they conform to the limitations of vertical and wind loads on any particular tower, and minimum clearances, as per I.E. Rules, required to be maintained between the line conductor to ground, telephone lines, buildings, streets, navigable canals, power lines, or any other object coming under or near the line.

1.2 A Sag Template is specific for the particular line voltage, the conductor used and the applicable design conditions. Therefore, the correct applicable Sag Template should be used.

1.3 A Sag Template consists of a set of parabolic curves drawn on a transparent celluloid or acrylic clear sheet duly cut in over the maximum conductor sag curve to allow the conductor curve to be drawn and the lowest points of the conductor sag to be marked on the profile when the profile is placed underneath it.

1.4 A typical calculation sheet for a sag template is enclosed at Appendix – A.

1.5 The set of curves in the sag template consists of:
   a) ‘Cold or Uplift Curve’ showing sag of conductor at minimum temperature (minus 2.5°C) and still wind.
   b) ‘Hot or Maximum Sag Curve’ showing maximum sag of conductor at maximum temperature and still wind including sag tolerances allowed (normally 4%), if any, and under maximum ice condition wherever applicable.
   c) ‘Ground Clearance Curve’ which is drawn parallel to the ‘Hot or Maximum Sag Curve’ and at a distance equal to the specified minimum ground clearance for the relevant voltage.
   d) ‘Tower Footing Curve’ which is drawn parallel to the ‘Ground Clearance Curve’ and separated by a minimum distance equal to the maximum sag at the basic design span.

1.6 The Sag Template is plotted to the same scale as the profile, i.e., 1 cm = 20 M horizontal and 1 cm = 2 M vertical. It is generally plotted for spans up to 1000 metres. This is necessary for tower spotting when there are large variations in the ground levels along the line route.

1.7 A typical ‘Sag Template’ drawing is shown in Appendix – B.

2.0 TOWER SPOTTING:
2.1 The Sag Template is applied to the profile by moving the same horizontally while always ensuring that the vertical axis is held vertical, i.e., in line with the vertical lines on the profile sheet.

2.2 The following clearances shall be provided between the lowest conductor of the line and the ground as per Rule 77 of the Indian Electricity Rules, 1956.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nominal System Voltage</th>
<th>Minimum Ground Clearance (Metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>132 kV</td>
<td>6.10</td>
</tr>
<tr>
<td>2.</td>
<td>220 kV</td>
<td>7.00</td>
</tr>
<tr>
<td>3.</td>
<td>400 kV</td>
<td>8.84</td>
</tr>
<tr>
<td>4.</td>
<td>800 kV</td>
<td>12.40</td>
</tr>
</tbody>
</table>
2.3 The left hand side of the tower footing curve is placed at the starting point of each section. Initially, the template is shifted to the right, ensuring at all times that the tower footing curve is touching the starting point, to a position where the ground clearance curve is just above the ground profile, i.e., the ground clearance curve should not touch or cross the ground line plotted on the profile. The second tower location is then marked at the point where the tower footing curve on the right hand side cuts the ground profile.

2.4 The second tower location is then used as the reference and the third tower location is marked in a similar manner as above. This is continued till the end of the section is reached.

2.5 It may be possible that a very short or very long span remains at the end of the section. In such cases, depending on the economics of the options, the span can be distributed evenly or other spans in the section can be increased (not normally exceeding the basic span) by using tower extensions wherever possible.

2.6 The ground clearance curve shall not only clear the route centre line profile but also the profile to the left or right of the centre line up to a distance equal to maximum cross arm spread on either side.

2.7 Besides normal ground clearance, the clearance between power conductor and objects like other power or telecommunication lines, houses, trolley wires, roads, railway tracks, canal embankments etc., is also to be checked. In these cases, the clearance of the conductor from these objects is to be maintained.

2.8 The requisite or extra clearance can be obtained either by reducing the span or providing extension to tower body depending on which alternative is most economical. Normally, 3 metre & 6 metre extensions are available for towers upto 220 kV. 220 kV Special Towers with 4.5 metre, 9 metre & 18 metre extensions designed for long spans are also available. 3 metre, 6 metre, 9 metre, 18 metre & 25 metre extensions are available for 400 kV towers.

2.9 The tower locations with extensions or towers with additional heights are marked on the ground profile at that point of the tower footing curve which is at a height equal to the tower extension or the difference in height with reference to the height of the bottom cross arm of the special tower (with extension, if provided) above the ground profile. This point above the ground profile is used as the reference / initial point for the tower footing curve when spotting the next tower location.

2.10 When a tower location with extension or a tower with additional height is to be marked on the ground profile, then a point is marked at that location on the ground profile which is at a height equal to the tower extension or the difference in height with reference to the height of the bottom cross arm of the special tower (with extension, if provided). This point above the ground profile is used as the reference point for the tower footing curve.

2.11 A figure showing the application of a sag template on the profile is given at Appendix – C.

2.12 In spans where towers are located at different ground levels, the lowest point of the conductor sag may be outside the span. This is termed as an “Uplift” condition. This indicates that the total weight of conductor is taken up by the tower at the higher ground level and the tower at the lower ground level is being pulled up by a force equal to the weight of conductor between the lower support and the lowest point of the conductor sag. If the upward pull of the uphill span becomes greater than the downward load of the next adjacent span, actual uplift will be caused and the conductor would tend to swing clear upwards of the tower. The suspension towers cannot be used under uplift conditions. This type of condition can be resolved by providing extensions to the suspension tower at the lower level or by using a B – type tower designed for uplift conditions.
2.13 The intermediate spans in a section should preferably be as near as possible to the basic design span. In case any individual span becomes too short on account of undulations in ground profiles, one or more line supports of the section, wherever possible, may be extended by inserting standard body extensions to increase the span length.

2.14 While crossing over existing power lines, one of the towers of the crossing span of the new line is preferably located near the existing power line for taking advantage of the higher height of the conductors near the tower. This reduces the necessity of increasing the height of the towers of the new line for obtaining the requisite clearance. Double suspension / tension insulator strings, depending on the type of the towers, are to be used in the new line on such crossings.

2.15 While crossing below existing power lines of higher voltage, both the adequate ground clearance for the new line and the specified clearance of the new line from the existing power line shall be ensured. This can be achieved by using towers / structures of lesser height or by using sub station structures (if there is no right of way problem) in the new line. Alternatively, the height of the existing power line can be increased by providing tower extensions. Double suspension / tension insulator strings, depending on the type of the towers, are to be provided on the existing power line at such crossings.

2.16 The length of double suspension insulator strings is more than that of single suspension strings because of the yoke plates provided in them. Therefore, when double suspension insulator strings are used, additional ground clearance shall be provided when spotting towers so that the specified ground clearance is available after stringing.

2.17 The following clearances shall be provided between the lowest conductor of the line crossing over another line and the top most conductor / earth wire of the line crossing underneath as per Rule 87 of the Indian Electricity Rules, 1956.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nominal System Voltage</th>
<th>132 kV</th>
<th>220 kV</th>
<th>400 kV</th>
<th>800 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Low &amp; Medium</td>
<td>3.05</td>
<td>4.58</td>
<td>5.49</td>
<td>7.94</td>
</tr>
<tr>
<td>2.</td>
<td>11 – 66 kV</td>
<td>3.05</td>
<td>4.58</td>
<td>5.49</td>
<td>7.94</td>
</tr>
<tr>
<td>3.</td>
<td>132 kV</td>
<td>3.05</td>
<td>4.58</td>
<td>5.49</td>
<td>7.94</td>
</tr>
<tr>
<td>4.</td>
<td>220 kV</td>
<td>4.58</td>
<td>4.58</td>
<td>5.49</td>
<td>7.94</td>
</tr>
<tr>
<td>5.</td>
<td>400 kV</td>
<td>5.49</td>
<td>5.49</td>
<td>5.49</td>
<td>7.94</td>
</tr>
<tr>
<td>6.</td>
<td>800 kV</td>
<td>7.94</td>
<td>7.94</td>
<td>7.94</td>
<td>7.94</td>
</tr>
</tbody>
</table>

2.18 The minimum clearances required as per Rule 80 of the Indian Electricity Rules, 1956 shall be maintained, according to the voltage of the lower line, from the conductors of the line passing near a pole / tower or any supporting structure of the second line.

2.19 For crossing of a non – navigable river, the clearance of the bottom conductor of lines upto 220 kV shall be at least 3 metres above the highest flood level (HFL). The clearance of the bottom conductor of 400 kV lines in such a case shall be reckoned with respect to the highest flood level (HFL).

2.20 For crossing of navigable rivers, the clearance as approved by the concerned navigation authorities shall be maintained.

2.21 The crossing span of National Highways and major roads shall not normally exceed 250 metres. One of the towers of the crossing span can be located near the road in order to obtain
additional clearance. It is preferable to provide an extra clearance of 3 metres in addition to the statutory clearance over National Highways and important roads for maintaining adequate clearance from over dimensional consignments (ODC) and to account for increase in road level due to subsequent carpeting. Double suspension / tension insulator strings, depending on the type of the towers, shall be used on such crossings.

2.22 The minimum height above rail level of the lowest portion of any conductor of the line under conditions of maximum sag shall be as follows as per presently prevailing provisions of the Railway Regulations. The requirements as may be prevailing at the time of erection of a line should be obtained from the Railway authorities.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Voltage</th>
<th>Broad, Metre &amp; Narrow Gauges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Above 66 kV and upto 132 kV</td>
<td>14.60 metres</td>
</tr>
<tr>
<td>2.</td>
<td>Above 132 kV and upto 220 kV</td>
<td>15.40 metres</td>
</tr>
<tr>
<td>3.</td>
<td>Above 220 kV and upto 400 kV</td>
<td>17.90 metres</td>
</tr>
<tr>
<td>4.</td>
<td>Above 400 kV and upto 500 kV</td>
<td>19.30 metres</td>
</tr>
<tr>
<td>5.</td>
<td>Above 500 kV and upto 800 kV</td>
<td>23.40 metres</td>
</tr>
</tbody>
</table>

NOTE: It is advisable to maintain an additional clearance of 3 metres over and above the minimum height while spotting towers on railway crossing spans because the desired sag cannot be achieved due to the short span and use of double tension hardware.

2.23 Double tension insulator strings with one additional disc insulator shall be used on railway track crossing spans.

3.0 CHECKING FOR TOWER LOADING:

3.1 After all the towers in the section have been located, the lowest point of the conductor sag in each span is marked with the hot curve. The cold curve is then placed on the profile between each span and the lowest point of the conductor sag is also marked.

3.2 The weight spans on the towers, under cold and hot conditions, are obtained by measuring the distance between the tower location and the lowest points of sags on both sides of a tower for each condition. The effect of weight spans of one side and effect of both sides are calculated from these values for checking the tower loading under both cold and hot conditions.

3.3 For the purpose of checking the tower loading due to wind, the wind span is taken as the “sum of adjacent spans” and compared with the tower spotting data.

3.4 The loading on the various types of towers shall not exceed the design values since each tower is designed to withstand a definite load only in each of transverse, vertical and longitudinal directions. These limits are given in a chart form called “Tower Spotting Data” which is prepared by each tower supplier. These charts define the limits for permissible individual span, weight span (effect of one side as well as both sides), wind span, and the degree of line deviation allowed on each tower.

3.5 A sample tower spotting data is enclosed at Appendix – D.

3.6 The tower spotting data for the particular type & design of towers being provided on the line should be obtained and used. The loading on the towers shall not exceed the load specified in the tower spotting data.
4.0 **TOWER SCHEDULE:**

4.1 After tower spotting has been done, a tower schedule is prepared which contains all the information such as location numbers, type of tower, span length, section length, sum of adjacent spans, weight spans (effect of one side as well as both sides) under maximum and minimum sag conditions, angle of deviations, type of hardware (suspension / tension, and single / double), and brief details of objects in, along and near the line route.

4.2 A sample tower schedule based on the Profile at Appendix – A of Chapter – 1 of this section is enclosed at Appendix – E. For the purpose of showing the manner in which the tower schedule is prepared, some assumed figures have been given for the portions of the line on both sides of the Profile which are not available in the Profile.

5.0 **BILL OF MATERIAL:**

5.1 A typical Bill of Material for a 220 kV Double Circuit line showing the items required is enclosed at Appendix – F.
**TYPICAL SAG TEMPLATE CALCULATIONS**

Conductor: ACSR “Zebra” (420 mm²)
Construction: 54 Aluminium / 7 Steel / 3.18 mm

**PARAMETERS:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Span (ℓ)</td>
<td>350 metres</td>
</tr>
<tr>
<td>Ultimate Tensile Strength of Conductor (U.T.S.)</td>
<td>13290 Kg</td>
</tr>
<tr>
<td>Overall diameter of the Conductor (d)</td>
<td>28.62 mm</td>
</tr>
<tr>
<td>Weight of the Conductor (w)</td>
<td>1.621 kg/m</td>
</tr>
<tr>
<td>Wind Pressure (P)</td>
<td>83.38 Kg/m²</td>
</tr>
<tr>
<td>Coefficient of linear Expansion (α)</td>
<td>19.3 × 10⁻⁶ per °C</td>
</tr>
<tr>
<td>Young’s Modulus of elasticity (Final) (E_f)</td>
<td>0.686 × 10⁶ Kg/cm²</td>
</tr>
<tr>
<td>Young’s Modulus of elasticity (Initial) (E_i)</td>
<td>0.4675 × 10⁶ Kg/cm²</td>
</tr>
<tr>
<td>Maximum temperature (Ambient)</td>
<td>50 °C</td>
</tr>
<tr>
<td>Maximum temperature (Conductor)</td>
<td>75 °C</td>
</tr>
<tr>
<td>Minimum Temperature (Ambient)</td>
<td>(-) 2.5 °C</td>
</tr>
<tr>
<td>Minimum Temperature (Conductor)</td>
<td>(-) 2.5 °C</td>
</tr>
<tr>
<td>Every day Temperature</td>
<td>32.2 °C</td>
</tr>
<tr>
<td>Area of Cross section of Conductor (A)</td>
<td>4.845 cm²</td>
</tr>
<tr>
<td>Factor of Safety (F.O.S.) (at 32.2 °C)</td>
<td>4</td>
</tr>
<tr>
<td>Factor of Safety (F.O.S.) (Otherwise)</td>
<td>2</td>
</tr>
<tr>
<td>Weight of Conductor per unit area (δ)</td>
<td>( \delta = \frac{w}{A} = \frac{1.621}{4.845} = 0.334571723 ) Kg/m / cm²</td>
</tr>
<tr>
<td>Minimum Ground Clearance</td>
<td>7.01 metres</td>
</tr>
</tbody>
</table>

**CONDITION: I**

Temperature = 32.2 °C
Wind = NIL
Factor of Safety = 4

Working tension; \( T_1 = \frac{U.T.S.}{F.O.S.} = \frac{13290}{4} \) Kg
\( T_1 = 3322.5 \) Kg

Working Stress; \( f_1 = \frac{T_1}{A} = \frac{3322.50}{4.845} \) Kg/cm²
\( f_1 = 685.75851 \) Kg/cm²

Loading factor; \( q_1 = \sqrt{P^2 + w^2} = 1 \) (for no wind; \( P = 0 \))

The working stress is determined by the following formula:

\[ f_1^2 (f_1 - k) = \frac{E_f^2}{24} \delta^2 q_1^2 \]

\[ k = f_1 - \frac{E_f^2}{24} \delta^2 q_1^2 \]

\[ k = 685.75851 - \frac{(350)^2 \times (0.334571723)^2 \times (1)^2 \times (0.686 \times 10^6)}{24 \times (685.75851)^2} \]

\[ k = 685.75851 - 833.46049 \]

or,
\[ k = (-) 147.70198 \]
**CONDITION: II**

Temperature = 75 °C

Wind = NIL

Loading factor; \( q_2 = \sqrt{\frac{P^2 + w^2}{w}} = 1 \) (for no wind; \( P = 0 \))

Difference of temperature; \( t = 75 - 32.2 = 42.8 \) °C

The working stress is determined by the following formula:

\[
f_2^2 \left[ f_2 - (k - \alpha t E_f) \right] = \frac{f^2 \delta q^2 E_f}{24}
\]

\[
f_2^2 \left[ f_2 - \{-147.70198 - (19.3 \times 10^{-6}) \times 42.8 \times (0.686 \times 10^6)\}\right] = \frac{(350)^2 \times (0.334571723)^2 \times (1)^2 \times (0.686 \times 10^6)}{24}
\]

\[
f_2^2 (f_2 + 714.36542) = 3.919470757 \times 10^8
\]

∴ \( f_2 = 555.553321 \) Kg / cm²

Working tension; \( T_2 = f_2 \times A \)

\[= 555.553321 \times 4.845 \]

\[= 2691.656 \text{ Kg / cm}^2 \]

Maximum Sag; \( s = \frac{f^2 \delta q^2}{8 \times f_2} \)

\[= \frac{(350)^2 \times (0.334571723) \times (1)}{8 \times 555.553321} \]

\[= 9.22 \text{ metres} \]

**CONDITION: III**

Temperature = (-) 2.5 °C

Wind = NIL

Loading factor; \( q_3 = \sqrt{\frac{P^2 + w^2}{w}} = 1 \) (for no wind; \( P = 0 \))

Difference of temperature; \( t = -2.5 - 32.2 = -34.7 \) °C

The working stress is determined by the following formula:

\[
f_3^2 \left[ f_3 - (k - \alpha t E_f) \right] = \frac{f^2 \delta q^2 E_f}{24}
\]

\[
f_3^2 \left[ f_3 - \{-147.70198 - (19.3 \times 10^{-6}) \times (-34.7) \times (0.686 \times 10^6)\}\right] = \frac{(350)^2 \times (0.334571723)^2 \times (1)^2 \times (0.686 \times 10^6)}{24}
\]

\[
f_3^2 (f_3 + 311.71908) = 3.919470757 \times 10^8
\]

∴ \( f_3 = 851.8511701 \) Kg / cm²
Working tension; \( T_3 = f_3 \times A \)
\[
= 851.8511701 \times 4.845 \\
= 4127.219 \text{ Kg/cm}^2
\]

∴ Factor of Safety \( = \frac{13290}{4127.2} = 3.22 \), hence O. K.

Maximum Sag; \( s = \frac{\ell^2 \delta q_3}{8 \times f_3} \)
\[
= \frac{(350)^2 \times (0.334571723) \times (1)}{8 \times 851.8511701} \\
= 6.01 \text{ metres.}
\]

The sag of different spans is calculated by the following formula:

\[
\text{Sag at any Span} = \text{Sag at Basic Span} \times \frac{(\text{Span Length})^2}{(\text{Basic Span})^2}
\]

The sags for spans ranging from 20 metres to 1000 metres are calculated separately for maximum and minimum temperature conditions. The sag curves are then plotted on a transparent graph paper with the same scale as used for plotting the profile, i.e., 1 cm = 20 metres for span length (horizontal) and 1 cm = 2 metres for sag (vertical).
### SAG TEMPLATE CURVE FOR 400 KV LINE

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>CONDUCTOR PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC SPAN: 400 MTR.</td>
<td></td>
</tr>
<tr>
<td>GROUND CLEARANCE: 0.94 M</td>
<td>1. HANG: NO.</td>
</tr>
<tr>
<td>MAXIMUM SAG: 12.862 M</td>
<td>2. DIA: 53.73 MM.</td>
</tr>
<tr>
<td>TEMPERATURE RANGE: (2.5°C)(32°F)(73°F)</td>
<td>3. WEIGHT: 2.064 Kgf/MM</td>
</tr>
<tr>
<td>CONDITION OF AIR: STILL</td>
<td>4. AREA: 397.050, MM.</td>
</tr>
<tr>
<td></td>
<td>5. UTS: 10434 Kgf.</td>
</tr>
</tbody>
</table>

---

**Notes:**
- *GROUND CLEARANCE: 8.84 M
- SAG ERROR: 0.15 M
- SAND DUNES CLEAR: 1.00 M
- TOTAL: 9.99 M
1 represents cold template or uplift curve
2 represents hot template or maximum sag curve
3 represents ground clearance curve
4 represents tower footing curve
IMRT Central Line represents Right Offset Level
IMLT Central Line represents Left Offset Level

APPLICATION OF SAG TEMPLATE ON PROFILE
### TOWER SPOTTING DATA

**220 KV D/C TRANSMISSION LINES**

**Normal Span** = 350 Metres.

**Conductor** : ACSR “ZEBRA”; **Earth wire** : 7 / 4.00mm (GSS)

All Spans in Metres

<table>
<thead>
<tr>
<th>TOWER TYPE</th>
<th>Suspension Type “A”</th>
<th>Angle Type “B”</th>
<th>Angle Type “C”</th>
<th>Angle Type “D”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Broken wire condition</td>
<td>GW, Or Any One Conductor</td>
<td>GW + One, Or Any Two Conductors</td>
<td>GW + One, Or Any Two Conductors</td>
<td>GW + Two, Or Any Three Conductors</td>
</tr>
<tr>
<td>2 Deviation not to exceed</td>
<td>2°</td>
<td>15°</td>
<td>30°</td>
<td>60°</td>
</tr>
<tr>
<td>3 Vertical load of individual span</td>
<td>Not to act Upwards</td>
<td>Up or Down</td>
<td>Up or Down</td>
<td>Up or Down</td>
</tr>
<tr>
<td>4 Individual Span not greater than (From vertical separation consideration)</td>
<td>514</td>
<td>537</td>
<td>565</td>
<td>627</td>
</tr>
<tr>
<td>5 Vertical load limitations (Metres) Max. Weight span</td>
<td>A</td>
<td>Effect of Groundwire: Both spans 525 525 525 525 Effect of Conductor: Both spans 315 315 315 315 Min. Weight span Groundwire: Both spans 228 (-) 228 (-) 228 (-) 228 Effect of Conductor: Both spans 137 (-) 137 (-) 137 (-) 137</td>
<td>B</td>
<td>Effect of Groundwire: Both spans 2º 805 15º 805 30º 805 60º 805 805 Effect of Conductor: Both spans 1º 852 14º 890 29º 892 59º 880 880 0º 896 13º 982 28º 978 58º 956 956 12º 1068 27º 1064 57º 1038 1038 56º 1116 1116 55º 1196 1196</td>
</tr>
<tr>
<td>6 Permissible sum of adjacent spans for various deviation angles a) Provided ground clearance is available</td>
<td>2º 805 15º 805 30º 805 60º 805 805</td>
<td>1º 852 14º 890 29º 892 59º 880 880</td>
<td>0º 896 13º 982 28º 978 58º 956 956</td>
<td>12º 1068 27º 1064 57º 1038 1038</td>
</tr>
<tr>
<td>7 Design longitudinal tension (kg) (32.2°C + F.W.) / (-2.5°C + 2/3 Wind)</td>
<td>Ground Wire 2190 / 2386 2171 / 2366 2115 / 2305 1896 / 2066 2066</td>
<td>Conductor 1974 / 2214 3915 / 4390 3815 / 4277 3420 / 3835 3835</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SAGS AND TENSIONS

1. Max. Tension at (-) 2.5 deg. C with 2/3 of full wind (Kgs.) 4423 2390
2. Sag at (-) 2.5 deg. C and still air (Metres) 6.024 5.421
<table>
<thead>
<tr>
<th></th>
<th>Conductor</th>
<th>Earthwire</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Tension at 32 deg. C and still air (Kgs.)</td>
<td>3323</td>
<td>1660</td>
</tr>
<tr>
<td>4. Tension at 32 deg. C and full wind (Kgs.)</td>
<td>3952</td>
<td>2220</td>
</tr>
<tr>
<td>5. Max. sag at 75 deg. C and still air in case of conductor, and 65 deg. C and still air case of earth wire(without creep) (Metres)</td>
<td>9.205</td>
<td>7.213</td>
</tr>
<tr>
<td>6. -----do----- (with 2%creep in case of conductor only) (Metres)</td>
<td>9.420</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** The above data is valid only for a particular design of towers and is shown as a sample. The specific data for the type of towers being provided on the line is to be used.
<table>
<thead>
<tr>
<th>LOC. NO. &amp; TYPE</th>
<th>SPAN IN METERS</th>
<th>SUM OF ADJ. SPANS</th>
<th>SECTION / LINE LENGTH</th>
<th>WEIGHT SPAN (HOT): MAX. TEMP. IN</th>
<th>OUT</th>
<th>TOTAL</th>
<th>WEIGHT SPAN (COLD): MIN. TEMP. IN</th>
<th>OUT</th>
<th>TOTAL</th>
<th>ANGLE OF DEVIATION</th>
<th>TYPE OF STRING</th>
<th>REMARKS / OFFSETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gantry</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 D (DE)</td>
<td>265</td>
<td>315</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 A</td>
<td>284</td>
<td>549</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 C (AP 1)</td>
<td>292</td>
<td>576</td>
<td>549</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 A</td>
<td>272</td>
<td>564</td>
<td>292</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 C (AP2)</td>
<td>272</td>
<td>544</td>
<td>564</td>
<td>117</td>
<td>117</td>
<td>234</td>
<td>101</td>
<td>101</td>
<td>202</td>
<td>22° 15' R</td>
<td>ST / ST</td>
<td></td>
</tr>
<tr>
<td>6 A</td>
<td>320</td>
<td>622</td>
<td>272</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 A</td>
<td>311</td>
<td>677</td>
<td>622</td>
<td>175</td>
<td>218</td>
<td>393</td>
<td>175</td>
<td>233</td>
<td>408</td>
<td></td>
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</tr>
<tr>
<td>8 A</td>
<td>311</td>
<td>638</td>
<td>949</td>
<td>109</td>
<td>163</td>
<td>272</td>
<td>94</td>
<td>171</td>
<td>265</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 A</td>
<td>311</td>
<td>622</td>
<td>1260</td>
<td>148</td>
<td>159</td>
<td>307</td>
<td>140</td>
<td>163</td>
<td>303</td>
<td>11 kV line height 5.2 M</td>
<td>DS</td>
<td></td>
</tr>
<tr>
<td>10 C (AP 3)</td>
<td>296</td>
<td>607</td>
<td>1571</td>
<td>152</td>
<td>148</td>
<td>300</td>
<td>148</td>
<td>148</td>
<td>296</td>
<td>27° 55' L</td>
<td>DT / ST</td>
<td></td>
</tr>
<tr>
<td>11 A</td>
<td>296</td>
<td>592</td>
<td>296</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Figures given in brackets in column for section / line length denote the total line length upto the angle tower.
## TYPICAL BILL OF MATERIAL FOR THE CONSTRUCTION OF
### 220 KV DOUBLE CIRCUIT LINE

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>220 kV D/C Tower with stub and cleats</td>
</tr>
<tr>
<td></td>
<td>i. ‘A’ type</td>
</tr>
<tr>
<td></td>
<td>ii. ‘B’ type</td>
</tr>
<tr>
<td></td>
<td>iii. ‘C’ type</td>
</tr>
<tr>
<td></td>
<td>iv. ‘D’ type</td>
</tr>
<tr>
<td>2.</td>
<td>+ 3.0 Mtr. Extension for 220 kV D/C Tower</td>
</tr>
<tr>
<td></td>
<td>i. ‘A’ type</td>
</tr>
<tr>
<td></td>
<td>ii. ‘B’ type</td>
</tr>
<tr>
<td></td>
<td>iii. ‘C’ type</td>
</tr>
<tr>
<td></td>
<td>iv. ‘D’ type</td>
</tr>
<tr>
<td>3.</td>
<td>+ 6.0 Mtr. Extension for 220 kV D/C Tower</td>
</tr>
<tr>
<td></td>
<td>i. ‘A’ type</td>
</tr>
<tr>
<td></td>
<td>ii. ‘B’ type</td>
</tr>
<tr>
<td></td>
<td>iii. ‘C’ type</td>
</tr>
<tr>
<td></td>
<td>iv. ‘D’ type</td>
</tr>
<tr>
<td>4. i.</td>
<td>220 kV D/C Special tower</td>
</tr>
<tr>
<td></td>
<td>ii. +9.0 Mtr. Extension for 220 kV D/C Special Tower</td>
</tr>
<tr>
<td>5.</td>
<td>GSS type structure</td>
</tr>
<tr>
<td></td>
<td>i. ‘AT6’ type Column</td>
</tr>
<tr>
<td></td>
<td>ii. ‘AT8’ type Column</td>
</tr>
<tr>
<td></td>
<td>iii. ‘AB’ type Beam</td>
</tr>
<tr>
<td>6.</td>
<td>Earthing Material</td>
</tr>
<tr>
<td></td>
<td>i. Pipe type earthing set</td>
</tr>
<tr>
<td></td>
<td>ii. Counter poise type earthing set</td>
</tr>
<tr>
<td></td>
<td>iii. Coke Churi</td>
</tr>
<tr>
<td>7.</td>
<td>ACSR Zebra conductor Hardware and accessories</td>
</tr>
<tr>
<td></td>
<td>i. Single tension Hardware compression type</td>
</tr>
<tr>
<td></td>
<td>ii. Double tension Hardware compression type</td>
</tr>
<tr>
<td></td>
<td>iii. Single suspension Hardware</td>
</tr>
<tr>
<td></td>
<td>iv. Double suspension Hardware</td>
</tr>
<tr>
<td></td>
<td>v. Preformed Armour Rod</td>
</tr>
<tr>
<td></td>
<td>vi. Vibration Damper</td>
</tr>
<tr>
<td></td>
<td>vii. Mid Span compression joint</td>
</tr>
<tr>
<td></td>
<td>viii. Aluminium Repair sleeve</td>
</tr>
<tr>
<td></td>
<td>xi. Jumper type suspension Hardware for single Zebra</td>
</tr>
<tr>
<td>8.</td>
<td>Disc Insulators</td>
</tr>
<tr>
<td></td>
<td>i. 120 kN Disc Insulator</td>
</tr>
<tr>
<td></td>
<td>ii. 70 kN Disc Insulator</td>
</tr>
<tr>
<td>9.</td>
<td>7 / 4.00 Earth wire Hardware and Accessories</td>
</tr>
<tr>
<td></td>
<td>i. Tension Assembly compression type</td>
</tr>
<tr>
<td></td>
<td>ii. Suspension Assembly</td>
</tr>
<tr>
<td></td>
<td>iii. Vibration Damper</td>
</tr>
<tr>
<td></td>
<td>iv. Mid Span joint</td>
</tr>
<tr>
<td></td>
<td>v. Repair sleeve</td>
</tr>
<tr>
<td></td>
<td>vi. Copper Earth bond</td>
</tr>
<tr>
<td>S. No.</td>
<td>Particulars</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>10.</td>
<td>ACSR Zebra Conductor</td>
</tr>
<tr>
<td>11.</td>
<td>7 / 4.00 mm GSS Earth wire</td>
</tr>
<tr>
<td>12.</td>
<td>GI Bolts and Nuts</td>
</tr>
<tr>
<td>i.</td>
<td>M 16 × 35 mm</td>
</tr>
<tr>
<td>ii.</td>
<td>M 16 × 40 mm</td>
</tr>
<tr>
<td>iii.</td>
<td>M 16 × 45 mm</td>
</tr>
<tr>
<td>iv.</td>
<td>M 16 × 50 mm</td>
</tr>
<tr>
<td>v.</td>
<td>M 16 × 55 mm</td>
</tr>
<tr>
<td>vi.</td>
<td>M 16 × 60 mm</td>
</tr>
<tr>
<td>vii.</td>
<td>M 16 × 65 mm</td>
</tr>
<tr>
<td>viii.</td>
<td>M 16 × 70 mm</td>
</tr>
<tr>
<td>ix.</td>
<td>M 16 × 75 mm</td>
</tr>
<tr>
<td>x.</td>
<td>M 16 × 80 mm</td>
</tr>
<tr>
<td>xi.</td>
<td>M 16 × 85 mm</td>
</tr>
<tr>
<td>xii.</td>
<td>M 16 × 175 mm Step Bolts</td>
</tr>
<tr>
<td>xiii.</td>
<td>GI spring washer, 16 × 3 mm</td>
</tr>
<tr>
<td>13.</td>
<td>Number Plates, 1 to</td>
</tr>
<tr>
<td>14.</td>
<td>Danger Plates; 220 kV</td>
</tr>
<tr>
<td>15.</td>
<td>Phase Plates (Set of three: R, Y, B)</td>
</tr>
<tr>
<td>16.</td>
<td>Circuit Plates (Set of two: I &amp; II)</td>
</tr>
</tbody>
</table>
CHAPTER – 3
CHECK SURVEY & LOCATION MARKING

1.0 CHECK SURVEY:
1.1 Check survey is carried out for the following purposes:
   a) To reconfirm the work carried out during detailed survey.
   b) To locate and peg mark the tower position on ground.
   c) To give direction pegs for excavation of tower foundation pits.

1.2 The theodolite survey is started from the known fixed angle point (the starting point of the line or any other fixed obligatory point) in the direction of given line deviation and continued up to a distance equal to the section length between the starting point and the next angle point. The wooden pegs placed during the detailed survey are checked and, if found, are used to align the route. Intermediate checks are also made by measuring offsets from the line to well defined objects shown in the profile very accurately. However, much reliance cannot be given for correct alignment based on offset distances. These objects only guide the surveyor in moving as closely on the correct alignment as possible.

1.3 If this next angle point is firmly marked in the field by means of a permanent peg mark or concrete pillar, then the closing error, with reference to the point reached during the check survey, is measured both in the longitudinal and the transverse directions. If the error is within 1% of the total section length, it can be ignored and the permanent mark made during detailed survey is taken as correct and necessary correction in the line deviation angle at the starting point is made and noted in the tower schedule.

1.4 If the second angle point reached is not marked in the field by the detailed survey gang or the mark is missing, the angle point is tentatively fixed at the place reached during check survey as per the deviation angle at the starting point and the first section length. The line alignment is continued to the next deviation angle and the next section length as per the profile. This process is continued till an angle point is reached which is found fixed in the field either by permanent pillar or by means of identification marks given in the profile.

1.5 Once a known angle point is reached then the closing error is judiciously distributed in all the previous temporary sections and all angle points are finally marked on ground by means of concrete pillars. Once the angle points are marked, correct angles of deviation and section lengths are measured and noted on the profile.

1.6 In order to help in correctly aligning all intermediate towers between two angle points, a number of alignment pegs are given during the exact distance measurement of the section lengths. The more the number of alignment pegs the better it will be for the readings as instrument errors are less if smaller distances are measured in one reading. These pegs are also very useful when main tower marking pillars are found missing at a later date (due to mischief of local people or negligence of excavation marking gang).

1.7 Any adjustment in section length, when required, is normally done in the last span of that section or in the span where very marginal clearance was kept at the time of tower spotting (if reduction in section length is required), or where enough clearance is available (if increase in section length is required).

2.0 SPOTTING AND PEG MARKING OF TOWER LOCATIONS:
2.1 Once each angle is fixed in the field with the help of permanent concrete pillars and exact section length is known and adjustments in section lengths made wherever required, the marking of all intermediate tower locations is done in the straight line joining the two angle
points. The alignment pegs given during the exact distance measurement of the section lengths are used in order to help in correctly aligning all intermediate towers between two angle points.

2.2 The tower locations are spaced at a distance equal to individual span length as given in the profile, or after the span lengths have been duly adjusted in case of closing error.

2.3 Directional peg marking is thereafter given at all tower locations for excavation pit marking. Directional pegs are essential for correct alignment of the tower centre line along longitudinal and transverse directions.

2.4 On suspension and dead end towers, the pegs are set along the centre line of route alignment and also perpendicular to it.

2.5 On angle towers, the marking of the pegs is rotated by an angle equal to half the angle of line deviation.
1.0 EXCAVATION PIT MARKING:

1.1 After the location marking has been done, the marking of the pits for excavation for the foundation of the location is carried out. This is based on the specific foundation drawing of the type and make of the tower which is to be erected at that location.

1.2 The tower legs, footings and faces are designated as shown in the drawing below.

![Diagram of tower legs, footings, and faces]

1.3 The pit marking shall be carried out according to the pit marking drawing which is prepared from the foundation drawing of the tower. The size of the pit, in case of open cut foundations, is worked out by adding 150 mm to the sides of the base pad on all the four sides for allowing working space. No margin is necessary in case of undercut foundations.

1.4 The excavation pit marking drawing indicates the distance of centres, sides and corners of the pits with reference to the centre point of the tower. These distances are measured and each pit boundary is marked in the field by means of spade or pick axe along the sides of the pit.
1.5 A typical excavation pit marking drawing is given below.

1.6 From the dimensions shown in the drawing, the triangle ABC is first marked with the help of a measuring tape. The distance CD, equal to F (width of the pit) is marked on the ground. The triangle AB'C is then marked by shifting the point B and without changing the points A and C. The distance CD', equal to F, is then marked. The sides DE and D'E, both equal to F, are then marked. The procedure is repeated for marking the other three pits.

1.7 The dimension G shown in the drawing is the centre to centre distance between stubs of the tower at their lowest point. The dimension M is the diagonal distance between the ends of the stubs of the tower. The excavation pit marking drawing is prepared on the basis of these dimensions.

1.8 Sample calculation of the volume of excavation is shown in Appendix – C.

1.9 The depth of actual excavation at the pit centre is measured with reference to the ground level at the centre of the tower location. A typical example of determining the actual depth of excavation of the pits is shown below.
2.0 **CLASSIFICATION OF SOIL:**
2.1 The different types of soils are generally classified as under.

2.2 **Normal Dry Soil:**
Normal dry cohesive soils of any colour, viz., loose murrum / sand, etc. which is readily removable with ordinary spades, pick axes and shovels.

2.3 **Hard soil / Hard murrum / Dense soil:**
Generally any soil such as stiff clay, gravel, cobble stone and black cotton soil which requires the close application of pick axes or jumpers or scrifiers to loosen it.

2.4 **Soft / disintegrated / fissured rock:**
Soil consisting of decomposed or fissured rock, hard gravel, kankar, lime stone, laterite or any other soil of similar nature.

2.5 **Hard rock:**
Soil in which chiselling, drilling or blasting is required for excavation.

2.6 **Sandy soil:**
Soil with negligible cohesion which is prone to collapsing when excavated.

3.0 **CLASSIFICATION OF FOUNDATIONS:**
3.1 The type of the foundation to be casted at any location depends upon the type of soil, sub – soil water level and the presence of surface water. While classifying foundations, the worst conditions are to be considered and not necessarily the conditions prevailing at the time of inspection. For example, there may be areas where sub – soil water rises when canal water is let out in the fields raising the sub – soil water level to a considerable degree. Similarly, the effect of monsoon or when nearby reservoirs are full is also to be considered and not the conditions prevailing in open season or summer when work is normally carried out. The classification of foundation is done as given hereunder.

3.2 **Normal Dry Foundation:**
This is used at locations where normal dry cohesive soils are met and where sub – soil water is met below the foundation base level.

3.3 **Wet Foundation:**
This is used at following kind of locations:
   a) Where sub – soil water is met at 1.5 metres or more below the ground level.
   b) Which are in surface water for long periods with water penetration not exceeding one metre below the ground level, e.g., paddy fields or sugar cane fields.
3.4 **Partially Submerged Foundation:**
This is used at locations where sub - soil water table is met between 0.75 metre and 1.50 metre below the ground level.

3.5 **Fully Submerged Foundation:**
This is used at locations where sub - soil water table is met within 0.75 metre below the ground level.

3.6 **Black Cotton Soil Foundation:**
This is used at locations where soil is clayey / expansive type, not necessarily black in colour, extending to the required depth of excavation of the pit, which shrinks when dry & swells when wet resulting in differential movement of the soil.

3.7 **Soft Rock or Fissured Rock Foundation:**
This is used at locations where decomposed or fissured rock gravel, kankar, limestone, laterite or any other soil of similar nature is met. Wet fissured rock foundation is adopted in case of fissured rock locations where water table is met at 1.5 metre or more below ground level. A separate foundation design shall be used if water level is encountered at less than 1.5 metre below ground level.

3.8 **Hard Rock Foundation:**
This is used at locations where chiselling, drilling and blasting is required for excavation of hard rock type foundations. Rock anchoring is to be provided to resist uplift forces for these locations.

3.9 **Sandy Soil Foundation:**
This is used where soil with negligible cohesion is met.

3.10 The procedure for classification of soil and foundation is as below:

a) For 400 kV lines: The classification is decided by the Design Wing on the basis of soil investigation got carried out through Bore Holes at suspension locations and Standard Penetration Test (SPT) at angle locations.

b) For 132 kV & 220 kV lines: The classification is decided by the Field Engineers on the basis of soil encountered after excavation of the pits.

4.0 **EXCAVATION OF TOWER FOUNDATION PITS:**

4.1 While excavating, the earth is cut vertically / tapered / in steps as per the soil conditions at site to avoid any kind of mishap caused by collapsing of the pit sides during the course of excavation and foundation work.

4.2 The excavated earth is to be kept at a sufficient distance so that it does not create any burden on the sides of excavated earth pits.

4.3 During excavation in sandy soil or water bearing strata, and particularly in black cotton soil where there is every likelihood of collapsing of the sides of the pits, shoring and shuttering made of wooden planks of sufficient thickness or steel frames of adequate strength to meet the requirement are to be provided.

4.4 Where water is encountered during excavation, dewatering shall be carried out manually or by mechanical means or power driven pumps to facilitate excavation and casting of foundations. The pumps shall be suitable for handling muddy water.
4.5 Excavation in soft rock is done with the help of chisels. Some types of soft rock soils need to be soaked in water before excavation can be carried out. It is not recommended to use blasting for excavation in soft rock.

4.6 For excavation 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 work or dwellings. At such locations, excavation shall be done by mechanical methods. To protect persons and animals from injuries and to protect nearby installations from flying debris, the pits can be covered with steel plates. Blasting shall be done in a manner such that the pits excavated are as near to the design dimensions as practicable. Holes are drilled at the base of the excavation for the anchor rods.

4.7 The details of the excavation & the type of soil(s) are entered in the excavation register.

4.8 A sample of the excavation register is enclosed at Appendix – A.

5.0 SETTING OF TEMPLATE:

5.1 A stub setting template is a specific tool for a type, design & make of tower. It is a light rigid steel framework and is used to hold the tower stubs at the correct alignment and slope during the concreting work. The template is adjustable type which can suit the standard tower as well as towers with standard extensions.

5.2 After the excavation is completed, the sides of the template are assembled and placed on the four sides of the location. The sides are then connected together, taking into consideration the type of tower (normal or with extension) to be erected, to form the shape of the template with the four corners located in the excavated pits.

5.3 The template is lifted and placed on jacks. Eight jacks are used, two for each corner of the template. The jacks are supported on sleepers which are placed across the pits so that the load of the template is distributed away from the excavated pits. The lengths of the sides and diagonals of the template are measured. These are compared with those given in the drawing and corrected as required.

5.4 Plumb lines, one in the transverse direction and the other in the longitudinal direction, are drawn from the peg markings given for the location.

5.5 The template is centred on the location with the help of the plumb lines. The template is levelled and the height of the base of the template above ground level is kept as given in the drawing.

5.6 The lengths of the sides and diagonals of the template are finally checked and corrected if required. The levelling of the template is also checked and corrected.

5.7 The stubs are then fixed on the legs of the template. The distance between the end of the stub and the base of the pit is checked with reference to the foundation drawing. If the distance is less, then the pit is accordingly excavated. In case the distance is more, the extra excavation is filled with lean concrete of 1 : 4 : 8 mix and allowed to set before further activities are taken up. NEVER USE SAND TO FILL THE EXTRA EXCAVATION.

5.8 The details of the dimensions & levels of the template are entered in the stub setting register.

5.9 A sample of the stub setting register is enclosed at Appendix – B.
FORMER BOXES:

6.1 Generally, the pyramid type of foundation is used which consists of two parts. The lower part is called the frustum and is the base of the foundation. The upper part is called the chimney which covers the stub angle.

6.2 Former boxes of the shape, size and dimensions for the individual type and make of tower as per approved foundation design and drawing are to be used.

6.3 Adequate quantity of former boxes for all types of towers, particularly suspension towers, shall be got fabricated so that work can be carried out at a number of locations and the desired progress can be achieved.

6.4 The dimensional drawing of former boxes shall be approved by the Executive Engineer.

6.5 Former boxes are made out of M. S. Sheets having adequate thickness so as to be rigid during the placing of the concrete. The chimney and pyramid portions are adequately braced to retain proper shape while concreting. To avoid honeycombs in the concrete, the former boxes shall be sufficiently tightened to prevent cement slurry from coming out.

6.6 Window is to be provided on the upper part of one face of large size frustums so that concrete may be placed easily in the lower part. This window shall be fitted back after placing concrete in the lower part.

6.7 Sample calculations for former boxes are enclosed at Appendix – C.

6.8 Sample calculations for concrete volume are also given in Appendix – C.

CONCRETE:

7.1 The general guidelines for the preparation of the concrete used for stub setting are as given in the following paras. The concrete shall be conforming to IS: 456 – 2000 (with latest amendments).

7.2 The materials used in the preparation of concrete shall generally conform to the Indian Standard Specifications as mentioned below (with their latest amendments) or as provided in the specifications of the contract / work order.

a) Cement:


7.3 The minimum cement consumption for different types of nominal mix concrete shall be as follows:

<table>
<thead>
<tr>
<th>Nominal Mix</th>
<th>Bags per Cubic Metre of Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 1½ : 3</td>
<td>8.2</td>
</tr>
<tr>
<td>1 : 2 : 4</td>
<td>6.5</td>
</tr>
<tr>
<td>1 : 3 : 6</td>
<td>4.5</td>
</tr>
<tr>
<td>1 : 4 : 8</td>
<td>3.5</td>
</tr>
</tbody>
</table>

7.4 The sand / fine aggregate (commonly referred to as bajri) used in the concrete should be clean and sharp angular grit type and of the best quality. It shall contain hard siliceous
materials, and shall be free from earth, organic matter, salts or any deleterious matters. The sources from which the sand / fine aggregate is taken shall be those which have been approved by the PWD or the RVPN Civil wing.

7.5 The water used in the concrete should be potable water. No saltish or brackish water is to be used for concreting.

7.6 The coarse aggregate (commonly referred to as grit or gitti) used in the concrete shall be of the best quality and broken to a maximum size of 20 mm. It shall also be free from small grit and dirt. The supply is to be taken from a quarry approved by the PWD or the RVPN Civil wing.

7.7 MIXING OF CONCRETE:

7.7.1 The concrete should be mixed in a mechanical mixer. Mixing of the concrete should be continued until there is uniform distribution of material and the mix is homogeneous in colour and consistency. All the cement and aggregates constituting the batch are to be dry mixed in the drum for at least one minute before water is added to the mix. The mixer shall be rotated at the speed recommended by the manufacturer and thereafter mixing shall be continued for at least 2 minutes and at least forty (40) revolutions after all materials are in the drum. For batches larger than 0.75 cub. m., mixing time shall be increased by 15 seconds for each additional 0.75 cub. m. or fraction thereof. All concrete shall be discharged within 3 minutes after the introduction of mixing water to the cement and aggregates.

7.7.2 In the eventuality where it is not possible to take mechanical mixers to the locations, hand mixing shall be permissible in case of emergency (when mechanical mixer are in use) such as failure of mixers, or where it is not practicable to haul the mixers up to the location. Also, for lean concrete sub – base, hand mixing may be resorted to.

7.7.3 When hand mixing is adopted, it shall be carried out on water tight platforms, such as 1.8 mm galvanised 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. Next, the fine aggregates shall be evenly spread out over coarse aggregates. Both the aggregates shall then be thoroughly mixed together and levelled. The required amount of cement shall thereafter be spread evenly over the mixed aggregates and wet mixing shall start from one end with the required amount of water using shovels. The whole lot shall not be wetted. The mixing shall proceed progressively. If the aggregates are wet or washed, cement shall not be spread out, but shall be put progressively.

7.7.4 For mixing in the 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.

7.7.5 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 mixing be done for less than 2 minutes.

7.7.6 If the aggregates are wet, the amount of water shall be reduced suitably.

7.7.7 Mixing shall normally be done close to the foundation, but in case this is not possible, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable so that there is no segregation or loss of any ingredient. The concrete is placed and compacted by means of poking rod / vibrator before it commences to set.
8.0 CASTING OF FOUNDATION:

8.1 General Preliminaries:

8.1.1 All wet locations must be kept completely dewatered both during the placing of the concrete and for 24 hours after completion. There should be no disturbance to concrete by water during this period. All arrangement for dewatering shall be made before starting the work of concreting.

8.1.2 The base pad of required depth as per foundation drawing is then placed using the specified concrete mix and allowed to set.

8.1.3 In case of RCC type foundation, the cover of 50 mm shall be provided all around between the reinforcement steel and the sides of the frustum / chimney.

8.2 Frustum & Chimney Type Foundation:

8.2.1 In case of RCC type foundation, the steel reinforcement shall be placed on the pad as per the design and the bar bending schedule.

8.2.2 The former boxes should be properly cleaned and oiled before using for concreting.

8.2.3 The frustum portion of the former boxes is then placed on the pad in the pit and centred with respect to the stub. Slurry of sand and water may be applied at the joints of the former boxes for sealing purpose to prevent the cement slurry flowing out.

8.2.4 The concrete is then poured into the frustum portion. After pouring of every 150 mm of concrete, poking rod or vibrator is used for proper compaction. In case of frustum with window on one face, the window is fitted when concrete has been placed upto that level.

8.3 Step Type RCC Foundation:

8.3.1 The steel reinforcement shall be placed on the pad as per the design and the bar bending schedule.

8.3.2 The shuttering for the first step of the foundation is first placed on the pad and concrete is poured within the shuttering. After pouring of every 150 mm of concrete, vibrator is used for proper compaction.

8.3.3 The above procedure is repeated for all the steps of the foundations one by one till the chimney level is reached.

8.4 Soft / Dry Fissured Rock / Undercut Foundation:

8.4.1 This is generally a mass concrete type of foundation.

8.4.2 In case of RCC type foundation, the steel reinforcement shall be placed on the pad as per the design and the bar bending schedule.

8.4.3 The concrete is poured inside the excavation upto the level / height as per the design. After pouring of every 150 mm of concrete, poking rod or vibrator is used for proper compaction.

8.5 Hard Rock Foundation:

8.5.1 This is generally a mass concrete type of foundation.

8.5.2 The anchor rods are placed in the holes drilled in the rock. Grout (1 : 1 : 2 with 10 mm size grit) or ready mix grout is poured in the drilled holes and poking rod is used to ensure complete filling of grout in the holes.
8.5.3 In case of RCC type foundation, the steel reinforcement shall be placed on the base of the foundation as per the design and the bar bending schedule.

8.5.4 The concrete is poured inside the excavation upto the level / height as per the design. After pouring of every 150 mm of concrete, poking rod or vibrator is used for proper compaction.

8.6 Casting of Chimney (Common Procedure):
8.6.1 After the frustum part is poured, the earthing connection is fitted on the designated stub / stubs. Earthing is provided on Leg 1. Additional earthing, if required, is provided on Leg 3. Counterpoise earthing is provided on all legs.

8.6.2 The chimney portion of the former box is fitted on the frustum. The earthing connection is passed through the joint of the two parts of the chimney. The chimney is centred and fixed so that equal spacing from the stub is available all around. The chimney is bolted to the frustum portion and slurry of sand and water is applied at the joints to prevent leakage of cement slurry.

8.6.3 The concrete is then poured into the chimney portion. After pouring of every 450 mm of concrete, poking rod or vibrator is used so that no empty spaces are left inside. The chimney is filled upto to the level shown in the foundation drawing.

8.6.4 The coping on the chimney, which is generally of a height of 75 mm, is done after the tower erection has been completed.

8.7 A typical completed chimney and pyramid foundation will look like the one shown in the drawing below.
For special types of foundations other than those described above, specific instructions / procedures shall be obtained from the Design / Civil wing in case these are to be casted by the Transmission wing.
8.9 In case of 400 kV lines, testing of the concrete is to be got done as specified in the Standard Field Quality Plan (SFQP) annexed with the work order. Samples of the concrete shall be taken as per the requirements and procedures given therein.

8.10 The entry of the quantities of cement and other information shall be recorded in the stub setting register.

9.0 BACKFILLING:

9.1 Former boxes are normally removed 24 hours after concreting. Concrete surfaces should be set right, where required, with rich cement and mortar immediately after removal of the former boxes.

9.2 After removal of the former boxes, the pits shall be back filled upto top of chimney concrete level with earth, which shall be free from grass, dung, wooden waste, postures & fodder, woods, shrubs, thorns, etc., in layers not exceeding 150mm, sprinkled with sufficient amount of water and well compacted with rammer or mechanical compactor. The soil which was excavated last should be filled in first. All top soil shall be placed at the surface in the case of towers located on cultivated land. Where the excavated material is not considered to be suitable for use as back filling, borrowed earth shall be used for back filling. Backfilling of hard rock foundations shall be done with borrowed earth and boulders / stones of a maximum size of 80 mm. Backfill shall not be dropped directly upon or against any foundation or facility where there is danger of displacement or damage.

9.3 Care should be taken during back filling. It should be ensured that back filling is done in the manner referred to above so that back – filled earth becomes homogenous with the surrounding parent soil with the passage of time.

9.4 In case backfilling is not done immediately after removal of former boxes, then curing of the concrete should be done by providing wet gunny bags till the back filling is done.

9.5 The stub setting template shall be removed after all the pits have been back filled to full depth.

9.6 The concrete should be cured by keeping the backfilling continuously wet for 14 days for OPC and 21 days for PPC. A 150 mm high earthen embankment (bandh) for filling water shall be made along the sides of the excavated pits at the end of the back filling. Water shall be filled in this embankment to keep the back filled earth wet for the remainder of the prescribed curing time.

9.7 All surplus soil, if any, including residual sand, stone and concrete waste, lying around shall be stacked within the tower base.

9.8 The date of back – filling shall be recorded in the stub setting register and signed by the Site Engineer in token of its verification.
### EXCAVATION REGISTER: RECORD OF VOLUME OF EXCAVATION & CLASSIFICATION OF FOUNDATION

**KV LINE FROM _______________________ TO _______________________**

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<th>Depth</th>
<th>Volume</th>
<th>Pit No. 2 Width</th>
<th>Depth</th>
<th>Volume</th>
<th>Pit No. 3 Width</th>
<th>Depth</th>
<th>Volume</th>
<th>Pit No. 4 Width</th>
<th>Depth</th>
<th>Volume</th>
<th>Total Volume (5+8+11+14)</th>
<th>Classification of foundation</th>
<th>Remarks</th>
<th>Signature of Contractor</th>
<th>Signature of Junior Engineer</th>
<th>Signature of Assistant Engineer</th>
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<td>Date of Stub Setting</td>
<td>Classification of Foundation</td>
<td>Template sides before concreting</td>
<td>Template diagonals before concreting</td>
<td>Template height above GL</td>
<td>Stubs back to back distance</td>
<td>Template diagonals after concreting</td>
<td>Steel Used</td>
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<td>Cement Consumed (Bags)</td>
<td>Make, type, grade of cement, week/year</td>
<td>Date &amp; number of cube samples</td>
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<td>Signature of Junior Engineer</td>
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SAMPLE CALCULATIONS FOR FABRICATION OF FORMER BOXES
(All dimensions in mm)

CALCULATION OF DISTANCE BY WHICH THE CENTRE OF THE BOTTOM OF THE STUB
SHIFTS FROM THE CENTRE OF THE TOP OF THE FRUSTUM.

Depth of stub inside the frustum = 475 – 50 = 425
Value of slope of tower face given by the tower designer:
\[ 2 \tan \alpha = 0.3053434 \]
or, \[ \tan \alpha = 0.1526717 \]
\[ \therefore \alpha = 8^\circ 40' 49.5'' (8.6804153^\circ) \]

From the sketch at the left,
\[ \tan \alpha = x \div 425 \]
or, \[ x = 425 \times \tan \alpha = 425 \times 0.1526717 \]
\[ \therefore x = 64.885473 \]
or, say, \[ x = 65 \]
CALCULATIONS FOR THE INCREASE IN THE SIZE OF THE TOP OF THE FRUSTUM DUE TO THE SLOPE OF THE CHIMNEY

From the sketch at the left,
\[ \cos \alpha = \frac{300}{y} \]
or, \[ y = \frac{300}{\cos \alpha} = \frac{300}{0.9885455} \]
\[ \therefore y = 303.47616 \]
or, say, \( y = 303 \)

CALCULATION FOR DIMENSIONS OF THE FOUR FACES OF THE FRUSTUM

The dimensions of the four faces of the frustum at the base of the frustum shall be as given below after considering the following:

a) Size of the top of the frustum as 303 mm.
b) Shifting of the centre of the bottom of the stub by 65 mm from the centre of the top of the frustum.

\[ 396 = \frac{1225 - 303}{2} - 65, \quad 526 = \frac{1225 - 303}{2} + 65 \]
\[ 560 = \sqrt{396^2 + 396^2}, \quad 744 = \sqrt{526^2 + 526^2}, \quad 658 = \sqrt{396^2 + 526^2} \]
The actual dimensions of the four faces of the frustum shall be as given below after considering the height of the frustum = 475 mm.

\[734 = \sqrt{(560^2 + 475^2)}, \quad 618 = \sqrt{(396^2 + 475^2)}, \quad 883 = \sqrt{(744^2 + 475^2)}, \quad 812 = \sqrt{(658^2 + 475^2)}\]

The values given in the drawing above are the finished dimensions.

When fabricating the faces of the frustum, the dimensions of the sheet used for all the four sides of the faces shall be increased by 50 mm.

Three sides, other than the bottom side, shall be bent for 50 mm and small size angles welded on them.

Holes shall be drilled in these bent sides for connection to the other faces of the frustum and to the bottom of the chimney.

The bottom side shall be bent for providing a base for the frustum. Small size angles are also welded on them for providing support.
CALCULATION OF THE LENGTH OF THE CHIMNEY

The length of the chimney is calculated as shown in the diagram above. The length of the chimney will be the length along the diagonal slope of the stubs / legs of the tower.

The length along the first slope for a height of 300 mm will be
\[ L_1 = \frac{300}{\cos \alpha} = 300 \div 0.9885455, \text{ or, } L_1 = 303.47616 \]

The length along the second slope for this height of 303.47616 mm will be
\[ L_2 = \frac{303.47616}{\cos \alpha} = 303.47616 \div 0.9885455, \text{ or, } L_2 = 306.99261 \]

The ratio of increase = \[\frac{306.99261}{300} = 1.0233087\]

The length of the chimney for a height of 2875 + 300 = 3175 mm will be:
Length of chimney = 3175 \times 1.0233087 = 3249 mm.

CALCULATION OF THE HEIGHT WHICH IS TO BE CUT FROM THE PARTS OF THE CHIMNEY FOR OBTAINING THE CORRECT SLOPE OF THE CHIMNEY

The height to be cut from the parts of the chimney for obtaining the correct slope of the chimney is
\[ z = 300 \sin \alpha \]
or, \[ z = 300 \times 0.1509231 \]
\[ \therefore z = 45.27694 \]
or, say, \[ z = 46 \]

From the above, the length of the chimney will therefore be 3249 mm.

The sheet to be used for fabricating the chimney parts will be of a length equal to 3249 + 46 = 3295 mm.
A height of 46 mm, as given below is to be cut from both ends of the sheets used for fabrication.

a) From the inside edge of the inner part.
b) From both the sides of the outer part.

The length of the chimney parts after cutting 46 mm from the inner part will be 3249 mm on the inner side of the chimney.

After cutting 46 mm from the outer part, the length remaining will be 3249 mm on the outer side of the chimney.

The manner in which the chimney parts are to be cut (shown in dotted lines) is illustrated in the sketches given below.

The values given in the sketches above are the finished dimensions.

When fabricating the faces of the chimney, the dimensions of the sheet used for all the four sides of the faces shall be increased by 50 mm.

Three sides, other than the top side, shall be bent for 50 mm and small size angles welded on them. Holes shall be drilled in these bent sides for connection to the other face of the chimney and to the top of the frustum.

The top side shall be bent for providing a level top for the chimney. Small size angles are also welded on them for providing support.
CALCULATION OF EXCAVATION AND CONCRETE VOLUMES OF TOWER FOUNDATION.
(Based on typical drawing of the tower foundation shown above in this Appendix)

CALCULATION OF EXCAVATION VOLUME

Excavation Volume

\[ \text{Excavation Volume} = 4 \times \{\text{Base of pad} + (2 \times 0.150 \text{ m})\}^2 \times \text{depth of the pit} \]
\[ = 4 \times (1.225 + 0.300)^2 \times 3.400 \]
\[ = 4 \times 1.525^2 \times 3.400 \]

Total Excavation Volume

\[ = 31.6285 \text{ cu.m.} \]

CALCULATION OF CONCRETE VOLUME

Concrete Volume

\[ \text{Concrete Volume} = \text{Concrete volume of Pad} + \text{concrete volume of Frustum} + \text{concrete volume of Chimney} + \text{concrete volume of Coping}. \]

Concrete Volume of Pad

\[ = 4 \times (\text{Base of pad})^2 \times \text{height of pad} \]
\[ = 4 \times 1.225^2 \times 0.050 \]
\[ = 0.3001 \text{ cu. m.} \]

Concrete Volume of Frustum

\[ = 4 \times \frac{\text{height of frustum}}{3} \times [(\text{Base of frustum})^2 + (\text{Top of frustum})^2 + \sqrt{(\text{Base of frustum})^2 \times (\text{Top of frustum})^2}] \]
\[ = 4 \times 0.475 \times \{1.225^2 + 0.300^2 + \sqrt{1.225^2 \times 0.300^2}\} \]
\[ = 4 \times 0.1583 \times 1.9581 \]
\[ = 1.2398 \text{ cu.m.} \]

Concrete Volume of Chimney

\[ = 4 \times (\text{width of chimney})^2 \times \text{height of chimney} \]
\[ = 4 \times 0.300^2 \times 3.100 \]
\[ = 1.116 \text{ cu.m.} \]

Concrete volume of Coping

(as for frustum)

\[ = 4 \times \frac{0.075}{3} \times \{0.300^2 + 0.100^2 + \sqrt{0.300^2 \times 0.100^2}\} \]
\[ = 4 \times 0.025 \times 0.130 \]
\[ = 0.013 \text{ cu.m.} \]

(The top of the coping has been taken as 100 mm based on the size of the stub angle)

Total Concrete Volume

\[ = 0.3001 + 1.2398 + 1.1160 + 0.0130 \]
\[ = 2.6689 \text{ cu.m.} \]
CHAPTER – 5
EREC TION OF TOWERS AND FIXING OF ACCESSORIES

1.0 TOWER ERECTION:

1.1 The towers shall be erected on the foundations not less than 14 days (if OPC has been used)/ 21 days (if PPC has been used) after concreting or till such time that the concrete has acquired sufficient strength. The towers are erected as per the erection drawings furnished by the manufacturers to facilitate erection. For the convenience of assembling the tower parts during erection operations, each member is marked in the factory to correspond with a number shown in the erection drawing. Any damage to the steel and injuring of galvanizing shall be avoided. No member shall be subjected to any undue over stress during erection.

1.2 There are three main methods of erection of steel transmission towers which are described as below:

a) Built up method or Piecemeal method.
b) Section method.
c) Ground assembly method.

1.3 Built Up Method:

1.3.1 This method is most commonly used for the erection of 132 kV, 220 kV and 400 kV transmission line towers due to the following advantages:

a) Tower materials can be supplied to site in knocked down condition, i.e., in pieces which facilitates easier and cheaper transportation.
b) It does not require any heavy machinery such as cranes, etc.
c) Tower erection activity can be done in any kind of terrain and throughout most of the year.
d) Availability of workmen at cheaper rates.

1.3.2 This method consists of erecting the towers member by member. The tower members are first set out and kept on the ground serially according to erection sequence to avoid time loss due to searching for them as and when required.

1.3.3 In order to maintain speed and efficiency, a small assembly party can be sent ahead of the main erection gang for sorting out the tower members, keeping the members in correct position on the ground and assembling those panels on the ground which can be erected as a complete unit. The main corner leg members are prepared by fitting all cleats / plates for joints & bracings and step bolts.

1.3.4 The erection progresses from the bottom upwards. The four main corner leg members of the first section of the tower are first erected and kept in position by fixing temporary rope guys. More than one leg section of each corner leg may be bolted together at the ground and erected in case they are short in length and light in weight.

1.3.5 The cross bracings of the first section, which may be assembled on the ground, are raised one by one as a unit and bolted to the already erected corner leg angles. The first section of the tower thus built and horizontal struts (belt members), if any, are bolted in position.

1.3.6 For smaller base towers / vertical configuration towers, one derrick / gin pole is used. For wide based towers and if one assembled section / panel of the tower is to be erected, then two derricks / gin poles are placed, one each on the top of diagonally opposite corner legs. These are guyed using ropes and temporary ground anchors.
1.3.7 For assembling the second section of the tower, the derrick / gin pole is placed on the top of one corner leg. First, the leg members of the second section are hoisted and assembled. The temporary rope guys are shifted to the legs of the second section when they are being raised for erection. The legs of the second section / storey are kept in position by fixing the temporary rope guys. The bracings of the second section are then hoisted and assembled.

1.3.8 The derrick is then shifted to the corner leg member on the top of the second section to raise the parts of third section of the tower in position for assembly. Derrick(s) / Gin pole(s) and the temporary rope guys for the leg members are thus moved up as the tower is built up. This process is continued till the complete tower is erected.

1.3.9 The stages in this method of erection are shown in Appendix – A and Appendix – B.

1.3.10 Cross – arms are assembled on the ground.

1.3.11 The bird guards and hangers for suspension towers are fitted on the cross – arms.

1.3.12 A rope is passed through a pulley fixed on the tower peak. The cross – arms are raised up with this rope and fixed to the main body of the tower.

1.3.13 The method of erection is shown in Appendix – C.

1.3.14 For heavier towers, a small boom is rigged on one of the tower legs for hoisting purposes.

1.3.15 The members / sections can be hoisted either manually or by pulling with a tractor or by winch machines operated from the ground.

1.4 Section Method:

1.4.1 The major sections of the tower are assembled on the ground and the same are erected as units. Either a mobile crane or a derrick / gin pole is used. The derrick / gin pole used is approximately 10m long and is held in place by means of guys on the side of the tower to be erected.

1.4.2 The two opposite sides of the tower section of the tower are assembled on the ground. Each assembled side is then lifted clear of the ground with the derrick / gin pole and is lowered into position on bolts to stubs or anchor bolts. One side is held in place with props or rope guys while the other side is being erected. The two opposite sides are then laced together with cross members and bracings / diagonals, and the assembled section is lined up and made square to the line.

1.4.3 After completing the first section, the derrick / gin pole is set on the top of the first section. The derrick / gin pole is made to rest on a strut of the tower immediately below the leg joint. The derrick / gin pole has then to be properly guyed into position.

1.4.4 The first face of the second section is raised. To raise the second face of this section, it is necessary to shift the foot of the derrick / gin pole on the strut of the opposite side of the tower. After the two opposite faces are raised, the bracings on the other two sides are fitted and bolted up.

1.4.5 The last lift raises the top of the towers. After the tower top is placed and all side bracings have been bolted up, all the guy are removed except the one which is to be used to lower the derrick / gin pole.
1.4.6 Sometimes, one whole face of the tower is assembled on the ground, hoisted and supported in position. The opposite face is similarly assembled and hoisted and then the bracing angles connecting these two faces are fitted.

1.4.7 The cross – arms are assembled and erected in the manner given at paras 1.3.9 to 1.3.11.

1.5 **Ground Assembly Method:**
1.5.1 This method consists of assembling the tower on the ground, and erecting it as a complete unit. This method is not useful when the towers are large and heavy and the foundations are located in arable land where assembling and erecting complete towers would cause damage to large areas or in hilly terrain where the assembly of complete tower on slopping ground may not be possible and it may be difficult to get the crane into position to raise the complete tower. This method is not generally adopted because of non-availability of good approach roads to tower location.

1.5.2 For this method of erection, a level piece of ground close to the footing is chosen for the tower assembly. On slopping ground, however, elaborate packing of the low side is essential before assembly commences.

1.5.3 The complete tower is assembled in a horizontal position on even ground. The tower is assembled along the direction of the line to allow the cross arms to be fitted.

1.5.4 After the assembly is complete, the tower is picked up from the ground with the help of a crane and carried to its location and set on its foundation.

1.6 **Tightening of Bolts & Nuts and Punching of Threads:**
1.6.1 All empty holes are to be filled in with nut and bolt of appropriate size and a spring washer.

1.6.2 All nuts shall be tightened properly using correct size spanners. Before tightening it should be ensured that filler washers and plates are placed in relevant gaps between members, bolts of proper size and length are inserted and one spring washer is inserted under each nut. In case of step bolts, spring washer shall be placed under the outer nut.

1.6.3 The tightening shall be carried on progressively from the top downwards, care being taken that all bolts at every level are tightened simultaneously. It is advisable to employ four persons, each covering one leg and the face to his right.

1.6.4 The threads of bolts shall project outside the nuts by one to two threads and shall be punched at three positions on the top inner periphery of the nut and bolt to ensure that the nuts are not loosened in the course of time.

1.6.5 If during tightening, a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be changed outright.

1.7 **Tack Welding of Bolts & Nuts:**
1.7.1 Tack welding is got done of all the nuts & bolts from the ground level upto bottom cross arm level, or as specified in the contract.

1.7.2 The threads of all the bolts projecting outside the nuts shall be welded with the nuts at two diametrically opposite places. The length of each welding shall be at least 10 mm, or as specified in the contract.

1.7.3 After welding, cold galvanizing paint (Zinc rich paint having at least 90% percent zinc content) shall be applied to the welded portion. At least two coats of the paint shall be applied.
1.8 **FIXING OF ACCESSORIES:**

1.8.1 The U – Bolts for earthwire suspension hardware are fitted on the top plate of the suspension towers.

1.8.2 The supports for the anti – climbing device are fitted on the main corner legs of all the towers. The anti – climbing devices (Flats with edges cut to a sharp point) are installed after the stringing work has been completed.

1.8.3 The number plates are fitted at the place provided for them on the face of the tower. Wherever there are roads near the tower, these should be fitted on the face from which they can be seen from the road.

1.8.4 The phase plates are fitted on the holes provided for them on the top leg of the cross – arms if the phase sequence is known at the time of erection of towers. Otherwise, these are fitted after the phase sequence is finalized.

1.9 Checking the Verticality of Erected Towers:

1.9.1 The finally erected tower shall be truly vertical after erection and no straining is permitted to bring it in alignment.

1.9.2 The verticality of the tower is checked using a theodolite placed away from the tower but in the longitudinal and transverse center lines of the tower.

1.9.3 The tolerance limit for verticality shall be one in 360 of the tower height.
Tower Erection: Built up Method: Erection of Tower Body
(Second Storey Upwards)

- Main leg of second storey
- Guy ropes for leg under erection
- Guy ropes for derrick / gin pole
- Already erected first storey
- Pulley
- Derrick / Gin Pole
- Pull
1.0 HOISTING OF INSULATOR STRINGS:

1.1 Single / Double suspension insulator strings are used on suspension towers and single / double tension insulator strings are used on angle and dead end towers. This is indicated in the tower schedule.

1.2 Before hoisting, all insulators are cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for the purpose.

1.3 Disc insulators shall be examined for any cracks / chipping, etc. Disc insulators having any hair cracks or chipping or defective glazing or any other defect shall not be used. The permissible limits of the area of defective glazing are given by the following formulas.

a) Single glaze defect: \(0.5 + \frac{D \times F}{20000}\) sq. cm.

b) Total glaze defect: \(1.0 + \frac{D \times F}{2000}\) sq. cm.

where,
\[
D = \text{Diameter of the disc in cm.}
\]
\[
F = \text{Creepage distance in cm.}
\]

1.4 The insulator strings for various line voltages are prepared by assembling disc insulators as given in the table below.

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<td>1 × 13</td>
</tr>
<tr>
<td>E &amp; M strength (kN)</td>
<td>70</td>
<td>70</td>
<td>N. A.</td>
<td>N. A.</td>
<td>120</td>
<td>120</td>
<td>70</td>
</tr>
<tr>
<td><strong>132 KV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of discs</td>
<td>1 × 9</td>
<td>2 × 9</td>
<td>N. A.</td>
<td>N. A.</td>
<td>1 × 10</td>
<td>2 × 10</td>
<td>1 × 9</td>
</tr>
<tr>
<td>E &amp; M strength (kN)</td>
<td>45</td>
<td>45</td>
<td>N. A.</td>
<td>N. A.</td>
<td>120</td>
<td>120</td>
<td>45</td>
</tr>
</tbody>
</table>

N. A.: Not Applicable.

1.5 Coordinated adjustable rod gaps are now not provided on the four approach towers to the sub station. It is therefore a general practice, in the case of 132 kV and 220 kV lines, to reduce one disc insulator from the tension insulator string on the line side of the terminal tower and on all insulator strings, suspension / tension as applicable, on the next three towers.
1.6 The hardwares are assembled as per the manufacturer’s drawing and their upper and lower parts are connected to the corresponding sides of the insulator string. Arcing horns / guard rings / corona rings, as provided, are fitted on the hardware. These shall be placed in the line direction on suspension string assemblies, and facing upwards / vertically on tension insulator string assemblies. The part of the hardware which is used for clamping the conductor is not fitted at this stage. The security clips in the insulators and the hardware should be properly opened.

1.7 The suspension strings are generally hoisted on the tower just prior to the paying out of conductors. However, these can also be hoisted after tower erection is completed.

2.0 INSTALLATION OF ROLLERS / TRAVELLERS / RUNNING BLOCKS:

2.1 For single suspension vertical / I – string insulator assemblies, the rollers are connected directly to the insulators using a D – shackle. For double suspension and V – string insulator assemblies, the rollers are connected to the yoke plate of the hardware. For most bundled conductor lines, the rollers are also connected to the yoke plate of the hardware.

2.2 Where paying out / stringing is to be done through tension tower, rollers are normally connected directly to the tower. If substantial line angles are involved, two rollers in tandem may be required to reduce the bending radius of the conductor or the load on each traveler, or both. Where bundled conductor travelers are used at the angle locations of over 5 degree, it is advisable to change to individual single conductor travelers after the passage of the running board to facilitate accurate sagging.

2.3 Sketch of travelers is show in Appendix – A.

2.4 In case of exposure to electrical hazards, traveling grounds should be used. The choice of locations should be based on the degree of exposure. When such hazards exist, as a minimum, traveler grounds should be installed at the first and last tower between tensioner and puller. When stringing is to be done in the proximity of energized lines, additional grounds / earthing shall be connected to the conductor as required, but at a maximum distance not exceeding 3 km.

2.5 Travellers with grounds are connected to the pulling end. Each traveler with grounds must be connected with temporary grounding sets to provide an electrical connection between the traveler and earth, or to some conducting medium that is at earth potential. Personnel should never be in series with a ground / earthing lead. Traveller grounds should have a suitable grounding stub located in an accessible position to enable placing and removing the grounding clamps. The grounding clamps shall be removed after taking due precautions. Traveller grounds also help protect the sheave linings.

2.6 The rollers / running blocks for earthwire are fixed to the U – bolts or on the fixing arrangement provided on the peak(s) of the suspension towers.

3.0 PROVIDING STAYS / ANCHORS FOR TOWERS CONDUCTOR / EARTHWIRE:

3.1 All angle / dead end towers shall be provided with stays / anchors to balance the one sided load on them when stringing is done initially on one side only. Double stays are provided on all cross arms and single stay is provided on the peak(s) of the angle / section towers.

3.2 Providing of stays is not necessary in case of dead end towers at both ends of the line in case the earthwire and conductors have been strung between the towers and the line gantries at the sub station.

3.3 Standing trees or any other objects or tower legs should not be used as stays for the towers and conductors / earth wire.
3.4 The stays are fixed at a sufficient distance from the tower so that the angle of the stays is approximately 30 degrees to the ground. In such an arrangement, the stays are at a distance of 1.5 times the height of the respective cross arm / peak.

3.5 The stay pits are excavated to a minimum depth of 2.0 metres. Normally, an anchor in the form of a piece of steel joist or rail of length 1.8 metres with a steel lead fixed on it is placed in this pit and the pit is backfilled tightly with the excavated earth or borrowed earth. For loose sand and wet black cotton soil conditions, a piece of steel joist or a sleeper (for greater width) of length 2.3 metres should be used for the anchor. The length of the steel lead is about 4.25 metres and its other end projects out of the ground. A trench, sloping at an angle of approximately 30 degrees to the horizontal, is dug from the base of the pit to the ground level for this lead.

3.6 Steel stay wires are fixed on the cross arms / peaks using D – shackles and pulled up to the stay pit. They are connected to the stay lead from the pit through a turnbuckle using bulldog clamps. The turnbuckle is then tightened to a tension sufficient to balance the load which will be imposed on the cross arms / peak(s) when stringing is carried out on the other side of the tower.

3.7 Stay pits as described at para 3.4 & para 3.5 above are also provided for anchoring of conductors and earthwire after rough sagging.

3.8 In case the conductor of the next / previous section has been payed out and rough sagged (at approximately 50% working tension) on the tower on which final sagging is to be done, providing of stays is also not necessary. This method is to be used only after ensuring that this kind of one end loading is permissible as per the tower foundation design and adequate clearance from power lines is available in the rough sagged section. This method is normally used for 400 kV lines.

4.0 GENERAL DIRECTIONS:

4.1 The fullest possible use of the maximum conductor and earth wire lengths should be made in order to reduce the number of joints to a minimum. The use of drums should be planned such that minimum short lengths of conductor / earth wire remain on the drum. The planning should also consider that conductor / earth wire joints are at least 30 metres away from the suspension towers.

4.2 All the joints on the conductor and earth wire should be of compression type and shall be compressed in accordance with the recommendations of the manufacturers for which all necessary tools and equipments like compressors, die sets, etc., should be used. The final conductor and earth wire surface shall be clean smooth and shall be without any projections, sharp points, cuts, abrasions, etc.

4.3 In case of mid span joints, care should be taken to mark the conductors to indicate when the fitting is centered properly. During compression of jointing operation, the conductor / earth wire should be handled in such a manner so as to prevent lateral or vertical bearing against the dies. After pressing the joint, all corners of the steel / aluminium sleeve should be rounded, and burrs and sharp edges removed and smoothened.

4.4 The rollers / running blocks, which are suspended from the tower for paying out, shall be so adjusted that the conductors / earth wire on them are at the same height as the suspension clamps to which they are to be finally secured. The grooves of rollers shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings. Before the rollers / running blocks, especially those at the tensioning end, are fitted on the cross – arms, a wooden triangular wedge is provided in the angles to
protect the steel angles. Jute cloth is then wrapped over the wedge & steel angles and under the slings to avoid damage to the slings as well as to protect the steel work.

4.5 The rollers which are used during paying out of conductor / earth wire may get stuck or sluggish and may therefore cause problems during paying out operation. If one or more of the rollers become jammed, sagging can become very difficult. A roller which swings in the direction of the pull is an indication of a defective roller. If sagging difficulties occur, the rollers should be checked. Tensions applied to the conductor / earth wire to overcome sticky or jammed rollers can cause sudden and abrupt movement of the conductor / earth wire in the sagging spans and quickly cause change of sag, particularly, if the conductor / earth wire is already tensioned to the required value.

4.6 One person should be posted on each tower with red and green flags and whistle so that he can give a signal, which is relayed to the pulling end by other similarly placed persons, to stop the paying out operation if any roller gets stuck or any mid span joint gets stuck in any roller or any other emergency occurs. Walkie – Talkie sets may also be used for this purpose. Walkie – Talkie sets stationed at the tensioner, puller and intermediate spans, as required, should be used specially for tension stringing.

4.7 Shutdown shall be obtained when working at crossing over or under existing energized overhead power lines.

4.8 The proposed transmission line may run parallel for certain distance with the existing transmission lines which may remain energized during the stringing period. As a result, there is a possibility of dangerous voltage build up due to electromagnetic and electrostatic coupling in the pulling wire conductors and ground wires, which although comparatively small during normal operations, can be severe during switching operation. Adequate safety precautions should be taken to protect employees and others from this potential danger.

4.9 Scaffolding shall be used where roads, rivers, channels, telecommunication lines, overhead power lines, railway lines, fences or walls have to be crossed during paying out and stringing operations. The power lines up to 33 kV are lowered from their supports during the above activities. Efforts shall be made so that normal services are not interrupted or damage caused to property. Shut down shall be obtained when working at crossing of overhead power lines.

4.10 Unbalanced loads on towers shall be avoided as far as possible. The sequence of stringing of conductors after stringing of the earthwire is shown in the sketch below.
4.11 Clearance between the conductors and ground is to be checked during erection and before handing over the line.

4.12 The placement chart for installing vibration dampers on lines up to 220 kV is given below.

<table>
<thead>
<tr>
<th>Type of Conductor / Earthwire</th>
<th>Number &amp; Distance from suspension / tension clamp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spans upto 366 metres</td>
</tr>
<tr>
<td>ACSR “Panther”</td>
<td>1 no. at 1.14 M</td>
</tr>
<tr>
<td>7 / 3.15 mm Earthwire</td>
<td>1 no. at 0.53 M</td>
</tr>
<tr>
<td>ACSR “Zebra”</td>
<td>1 no. at 1.45 M</td>
</tr>
<tr>
<td>7 / 4.00 mm Earthwire</td>
<td>1 no. at 0.66 M</td>
</tr>
</tbody>
</table>

REMARK: For suspension towers, the distance is measured from the center of suspension clamps. For tension towers, the distance is measured from the mouth / end of aluminium portion of the tension hardware.

4.13 The placement chart for installing vibration dampers on 400 kV lines is given below.

<table>
<thead>
<tr>
<th>Conductor / Earthwire</th>
<th>Number &amp; Distance from suspension / tension clamp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spans upto 600 metres</td>
</tr>
<tr>
<td>ACSR “Moose”</td>
<td>1 no. at 1.35 M</td>
</tr>
<tr>
<td>7 / 3.66 mm Earthwire</td>
<td>1 no. at 0.65 M</td>
</tr>
</tbody>
</table>

REMARK: For suspension towers, the distance is measured from the tip of suspension clamps. For tension towers, the distance is measured from the mouth / end of aluminium portion of the tension hardware.

4.14 The conductors and earth wire shall be tensioned correctly as per sag tension charts before they are finally transferred to the clamps. Dynamometers and sag boards are to be used in tensioning the conductors and earth wire. The sag is to be checked at intervals when conductors and earth wire are drawn up.

4.15 The margin of extra sag of 150 mm kept at all the important tension locations like Railway / River crossings when spotting towers on the profile should be checked and verified after final sag.

4.16 All compression joints should be carefully made and record of initial and final lengths of the joints is to be maintained.

4.17 Over stressing causing damage to towers should be avoided. Care should be exercised not to over tension the conductor.

4.18 In the case of single and double circuit towers with vertical conductor configuration, one end of a polypropylene rope of 25 mm dia. is tied to the end of the cross arm on which the conductor is being sagged and the other end is tied to the peak of the tower. This arrangement works as a support for the cross arm for the vertical load as a safety measure.
5.0 **PAYING OUT OF EARTHWIRE:**

5.1 The details of earth wire used for the lines of various voltage classes are as below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage Class</th>
<th>No. of earth wires</th>
<th>Stranding</th>
<th>Maximum Sag*</th>
<th>Maximum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>400 kV</td>
<td>2</td>
<td>7 / 3.66 mm</td>
<td>10167 mm</td>
<td>53 deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>220 kV</td>
<td>1</td>
<td>7 / 4.00 mm</td>
<td>6680 mm</td>
<td>65 deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>132 kV</td>
<td>1</td>
<td>7 / 3.15 mm</td>
<td>5840 mm</td>
<td>65 deg. C</td>
</tr>
</tbody>
</table>

Material: Galvanized steel stranded wire, 100 kgf quality.

* Under conditions of maximum earthwire temperature & still wind.

5.2 The sequence of paying out shall be from top to downwards, i.e., the earthwire shall be payed out first.

5.3 Earthwire drums are mounted on a turn table at the start of the section. The turn table is provided with a suitable braking device to prevent over running and backlash and to avoid damages to or lose running out and kinking of the earthwire.

5.4 The locations of the earthwire drums depend on the section length, length of earthwire on each drum and site conditions. They can be located either at suitable intermediate tower(s) (normally one drum length away) and / or at the other end of the section.

5.5 Earthwire drum battens should be removed just prior to moving drums on to drum stands / turntable. Drums should be transported and positioned at site on stands / turntable with the least possible amount of rolling.

5.6 A tractor is employed to pull the earthwire. The end of the earthwire is tightened in a come – along clamp (bolted type or automatic) and attached to the tractor. Care should be taken during paying out to ensure that the earthwire does not get damaged by being dragged over stones, etc. Ground rollers of sufficient height should be used when paying out over rocky terrain so that the earthwire does not touch the ground.

5.7 The earthwire shall be continuously observed for loose or broken strands or any other damage. These coils are to be removed carefully and repair sleeve / mid span joint is to be provided as required as per procedure given at para 8 / para 9.

5.8 The earthwire is pulled / payed out to a distance beyond the first tower. This distance is roughly a little more than double the height of the tower peak. The extra length of earthwire is pulled back, taken to the tower peak, passed through the earthwire roller / running block and brought down the other side of the tower. The earthwire is then pulled by the tractor towards the next location.

5.9 This procedure is continued / followed for the subsequent towers till the end of the section or the drum length is reached, whichever is earlier.

5.10 If the section length is more than one drum length. Then the next earthwire drum is taken up for paying out. The process is continued till the paying out of earthwire for the complete section is completed.

5.11 The mid span joints for earthwire are provided as required. All joints shall be made at least 30 metres away from the towers. No joints shall be made in tension spans or in the first span near an angle tower. No joint shall be used in any span crossing other major power lines. Earthwire joints shall be made in the manner prescribed by the manufacturer so that
they do not crack or get damaged in the stringing operations. The generally adopted procedure is described in para 9.2.

5.12 The earthwire is compressed in the dead end hardware at the section point where sagging will not be done.

5.12.1 If the ends of the earth wire are damaged, the damaged parts are cut off after the steel strands are tied up with at least two rounds of binding wire.

5.12.2 The steel tube is then slipped on to the steel strands and compressed to the specified load and dimensions.

5.12.3 Any sharp edges or burrs remaining after compressing the steel tube are filed off to give a smooth finish.

5.13 The vibration dampers are then fixed on the earth wire at the distance specified for the size of the earth wire. The distances are given at para 4.12/4.13.

5.14 The earth wire and tension hardware are hoisted up and fixed on the peak/earth wire cross arm of the tower.

5.15 The earthwire of the complete section is then pulled at the other end of the section where sagging is to be done. This is called rough sagging and the earthwire is pulled such that there is no slack and it is well clear of the ground and power lines in the intermediate spans of the section.

5.16 After being rough sagged as above, the earthwire is tied to the stay or anchor provided for it till it is finally sagged/tensioned.

6.0 PAYING OUT OF CONDUCTOR (DIRECT METHOD – UPTO 220 KV LINES):

6.1 The details of conductor used for the lines of various voltage classes are as below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Voltage Class</th>
<th>Code Name</th>
<th>No. of conductors</th>
<th>Stranding Steel</th>
<th>Maximum Sag*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7 / 3.53 mm</td>
<td>12865 mm</td>
</tr>
<tr>
<td>1</td>
<td>400 kV</td>
<td>ACSR “Moose”</td>
<td>2</td>
<td>54 / 3.53 mm</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>220 kV</td>
<td>ACSR “Zebra”</td>
<td>1</td>
<td>54 / 3.18 mm</td>
<td>9420 mm*</td>
</tr>
<tr>
<td>3</td>
<td>132 kV</td>
<td>ACSR “Panther”</td>
<td>1</td>
<td>30 / 3.00 mm</td>
<td>7770 mm*</td>
</tr>
</tbody>
</table>

* Under conditions of maximum conductor temperature of 75º C. & still wind.
# Including 2% for conductor creepage.

6.2 The sequence of paying out shall be from top to downwards, i.e., the top conductors shall be payed out first, followed by the middle and bottom conductors in succession. In case of horizontal configuration tower, middle conductor shall be strung before stringing of outer conductors is taken up.

6.3 This method is generally used in the construction of new lines up to 220 kV where maintenance of conductor surface condition is not critical and where terrain is easily accessible to a pulling or paying out vehicle.

6.4 One method of direct paying out conductors is the same as described above for earthwire. In this case also, the locations of the conductor drums depend on the section length, length of conductor on each drum and site conditions. They can be located either at suitable
Conductor drum battens should be removed just prior to moving drums on to drum stands/turntable. Drums should be transported and positioned at site on stands/turntable with the least possible amount of rolling.

A tractor is employed to pull the conductor. The end of the conductor is tightened in a come-along clamp (bolted type or automatic) and attached to the tractor. Care should be taken during paying out to ensure that the conductor does not get damaged by being dragged over stones, etc. Ground rollers of sufficient height which will keep the conductor clear of the ground should be used when paying out over rocky terrain.

The conductor shall be continuously observed for loose or broken strands or any other damage. These coils are to be removed carefully and repair sleeve/mid span joint is to be provided as required as per procedure given at para 8/para 9.

The conductor is pulled/payed out to a distance beyond the first tower. This distance is roughly a little more than double the height of the cross arm on which the conductor is to be strung. The extra length of conductor is pulled back, lifted up at the cross arm, passed through the conductor roller/running block and brought down. As far as possible, the conductor roller/running block, when fitted to the suspension string on the tower cross arms for sagging, is so adjusted that the conductor on the roller/running block is at the same height as the suspension clamp to which it will be fixed. The conductor is then further pulled by the tractor towards the next location.

Another method of direct paying out conductors is by mounting the conductor drum on a shaft in a “paying out trolley.” The paying out trolley is provided with a suitable braking device to prevent over running and backlash and to avoid damages to or lose running out and kinking of the conductor.

The conductor end is tied to an anchor at the starting point and the paying out trolley is pulled by a tractor. The paying out trolley is pulled beyond the first tower to a distance which is a little more than double the height of the cross arm on which the conductor is to be strung. The paying out trolley is brought back to the tower. The extra length is collected at the tower. This is lifted up and fitted in the roller. The paying out trolley is then further pulled by the tractor towards the next location.

The adopted procedure is continued/followed for the subsequent towers till the end of the section or the drum length is reached, whichever is earlier.

If the section length is more than one drum length, then the next conductor drum is taken up for paying out. The process is continued till the paying out of conductor for the complete section is completed.

The mid span joints for conductor are provided as required. All joints shall be made at least 30 metres away from the towers. No joints shall be made in tension spans or in the first span near an angle tower. No joint shall be used in any span crossing other major power lines. Conductor joints shall be made in the manner prescribed by the manufacturer so that they do not crack or get damaged in the stringing operations. The generally adopted procedure is described in para 9.1.

The conductor is then compressed in the dead end hardware at the section point where sagging will not be done.
6.14.1 If the ends of the conductors are damaged, the damaged parts are cut off after the aluminium strands are tied up with at least two rounds of binding wire. The depth of the hollow tube of the steel portion of the hardware is measured. A mark, which is at a distance equal to this measured length plus a length equal to the elongation of the steel tube during compression, is made on conductor from its cut end.

6.14.2 The aluminium strands of the conductor, after being tied up with at least two rounds of binding wire near this mark, are cut at this mark while ensuring that the steel strands are not scratched. The steel strands are tied up with at least two rounds of binding wire after the aluminium strands are cut off.

6.14.3 The aluminium tube part of the hardware is first slipped on to the conductor keeping the jumper end on the tower side. The steel tube part is then slipped on to the steel strands and compressed to the specified load and dimensions. Any sharp edges or burrs remaining after compressing the steel tube are filed off to give a smooth finish. Grease is applied over the compressed steel tube.

6.14.4 The aluminium tube is then pulled back over the steel tube. The holes in the aluminium tube are sealed with plugs. The aluminium tube is then compressed to the specified load and dimensions except the portion between the holes which is marked as ‘uncompressed zone’. The portion of the aluminium tube over the compressed part of the steel tube is not to be compressed. The compression is started from the insulator string end of the aluminium tube, skipping the ‘uncompressed zone’, and then worked towards the end of the aluminium tube.

6.14.5 Any sharp edges or burrs remaining after compressing the aluminium tube are filed off to give a smooth finish.

6.15 The conductor is fitted to the relevant insulator string & hardware. The vibration dampers are then fixed on the conductor at the distance specified for the size of the conductor. The distances are given at para 4.12 / 4.13.

6.16 The conductor and tension hardware are hoisted up and fixed on the cross arm of the tower.

6.17 The conductor of the complete section is then pulled at the section end where sagging is to be done. This is called rough sagging and the conductor is pulled such that there is no slack and it is well clear of the ground and power lines in the intermediate spans of the section.

6.18 After being rough sagged as above, the conductor is tied to the stay or anchor provided for it till it is finally sagged / tensioned.

7.0 TENSION STRINGING METHOD (400 KV LINES):

7.1 The tension method of stringing is employed for 400 kV lines where it is necessary to keep the conductor off the ground to minimize surface. The amount of right of way of travel by heavy equipment is also reduced.

7.2 Multi – conductor lines, such as 400 kV lines, are generally strung with the help of tension stringing equipment. In this method, the conductor is kept under tension during the paying out process. This method keeps the conductor clear of the ground and obstacles which might cause conductor surface damage.

7.3 A pilot wire is first payed out in the same manner as earthwire except that the pilot wire is passed through the rollers / travelers fixed on the cross arms.
7.4 The pilot wire is then used to pull in the conductors from the reel stands using specially designed tensioners and pullers. While running out the conductors, care should be taken such that the conductors do not touch and rub against the ground or objects which could cause scratches or damage to the strands. The conductor shall not be over-strained during erection. The conductor drum is jacked up on a steel shaft on a drum jack. The conductor shall be run out of the drums from the top in order to avoid damage due to chafing.

7.5 The site for pulling, tensioning, anchoring and splicing is selected considering accessibility, location of dead ends, length of conductor to be strung, available conductor and pilot wire lengths, puller capacity, and also placement of pullers, tensioners, conductor anchor locations, reel stands, pilot line winders, reel winders and the facility to provide an adequate grounding system.

7.6 The distance of the puller, tensioner and intermediate anchor sites from towers should be selected so that the towers are not overloaded. A minimum pulling line slope of three horizontal to one vertical from the tower to the site is to be provided. It is also necessary that the puller be positioned so that the pilot wire enters the machine at the smallest horizontal angle thereby minimizing the possibility of damaging it. When a bull wheel type puller is employed, the reel winder to recover the pilot wire is located at the pulling site. The pilot line winder is located at the tensioner site.

7.7 The arrangement of the tensioner and reel stands should be such that the lateral angle between the conductor as it approaches the bull wheel and the plane of rotation of the wheel is not large enough to cause the conductor to rub on the sides of the groove. Bird-caging problems in large conductors can be eliminated by using a maximum fleet angle of 1.5 degree from the plane normal to the conductor reel axis and a back tension of approximately 4500 N. Problems of bird-caging are normally more acute in the case of large conductors having three or more aluminum layers.

7.8 Anchors are to be provided for holding equipment in place and holding conductors against tensions imposed after rough sagging. The type of anchor is dependent upon the soil conditions and stringing and sagging tensions. The anchors are provided in the same manner as for towers and conductors/earthwire. Slack should be removed from all anchor lines prior to application of load to minimize the possibility of equipment movement or impact loads to the anchors.

7.9 Adequate grounding should be provided at all sites. The methods required and equipment used for grounding are determined by the degree of exposure to electrical hazards and the soil conditions at the site. All equipment, conductors, anchors and structures within the work area must be bonded together and connected to the ground source.

7.10 After the installation of the pilot wires, a running ground should be installed between the drum stand or tensioner for conductor, or puller for pulling line, and the first tower before pulling in any conductor or conductive type pulling wires. This ground must be connected solidly to the grounding already prepared at the site.

7.11 Pilot wires are pulled in under tension. The pilot wire is connected to a single conductor through swivel link, or to bundle conductors through swivel links and a running board.

7.12 Conductor of only one manufacturer should preferably be used in a given pull, and preferably in any given ruling span. This precaution helps in minimizing the possibility of significant difference in sag characteristic of conductor.

7.13 The conductor is attached to the pilot wire or to the running board or to another drum of conductor to be pulled successively by the use of one end open woven wire grips (also
called “wire socks”) having compatible strength and size as close as possible for the conductor on which they are used. Overall diameter of the grip over the conductor or rope should be small enough to pass over the sheaves without causing damage to the sheave or its lining. The grip should also be capable of mating with the proper size swivel link. Metal bands are installed over the grip to prevent it from accidentally coming off and dropping the conductor. The open end of the grip should be secured with two bands. This should then be wrapped with tape to prevent accidentally stripping the grip off the conductor if the end were to snag or catch.

7.14 Speeds of 3 – 4 km / hour should be maintained so as to provide a smooth passage of the running board or connecting hardware, or both, over the travelers. Slower speeds may cause significant swinging of the traveler and insulator hardware assemblies. Higher speeds may create a potential hazard of greater damage in case of a malfunction.

7.15 The maximum tension imposed on a conductor during paying out operations should not exceed that necessary to clear obstructions on the ground. This clearance should be confirmed by observation. In general, a tension of about one – half of the sagging tension is a good criterion. If greater tensions are required, then, pre – stressing of conductors may possibly result based on the tension and time involved. It should be kept in mind that when long lengths of conductor are strung, the tension at the pulling end might exceed the tension at the tensioner by a significant amount. Difference in tension is caused by the length of conductor strung, number and performance of travelers, differences in elevation of supporting towers, etc.

7.16 Light and steady back tension should be maintained on the conductor drums at all times which shall be sufficient to prevent overrun in case of a sudden stop. It should also be sufficient to cause the conductor to lie snugly in the first groove of the bull wheel and to prevent slack in the conductor between bull wheels. As the drum empties, the force available to overcome the brake drag is reduced, and the tension therefore rises. This may cause the conductor to wedge into the underlying layers on the reel. The brake on the drum stand should therefore be periodically loosened as the conductor is payed out.

7.17 To prevent the problem of bird caging, the drum should be positioned so that it rotates in the same direction as the bull wheels. There should be sufficient distance between the drum and tensioner to permit the strand looseness in the conductor to distribute along the intervening length of conductor and simultaneously maintain enough back tension on the drum to stretch the core and inner strands to sufficiently tighten the other strands.

7.18 Conductor stringing, sagging, plumb marking, clipping, spacing and fixing of dampers should be completed as soon as possible to prevent conductor damage from weather, particularly during high wind conditions. Conductor should not be strung if adverse weather is predicted before the entire sequence can be completed.

7.19 When a bull wheel type puller is utilized, the pilot wire is recovered during the pulling operation on a separate piece of equipment. A reel winder is placed behind the puller in an arrangement similar to the reel stand at the tension site.

7.20 When about 3 or 4 rounds of the conductor remain on the drum, the paying out operation is stopped. The remaining conductor is unwound from the drum. The empty drum is replaced with a new drum. The ends of the conductors from the old and new drums are coupled together using woven wire grips / socks with both ends open. It should be particularly ensured, as given at para 7.13 above, that metal bands are installed and wrapped with tape over both the open ends of the grip to prevent it from accidentally coming off and dropping the conductor. If the ends are not banded and taped, the grips may slip off when passing through the tensioner. The paying out operation is then continued.
When the ends of the conductors from the old and new drums come out of the wheels of the tensioner, the paying out operation is stopped for jointing the conductors. Any of the two methods given below are employed for providing slack or loose length in the two conductors for jointing the ends of the two conductors.

a) Come along clamps are fitted on the two conductors and these are pulled together using tensioning equipment such as turn buckle or pulling and lifting machine. The ends of the conductors thus become loose.

b) A come along clamp is fitted on the conductor under tension in the paying out and connected to an anchor or stay using a wire rope sling. The conductor is held on this anchor or stay. The conductor end from the tensioner is released so that sufficient loose length is available.

The wire sock is removed. The ends of the two conductors are jointed together with a mid span joint as per the generally adopted procedure given in para 9.1. The joint is covered with a joint protector so that it is not damaged when passing through rollers / travellers. The tension in the conductor(s) is released and the paying out operation is then continued. The joint protectors are removed after paying out has been completed.

The conductors, joints and clamps shall be installed in such a manner that there is no bird caging, over tensioning of individual wires or layers or other deformation or damage to the conductors. Clamps or hauling devices should, under erection conditions, allow no relative movement of strands or layers of the conductors.

After the paying out is complete, the conductor is compressed in the dead end hardware at the section point where sagging will not be done.

Steel wire rope is passed through a pulley fixed on the tower cross arm. One end is connected to the conductor and the other end to a pulling arrangement on the other side of the tower. This wire rope is pulled till the load of the conductor is transferred to it. The remaining conductor, now without tension, is cut at approximately the center of the tension tower at this end.

The conductor is compressed, fitted in the hardware, hoisted and anchored to the tower cross arm in the manner described at para 6.14 to para 6.20.

A sketch of Tension Stringing operation is shown in Appendix – B.

REPAIRING OF CONDUCTOR & EARTH WIRE:

Repairs to conductors and earthwire, if necessary in the event of damage to isolated strands of a conductor or earth wire during the course of erection, should be carried out during the paying out operations with repair sleeves. Repairing of conductor surface shall be done only in case of minor damage, scuff marks, etc., keeping in view both electrical and mechanical safety requirements.

Repair sleeves may be used on conductors or earth wire when the damage is limited to the outer layer only and does not affect more than one sixth of the strands of the outer most layer. No repair sleeve shall be fitted within 30 metres of tension or suspension hardware fittings. More than one repair sleeve per conductor should normally not be permitted in any one span.

The surface of the conductor or earth wire where the repair sleeve is to be provided is cleaned with fine emery paper. The open end of the repair sleeve is fitted on the conductor or earth wire so as to cover the portion in need of repair. The cover of the repair sleeve is slid into place. The repair sleeve is then compressed to the required load.
8.4 Any sharp edges or burrs remaining after compressing the repair sleeve are filed off to give a smooth finish.

9.0 PROVIDING MID SPAN JOINTS FOR CONDUCTOR / EARTHWIRE:

9.1 Mid Span Joints for Conductor:

9.1.1 If the ends of the conductors are damaged, the damaged parts are cut off after the aluminium strands are tied up with at least two rounds of binding wire.

9.1.2 The aluminium tube portion of the mid span joint is slipped on to one of the conductors.

9.1.3 A mark is made on the conductors at a distance from their open ends which is equal to half the length of the steel tube portion plus its elongation during compression. The conductor strands are tied up near this mark with two rounds of binding wire. The aluminium strands are cut at these marks to expose the steel core, taking care not to nick the steel strands. The steel strands are tied up with at least two rounds of binding wire as the aluminium strands are cut off.

9.1.4 The two ends of the steel core of the conductors are inserted into the steel tube of the mid span joint making sure that the ends are at the center of the steel tube, i.e., equal lengths of the steel cores of both the conductors remain outside the tube. The steel tube is then compressed, beginning from the center and then first one side and then the other side, to the specified load and dimensions. Any sharp edges or burrs remaining after compressing the steel tube are filed off to give a smooth finish. Grease is applied on the compressed tube.

9.1.5 The aluminium strands of the conductor are cleaned, particularly in the case of old and blackened conductors. The aluminium tube is slipped over the steel joint taking care to ensure that the center of the tube is in the center of the joint. This can be done by marking both the conductors, from the center of the steel joint, at a distance equal to half the length of the aluminium tube.

9.1.6 The holes in the aluminium tube are plugged with aluminium plugs. The aluminium tube is then compressed to the specified load and dimensions except the portion between the holes which is marked as ‘uncompressed zone’. The portion of the aluminium tube over the compressed part of the steel tube is not to be compressed. The compression is started from the end of the ‘uncompressed zone’ and then worked towards the end of the aluminium tube.

9.1.7 Any sharp edges or burrs remaining after compressing the aluminium portion are filed off to give a smooth finish.

9.2 Mid Span Joints for Earthwire:

9.2.1 The mid span joints are provided on earthwire in the same manner as the steel portion of the conductors.

10.0 FINAL SAGGING OF CONDUCTOR:

10.1 After being rough sagged, the conductor / earth wire shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.

10.2 The final sagging of the conductor is done using any of the methods given below.

(a) Sagging winch and a 4 way + 4 way pulley arrangement.

(b) A 2 way + 3 way or a 4 way + 4 way pulley arrangement. This is used for lines upto 220 KV only.

The pulley arrangement is used with steel wire rope of adequate size & strength as per load requirement.
10.3 A come along clamp is fitted on each rough sagged conductor at a distance from the tower on which the final sagging is being carried out. The come along clamp is then connected to the pulley arrangement which is being used for final sagging through a steel wire rope which is generally referred to as “lead”. The length of this lead is such that, after final sag, the come along clamp remains far enough from the tower so that the loose portion of the conductor on the tower side can be pulled up to the cross arm for the purpose of measurement. The different methods employed for final sagging are described in the ensuing paras.

10.4 SINGLE CONDUCTOR:
10.4.1 When the method at para 10.2 (a) above is adopted, a single steel wire rope (lead) is connected to the come along clamp on the conductor. The other end of this lead is connected to the dynamometer which is connected to one end of the pulley system. The other end of the pulley system is connected to the tower cross arm.

10.4.2 The pulling rope of the pulley system above is brought down through single way pulleys installed on the cross arm and on the tower leg at cross arm level. The pulling rope is attached to a tractor through a pulley on the tower leg near ground level. The tractor pulls the pulling rope till the required sag and tension of the conductor are reached.

10.4.3 A sketch showing the above arrangement is given at Appendix – C.

10.4.4 Another way of employing the above method (as given above at para 10.4.1 and para 10.4.2) is the same except that, instead of using a tractor, a sagging winch is used for final sagging. Initially, the pulling rope is attached to a tractor through a pulley on the tower leg near ground level and the tractor pulls the pulling rope till about 80% of the required tension is attained. The rope is then transferred to the sagging winch which is installed on the tower leg near ground level. The sagging winch is then operated to pull the conductor to the required sag and tension.

10.4.5 A sketch showing the above arrangements is given at Appendix – D.

10.4.6 When adopting the method at para 10.2 (b) above, the pulley system is fixed to a ground anchoring point. The pit for anchoring the pulley system is of the same type as that used for towers / conductors as given at para 3.5 except that the steel joist / piece of rail used is 2.3 metres long. The anchoring is done at a distance from the tower such that the angle of the sagging rope to the ground will be about 15°.

10.4.7 One end of the steel sagging rope (lead) is connected to the come along clamp on the conductor and passed on to the other side of the tower (on which sagging is being done) through a single way pulley fitted on the cross arm. The other end of this rope is connected to the dynamometer which is connected to the pulley system. The pulling rope, which is generally taken from the anchoring point end of the pulley system, is attached to a tractor which pulls it (preferably towards the tower side) till the required sag and tension are reached. The pulling rope may be taken from the dynamometer end of the pulley system and pulled away from the tower if it is not possible for the tractor to pull the rope towards the tower side.

10.4.8 A sketch showing the above sagging arrangement is given at Appendix – E.

10.5 TWIN CONDUCTORS:
10.5.1 The method at para 10.2 (a) above is adopted for twin conductors. One steel wire rope lead is passed through an equalizing pulley, of diameter equal to the sub – conductor spacing, and its ends are connected to both the come along clamps on the conductors. This is done so that the tension on both the conductors remains the same. The equalizing pulley is
connected to one end of the pulley system. The other end of the pulley system is connected to the dynamometer. The double tension hardware is hoisted and anchored on the cross arm. The dynamometer is connected to the yoke plate of the double tension hardware.

10.5.2 Sketches showing the above arrangements are given at Appendix – F and Appendix - G.

10.5.3 In the method described at para 10.5.1 above, two leads and two pulley systems, one for each conductor, can be used in place of equalizing pulley. Both the pulley systems are connected to the yoke plate of the double tension hardware and tensioned together one by one. However, dynamometer is used only on one conductor and the sag on the other conductor is matched with the sag of the first conductor.

10.5.4 A sketch showing the above arrangements is given at Appendix – H and Appendix – I.

10.5.5 The pulling rope of the pulley system above is brought down through single way pulleys installed on the cross arm and on the tower leg at cross arm level. The sagging winch is installed on the tower leg near ground level. Initially, the pulling rope is attached to a tractor through a pulley on the tower leg near ground level and pulled till about 80% of the required tension is attained. The rope is then transferred and fixed on the sagging winch which is then operated to pull the conductor to the required sag and tension.

10.6 EARTH WIRE:

10.6.1 The method used for final sagging of earthwire is the same as that used for single conductor stringing.

10.7 The tensioning and sagging shall be done in accordance with the approved ‘initial’ sag – tension charts for conductors and final sag – tension chart for earth wire before the conductors and earth wire are finally attached to the towers through the insulator strings for the conductor and earth wire clamps for the earth wire. If sagging is done using ‘final’ sag – tension charts for conductors, then the following corrections are made in the sag / tension employed at the time of stringing.

a) For 132 kV & 220 kV lines: An over – tension of 12% – 13 % over the tension calculated from the final sag – tension chart is employed which corresponds to a sag 8.3% less than the sag shown on the final sag – tension.

b) For 400 kV lines: The tension and sag applicable for a temperature 26° C less than the prevailing temperature is employed.

10.8 The tension required is calculated on the basis of the equivalent span for the section. The equivalent span is calculated by the following formula:

\[
\text{Equivalent Span} = \sqrt{\left(\frac{\Sigma l^3}{\Sigma l}\right)},
\]

where \( l \) = individual span.

10.9 The tension to be given to the conductor / earthwire is read out from the sag tension chart. A line is drawn vertically upwards from the equivalent span point on the horizontal scale until it cuts the tension curve for the ambient temperature at the time of final sagging. A horizontal line is then drawn from this point to the left upto the vertical scale for tension. The point where this line cuts the tension scale is the tension to be given to the conductor. The horizontal line is also extended, if required, to the point where it cuts the sag curve for the actual spans in which the sag is to be measured.
10.10 A typical sag tension chart showing how the tensions and sags are calculated as per site conditions is enclosed as Appendix – J.

10.11 The sag should be checked in the last span of the section (away from the sagging end) in case of sections of up to eight spans. For sections with more than eight spans, the sag is also checked in one intermediate span also which should preferably be approximately in the middle of the section and as near the length of the equivalent span of the section as practicable. The sag should also be checked when the conductors have been drawn up and transferred from rollers / running blocks to the insulator clamps.

10.12 At sharp vertical angles, the sags should be checked on both sides of the angle. The conductors and earth wire should be checked on the running blocks for equality of tension on both sides. The suspension insulator assembly should normally assume a vertical position when the conductor is clamped.

10.13 Tensioning and sagging operations should be carried out in normal weather when rapid changes in temperatures are not likely to occur. Sagging of conductor on excessively windy days should be avoided since serious error can result due to conductor uplift caused by wind pressure on the conductor. In case severe wind conditions occur when sagging is in progress, the sagging must be stopped till peaceful conditions prevail to resume sagging.

10.14 Sag boards and dynamometers should be employed for measuring sag and tension respectively. The dynamometers employed should be periodically checked and got calibrated with a standard dynamometer. The sag boards are fitted on the towers at a distance below the cross arm which is equal to the sag plus the distance of the conductor in the roller from the cross arm. The required sag is reached when the bottom of the conductor is in the line of sight between the two sag boards.

10.15 The conductors and earth wire shall be pulled upto desired sag and left in the rollers / travelers for at least one hour after which the sag shall be re-checked and adjusted, if necessary, before transferring the conductors and earth wire from the rollers / travelers to the suspension clamp.

10.16 During sagging, care shall be taken to eliminate differential sags in the sub – conductors as far as possible. Once a section has been sagged, the sub – conductors of the bundle should be checked for evenness, and corrected when required.

11.0 DEAD ENDING OF CONDUCTOR:
11.1 After the conductor has been pulled to the required sag and tension, the loose conductor is pulled up to the cross arm using a sisal / propylene rope passing through a pulley fitted on the cross arm. A mark is made on the conductor corresponding to the anchoring point on the cross arm. This mark indicates the length of the conductor from the come – along clamp to the anchoring point on the tower cross arm. The conductor is brought back to the ground.

11.2 The length of the tension hardware assembly with insulator string is measured from its anchoring point to the end of the steel portion of the hardware. This length plus a length equal to the elongation of the steel tube during compression is deducted from the length of the conductor as marked earlier. The aluminium strands of the conductor, after being tied up with at least two rounds of binding wire, are cut at this new mark while ensuring that the steel strands are not scratched. The steel strands are tied up with at least two rounds of binding wire after the aluminium strands are cut off.

11.3 The depth of the hollow tube of the steel portion of the hardware is measured. A mark is made on the steel strands, from the cut end of the aluminium strands of the conductor, which is at a distance equal to the measured length plus a length equal to the elongation of
the steel tube during compression. The steel strands are tied up with at least two rounds of binding wire on both ends of the mark and cut.

11.4 The aluminium tube is first slipped on to the conductor keeping the jumper end on the tower side. The steel tube is then slipped on to the steel strands and compressed to the specified load and dimensions. Any sharp edges or burrs remaining after compressing the steel portion are filed off to give a smooth finish. Grease is applied over the compressed steel tube. The aluminium tube is pulled back over the steel tube. The holes in the aluminium tube are sealed with plugs. The aluminium tube is then compressed to the specified load and dimensions except the portion between the holes which is marked as ‘uncompressed zone’. The portion of the aluminium tube over the compressed part of the steel tube is not to be compressed. The compression is started from the insulator string end of the aluminium tube, skipping the ‘uncompressed zone’, and then worked towards the end of the aluminium tube.

11.5 Any sharp edges or burrs remaining after compressing the aluminium portion are filed off to give a smooth finish.

11.6 The vibration dampers are then fixed on the conductor at the distance specified for the size of the conductor. The distances are given at para 4.12 / 4.13.

11.7.1 If the anchoring of the pulling arrangement has been done on the cross arm as shown in the sketch as at Appendix – C or Appendix – D, or on the ground as shown in the sketch as at Appendix – E, the conductor is then fitted with the relevant insulator string & hardware, hoisted up and fixed on the cross arm of the tower.

11.7.2 The rope which was used to measure the length of the conductor is tied between the third and fourth insulators of the insulator string. The complete hardware and conductor are pulled up towards the cross arm with this rope. A slight over tension is given on the conductor to facilitate the fixing of the tension hardware.

11.7.3 The end of the tension hardware is anchored to the tower cross arm. The tension in the pulley system is then slowly released. If the other end of the tower has already been strung, then the tension in the stays is also reduced while releasing the tension in the pulley system. The tensioning arrangement is thereafter removed and shifted to the next cross arm.

11.8.1 If the anchoring of the pulling arrangement has been done on the double tension hardware as has been shown in the sketches at Appendix – F and Appendix – H, the rope which was used to measure the length of the conductor is tied to the conductor. The conductor is pulled up towards the cross arm with this rope. A slight over tension is given on the conductor to facilitate the fixing of the conductor.

11.8.2 The end of the conductor is connected to the yoke plate of the double tension hardware.

11.8.3 Unevenness or mismatch in the sag of twin conductors, if any, should be rectified as far as possible with the help of sag adjusters. For this purpose, over tension is given on the conductors for varying the length of the sag adjusters. The limit for sag mismatch is 40 mm.

11.8.4 The tension in the pulley system is thereafter slowly released. If the other end of the tower has already been strung, then the tension in the stays is also reduced while releasing the tension in the pulley system. The tensioning arrangement is removed and shifted to the next cross arm.
12.0 DEAD ENDING OF EARTHWIRE:
12.1 After the earthwire has been pulled to the required sag and tension, the loose earthwire is pulled up to the peak / earth wire cross arm using a sisal/ propylene rope passing through a pulley fitted on the peak / earth wire cross arm. A mark is made on the earthwire corresponding to the anchoring point on the peak / earth wire cross arm. This mark (M1) indicates the length of the earthwire from the come – along clamp to the anchoring point on the tower peak / earth wire cross arm. The earthwire is brought back to the ground.

12.2 The length (L1) of the tension hardware assembly is measured from its anchoring point to the end of the steel tube of the hardware. The depth (L2) of the hollow portion of the steel tube of the hardware is measured. This length (L2) is deducted from the length (L1) of the earthwire tension hardware assembly giving a length L3 = L1 – L2. The distance of the mark (M1) from the anchoring point on the tower is re – marked by reducing it by the length L3. The earthwire, after being tied up with at least two rounds of binding wire, is cut at this new mark.

12.3 A mark is made on the steel strands from the cut end which is at a distance equal to the measured length plus a length equal to the elongation of the steel tube during compression.

12.4 The steel tube is then slipped on to the steel strands and compressed to the specified load and dimensions. The compression is started from the tower end of the steel tube, and then worked towards its end.

12.5 Any sharp edges or burrs remaining after compressing the joint are filed off to give a smooth finish.

12.6 The vibration dampers are then fixed on the earthwire at the distance specified for the size of the earthwire. The distances are given at para 4.12 / 4.13.

12.7 The rope which was used to measure the length of the earthwire is tied to the earthwire. The complete hardware and earthwire are pulled up towards the peak with this rope. A slight over tension is given on the earthwire to facilitate the fixing of the tension hardware.

12.8 The end of the tension hardware is anchored to the tower peak. The tension in the pulley system is then slowly released. If the other end of the tower has already been strung, then the tension in the stay is also reduced while releasing the tension in the pulley system. The tensioning arrangement is thereafter removed and shifted to the cross arm.

12.9 The earth bond is connected between the tension hardware and the leg of the tower on which hole is provided for it.

13.0 CLIPPING IN / CLAMPING OF CONDUCTORS:
13.1 The conductors should be clamped within 96 hours of final sagging.

13.2 After final sagging and fixing of the conductors on the towers, the center of the roller is marked on the conductor. After the conductor has been marked, it is lifted from the roller and brought down to the ground. A hoist or a set of two – way & three – way pulleys with rope suspended from the tower cross arm is used for this purpose. The hook used for lifting the conductor should not mark any notch on the conductor or cause severe bends. In case of conductors of the top and middle cross arms, these can be brought down to the middle and bottom cross arms respectively. In case of bundle conductors, the multiple conductors may be lifted simultaneously by using a yoke arrangement attached to the lifting hook.

13.3 The armour rods are first fitted on the conductor after matching the centres marked on the conductor and the armour rods. The anti vibration pads provided in suspension hardware
Stringing of Conductors and Earth Wire

for 400 KV lines is fixed on the armour rods. The conductor is then placed in its permanent suspension clamps and tightened.

13.4 When clipping is being done, care must be exercised to ascertain that the conductors are grounded prior to clipping despite the fact that the lines being clipped are not attached to any electrical source. A local ground / earthing is provided on the conductor at the location of work.

13.5 After tightening the suspension clamps on the conductor, the conductor is again raised and the clamp is fitted in the suspension insulator string.

13.6 The vibration dampers are then fixed on the conductor at the distance specified for the size of the conductor. The distances are given at para 4.12 / 4.13.

13.7 The armouring and clamping operation can also be carried out by trained & experienced personnel sitting in aerial chair. After marking, the conductor is lifted free of the roller and the roller is removed. The armouring and clamping operation is then carried out. The lifting hooks are lowered and the suspension clamp is fitted to the suspension insulator string.

14.0 CLIPPING IN / CLAMPING OF EARTHWIRE:

14.1 A small derrick is fitted on the tower peak and a pulley and rope are fixed on it. The rope is tied to the earthwire and the earthwire is lifted off the roller. The earthwire is fitted in the clamp of the suspension hardware. The clamp is tightened and then fitted on the hardware.

14.2 The vibration dampers are then fixed on the earthwire at the distance specified for the size of the earthwire. The distances are given at para 4.12/ 4.13.

14.3 The earth bond is connected between the suspension hardware and the leg of the tower on which hole is provided for it.

15.0 INSTALLATION OF SPACERS:

15.1 Spacers are installed on bundled conductor lines after the clamping / clipping operations. The installation of the spacers on the conductor varies with the type and manufacture of the spacer and is to be done in accordance with the manufacturer’s recommendations. The number of spacers in each span and the spacing between them is kept as per the approved spacer placement chart supplied by the manufacturer of the spacers.

15.2 This work is carried out by placing the erection crew on the conductors in what is normally known as spacer cycle or conductor car to ride from the towers. Depending on the length of line on which spacers are to be provided and the equipment available, conductor cars can be hand powered, or towed by persons on the ground or on adjacent towers with ropes, or powered by a small engine on the car itself. Care must be exercised to ensure that the concentrated load of the man, car and equipment does not increase the sag appreciably to cause a hazard from obstructions over which the car will pass.

15.3 The load of the man, car and equipment should be equally distributed on all sub – conductors of the phase. This is particularly important at the time each spacer is attached.

16.0 INSTALLATION OF Spacer DAMPERS:

16.1 Spacers Dampers are installed in case of lines where vibration dampers are not used. These are installed in the same manner as the spacers are provided. The number of spacer dampers and spacing between them is kept as per the design requirement and placement chart of the manufacturer of the spacer dampers.
16.2 These are normally placed on the conductors immediately after clamping / clipping to prevent any possible damage to the conductors due to vibration caused by wind which can occur at critical tensions and wind conditions in a matter of a few hours.

17.0 JUMPERING:
17.1 The jumpers at the section and angle towers shall be formed to parabolic shape taking into consideration the natural curve of the conductor formed due to its winding on the drum. The length of the jumper should be cut so that the jumper drop is as per drawing to meet the minimum clearance requirements. Pilot suspension insulator string should be used, if provided in the design of large angle towers or if found necessary otherwise, to restrict the jumper swings to the design values.

17.2 Clearance between jumpers and the tower steel work is to be checked during erection and before handing over the line.
SKETCHES OF ROLLERS / TRAVELLERS / RUNNING BLOCKS

(All dimensions are in mm)
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Single Conductor, Anchoring on Cross Arm, Pulling by Tractor

Come along clamp

Lead

4 way pulley

Dynamometer

Pulley

Conductor

Pull
SAGGING WITH 2 WAY + 3 WAY OR 4 WAY + 4 WAY PULLEY ARRANGEMENT

Single Conductor, Ground Anchoring, Pulling by Tractor

Diagram showing pulley arrangement with labels for Come-along clamp, Pulley, Steel rope/lead, 2 way pulley, 3 way pulley, Dynamometer, Pulling end, and Anchor.
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT

Twin Conductor, Anchoring on Cross Arm. Pulled by Winch
(Using Equalizing Pulley)

- Cone along clamp
- Lead
- Equalizing Pulley
- 4 way pulley
- 4 way pulley
- Dynanometer
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchoring on Cross Arm, Pulling by Winch
(Using Equalizing Pulley)

Conductors

Equalizing pulley

Come along clamps

Dynamometer

4 way + 4 way pulley system

Plan
SAGGING WITH 4 WAY 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchored on Cross Arm, Pulled by Winch (Using Two Pulley Systems)

Pulley
Dynamometer
Conductors
Come along clamp
Lead

ELEVATION
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchoring on Cross Arm, Pulling by Winch
(Using Two Pulley Systems)

Come along clamps
Conductors
Dynamometer

4 way + 4 way pulley system

Come along clamps
Conductors
Dynamometer

4 way + 4 way pulley system

PLAN
### SAG Tension Chart for ACAR "PANTHER" Conductor

#### Conductor Specifications:
- **Material:** ACAR
- **Nominal Size:** "PANTHER"
- **Total Area:** 241.49 sq. mm
- **Stranding:** 36 Al + 7 Steel / 3.00 mm
- **Diameter:** 21 mm
- **Weight:** 0.975 kg / metre
- **Ultimate Strength:** 9127 kg
- **Modulus of Elasticity (Final):** 7890 kg / sq. mm
- **Coefficient of Linear Expansion:** 17.75 x 10^-6 per deg C

#### Use of SAG Tension Chart:
1. Calculate the Equivalent Span as given at para 10.6 of Chapter 6 of Section II.
2. Set at 325 M. Also, assume a temperature of 40 deg C.
3. Mark the point A at 325 M on the x-axis for the equivalent span.
4. Move vertically upward from A till the line crosses the curve for 40 deg C at `T`.
5. Move horizontally to the left from `T` to cut the y-axis for tension at point C. Read the tension. This is 2050 kg. This is the tension to be applied at the time of stringing.
6. Suppose the sag is to be measured in a span which is 335 M. Move along the curve for the actual span of 335 M from the tension line at 2050 kg at `T`.
7. Move vertically downward at this point from the y-axis for the sag at `T`. Read the sag. This is 5.25 M. This is the sag to be measured during the stringing.

#### Scales:
- EQ. SPAN: 1 CM = 5 M
- SAG: 1 CM = 0.5 M
CHAPTER – 7
EARTHING

1.0 GENERAL:

1.1 Earthing of each tower is to be done after the foundation has been casted.

1.2 The earthing connection which was fixed to the stub during concreting of the chimney and taken out horizontally below the ground level is used for earthing.

1.3 As given at para 8.6.1 of Chapter – 4 of this section, this earthing connection is generally provided on Leg 1 and additional earthing, if required, is provided on Leg 3 for pipe type earthing. For counterpoise earthing, the earthing connection is provided on all the four legs.

1.4 The installation of the earthing shall be done in accordance with IS : 5613 – 1989 (Part 3 / Section 2) for 400 kV lines or IS : 5613 – 1985 (Part 2 / Section 2) for 220 kV and 132 kV lines.

2.0 PIPE TYPE EARTHING:

2.1 The pipe type earthing is generally provided outside the base of the tower.

2.2 A typical example of pipe type of earthing is given in Appendix – A.

2.3 A hole of the required diameter and depth is augured in the earth for the earthing pipe.

2.4 The earthing pipe is then put inside the hole.

2.5 A mixture of coke and salt is filled in the hole in which the earthing pipe is provided.

2.6 The earthing strip which was fitted to the stub of the tower leg is then connected to the earthing pipe.

2.7 The Railway authorities specify that the size of the pipe used for earthing should be of 38 mm diameter. Therefore, for towers on both sides of the Railway crossing, 2 pipes connected together are to be used for earthing.

2.8 In case of difficult locations, the pipe may be laid horizontally or slanting and within the tower base or foundation pit.

3.0 COUNTERPOISE EARTHING:

3.1 Counterpoise earthing consists of four lengths of galvanized steel stranded wires, each fitted with a lug for connection to the tower leg at one end. Galvanized steel stranded wire of the size given below is used for this purpose.

<table>
<thead>
<tr>
<th>Voltage Level of Line</th>
<th>Depth of Burial</th>
<th>Length of Each Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 kV</td>
<td>1000 mm</td>
<td>25 metres</td>
</tr>
<tr>
<td>220 kV &amp; 132 kV</td>
<td>450 mm</td>
<td>15 metres</td>
</tr>
</tbody>
</table>

The wires are connected to each of the legs and taken radially away from the tower and embedded horizontally below ground level. The depth of burial below ground level and the length of each wire are normally kept according to the values given in the table below. However, the length of each wire may be increased if the resistance requirements are not met.
3.3 A typical example of counterpoise type earthing of tower is given in Appendix – B.

4.0 TOWER FOOTING RESISTANCE:
4.1 The tower footing resistance of all towers shall be measured in dry weather after their erection and before the stringing of earthwire. In no case the tower footing resistance shall exceed 10 ohms. In case the resistance exceeds this value, multiple pipe earthing or counterpoise earthing shall be adopted in accordance with the relevant procedure given above.

4.2 The additional earthing shall be done without interfering with the foundation concrete even though the earth strip / counterpoise lead remains exposed at the tower end.

4.3 The connections in such cases shall be made with the existing lattice member holes on the leg just above the chimney top.
TYPICAL EXAMPLE OF PIPE TYPE EARTHING

All dimensions in millimeters.
APPENDIX – B

Typical Example of Counterpoise Type of Earthing of Tower

All dimensions in millimetres.

TERMINALS 6 mm THICK

COMPRESSED JOINT

7/3.15 mm or 7/3.66 mm GSS Earth wire

7/3.15 mm or 7/3.66 mm GSS Earth wire

TOWER LEGS
CHAPTER – 8

PROTECTION OF TOWER FOOTINGS

1.0 GENERAL:
1.1 Special measures for protection of foundations shall be taken in respect of locations close to
/ in nallah, river beds, etc. Protection of foundations is also to be provided in the case of
foundations located on the sloping ground of sand dunes or hills.

1.2 The above is to be done, based on site conditions, by employing any or a combination of the
following three methods which are best suited for the site conditions.
   a) Benching.
   b) Protection against cutting of soil by flow of water.
   c) Rivetment.

1.3 A drawing showing the typical use of benching and rivetment for protection of tower
footings is given at Appendix – A.

2.0 BENCHING:
2.1 This method is generally used if the soil is gently sloping and there is no significant
difference in the levels of the soil around the foundation. The soil at the higher level is cut
and spread in the lower level so that the soil near the foundation becomes level.

3.0 PROTECTION AGAINST CUTTING OF SOIL BY FLOW OF WATER:
3.1 This method is generally used where the tower foundation is located at a distance from the
edge of river / nalla, etc. The foundation is protected by providing suitable crate of
galvanized wire netting and meshing packed with boulders.

4.0 RIVETMENT:
4.1 This method is generally used where the ground surface is irregular or where there is
significant difference in the levels of soil around the tower foundation. The rivetment
protection is provided in the form of stone masonry walls around those sides of the
foundation where such protection is required.

4.2 Depending on the site conditions, the following are to be decided:

   a) The side or sides on which the rivetment is to be provided.
   b) Height of the masonry wall.
   c) Length of the masonry wall.

4.3 The rivetment is got constructed generally as given in the typical drawing enclosed at
Appendix – B. This drawing also shows a cross section of the masonry wall for the
rivetment. The drawing is applicable only for a height of masonry wall not exceeding 5
metres.

4.4 The stone masonry wall is constructed at a distance from the tower legs which corresponds
to the angle of repose of the soil. The stone masonry is constructed with 1:5 cement mortar.
The size of stones used for masonry work shall be $300 \times 150 \times 150$ mm or below. The
dimensions are calculated as given in the drawing.

4.5 A base of height 200 mm is first provided. The remaining part of the masonry wall is
constructed on this base to a height of 75 mm above the ground level at the center of the
tower. The width of the masonry wall at the top is 600 mm. Coping of height 75 mm is
provided on the top of the masonry wall with M – 15 concrete (1:2:4 nominal mix).
4.6 Weep holes, staggered horizontally and vertically, for draining of water from inside the rivetment are provided in the masonry at every 2 metres interval. These are generally in the form of 100 mm dia. A. C. pipes. These are given a fall of 1 in 8 from the back to the face of the masonry. The top most weep hole is at a minimum distance of 300 mm below the top. The lowest weep hole shall be 300 mm above the ground outside the masonry wall. A stone packing of size $1000 \times 1000 \times 1000$ mm using river shingles or stones of size 75 mm to 150 mm is provided inside the masonry wall at the opening of each weep hole.

4.7 The inside of the rivetment is filled with earth upto the reference ground level. The earth is rammed to compaction in layers of 150 mm.

4.8 The pointing of the face of the stone masonry wall is done using 1:6 cement mortar.
APPENDIX – A

ELEVATION

Typical Use of Benching and Rivetment for Protection of Tower Footing
TYPICAL SKETCH SHOWING CROSS SECTION OF RIVETMENT OF TRANSMISSION LINE TOWER FOUNDATION

NOTES:
1. All dimensions in mm.
2. This drawing is valid for rivetment wall height H not exceeding 60 m.
3. Minimum depth of rivetment wall below ground level at outer face of rivetment wall shall be 600 mm.
4. Weep holes shall be of 150 mm dia. AC pipes in case of large rivetments.
5. Masonry work to be done in 1:5 cement mortar.
6. Size of stone for masonry work: 300 x 150 x 150 mm and below.
7. Size of stone for packing at weep hole: 75 to 150 mm.
CHAPTER – 9
CLEARING OF RIGHT OF WAY

1.0 GENERAL:

1.1 It is advisable to carry out the work of clearing the right of way as early as possible during the construction of the line.

1.2 The work of clearing of right of way should preferably be carried out in the seasons when there are no standing crops in the agriculture fields. This has two advantages. Firstly, there is least resistance from the farmers. Secondly, there is no need to pay any cost towards compensation for damage to crops.

1.3 However, tree cutting necessary for paying out and sagging of conductor may be got done during the stringing operation.

2.0 CLEARANCE OF RIGHT OF WAY:

2.1 The width of right of way for the various line voltages is repeated below.

<table>
<thead>
<tr>
<th>Line Voltage</th>
<th>Width of Right of Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>132 kV</td>
<td>27 metres</td>
</tr>
<tr>
<td>220 kV</td>
<td>35 metres</td>
</tr>
<tr>
<td>400 kV</td>
<td>52 metres</td>
</tr>
</tbody>
</table>

2.2 A drawing showing the requirements of line clearance within the right of way is given at Appendix – A.

2.3 Cutting of trees, shrubs, bushes, etc. in the right of way is to be got done as shown in the drawing above. All trees, shrubs, bushes, etc. which infringe on the clearances are to be cut.

2.4 Small bush growth, shrubs and trees whose height is not expected to rise beyond 3 meters may be allowed to remain.

2.5 Grass growth on the boundary walls (Dola) of agriculture fields which can grow to a height such as to infringe on the clearance are to be cut.

2.6 Trees outside right of way but of such height as may infringe on line clearance are to be trimmed accordingly.

2.7 Trees or bushes growing inside or very close to the legs of towers shall be cut / removed.
Note: - Portion of tree falling within zone to be topped or trimmed.

LINE CLEARANCE (RIGHT OF WAY) REQUIREMENT
CHAPTER – 10

FINAL CHECKING

1.0 PRECAUTIONS & GENERAL INSTRUCTIONS:
1.1 Conductor / earth wire should not be climbed up under any circumstances in spans where crossing of other power lines are involved without obtaining shutdown of these other power lines.

1.2 The word tower should be deemed to include all kinds of structures used in the transmission line.

1.3 During patrolling, the points given in the ensuing para 2 to para 7 are to be checked and report prepared for each location and span in the proforma given in Appendix – A.

1.4 After the final checking of the line has been completed, the report of defects observed in the line is to be prepared by the Assistant Engineer in the proforma given in Appendix – B and a copy sent to the Executive Engineer / Superintending Engineer. In case of works got done on contract, a copy of the report is also sent to the Contractor for attending / rectifying the defects.

1.5 During the patrolling itself, in case of departmental work, small defects which can be removed are to be attended and remark to this effect be noted in the proforma given in Appendix – B.

1.6 In case of rectification / maintenance which is required to be done under shutdown of other power lines, the Assistant Engineer Incharge of the line shall prepare a programme for taking shutdown / shutdowns and arrange for the same through the Executive Engineer / Superintending Engineer.

1.7 Additional manpower and tools and plants as required for the shutdown works shall be got arranged by the Assistant Engineer – In – Charge of the line / Contractor (as applicable) before taking the shutdown.

1.8 After the rectification / maintenance work is carried out, entry to this effect shall be made in the proforma given in Appendix – B & copy sent to the Executive Engineer / Superintending Engineer.

1.9 The patrolling of Transmission line is to be carried out as and when erection of substantial sections of the line or the total line is completed.

1.10 The rectification shall generally be completed before the line is taken over and cleared for energization. In the case of work contracts, the Engineer – In – Charge shall issue a taking over certificate to the Contractor as proof of the final acceptance of the line when the whole of the works have been completed and have passed all the tests prescribed in the contract to his satisfaction. The Engineer – In – Charge shall not unreasonably withhold nor will he delay the issuance of such certificate on account of minor omissions or defects which do not affect the commercial operation of and / or cause any serious risk to the transmission line. Such certificate shall not relieve the Contractor of any of his obligations which otherwise become due by the terms and conditions of the contract. The Contractor shall give an undertaking to finish any outstanding work expeditiously.
2.0 TOWER FOOTING AND FOUNDATION:
2.1 Whether back filling is complete and there is no settling / shrinking of earth in the pit. There should be no earth on the tower legs. Earth should be 300 mm below the chimney top / coping.

2.2 Whether coping has been done as required. Check shape and height. Coping is to be done up to the lowest bracing on the leg.

2.3 Whether required rivetment / benching has been done. Check condition of rivetment. Earth should be 300 mm below the chimney top / coping.

3.0 EARTHING:
3.1 Whether earthing has been done.

3.2 Measure and record the value of earth resistance. In case the earth resistance is more than 10 ohms, additional earthing is to be got provided.

4.0 TOWERS:
4.1 Whether all tower members have been fitted correctly with correct size of bolts and nuts with spring washers and tightened. There should be no bent or damaged members.

4.2 Whether bolts and nuts are provided on all blank holes.

4.3 Whether punching / tag welding of bolts and nuts has been done. Check painting in case of tag welding.

4.4 Whether the number plates, phase plates and danger plates have been fitted. Check circuit plates in case of double circuit towers.

4.5 Whether anti – climbing device has been fitted. If applicable, whether barbed wire has been provided.

4.6 Whether bird guards have been fitted.

4.7 Check verticality of tower visually. In case of doubt, measure with theodolite.

4.8 Whether Aviation obstruction fixtures / lights / painting have been provided where required.

5.0 CONDUCTOR:
5.1 Check the condition of the conductors. There should be no loose strands or damage to the strands.

5.2 Whether the required number of spacers has been provided as per recommended chart. Whether the spacers of all three phases are in line. (For 400 kV lines)

5.3 Whether sub – conductor sag mismatch is within the limit of 40 mm. (For 400 kV lines)

5.4 Whether correct number and type of disc insulators have been provided. Insulators should be generally clean. They should not be damaged. All locking pins / clips are provided and split open.

5.5 Whether arcing horn, arcing ring & corona control ring, as applicable, fitted correctly on suspension and tension strings.
5.6 Whether all required split pins have been fitted and opened on conductor hardware fittings.

5.7 Whether armour rods / armour grips, as applicable, have been fitted in the suspension hardware.

5.8 Whether vibration dampers have been fitted on the conductors and are vertical.

5.9 Whether proper shape and length of jumpers have been provided and required electrical clearance from tower body is available. Whether lock nuts have been provided on the bolts of the jumper cones. In case of 400kV lines, two rigid spacers are to be provided on each conductor jumper.

6.0 EARTHWIRE:

6.1 Check the condition of the earth wire. There should be no loose strands or damage to the strands.

6.2 Whether all required split pins have been fitted and opened on earth wire hardware fittings.

6.3 Whether vibration dampers have been fitted on the earth wire and are vertical.

6.4 Whether earth bonds have been provided on earth wire suspension and tension hardwares. On angle / tension towers, these are to be provided on tension hardwares on both the sides.

6.5 Whether proper shape and length of jumpers have been provided. Whether lock nuts have been provided on the bolts of the jumper cones.

6.6 Whether aviation warning markers / globules have been provided.

7.0 RIGHT OF WAY & CLEARANCES:

7.1 Whether required tree cutting has been done in the right of way.

7.2 Whether required clearances are available from the ground and roads.

7.3 What is the clearance from power lines, telecommunication lines and railway tracks. (To be measured and recorded)
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Location No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Continue as required</th>
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<tbody>
<tr>
<td></td>
<td>Span</td>
<td>1-2</td>
<td>2-3</td>
<td>3-4</td>
<td>4-5</td>
<td>5-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Back filling complete and no settling / shrinking of earth in the pit.</td>
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<tr>
<td>2.</td>
<td>No earth on the tower legs. Earth 300 mm below the top of chimney / coping.</td>
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<tr>
<td>3.</td>
<td>Coping done as required.</td>
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</tr>
<tr>
<td>4.</td>
<td>Required rivetment / benching done. Condition of rivetment. Earth 300 mm below the top of chimney / coping.</td>
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<tr>
<td>5.</td>
<td>Earthing done.</td>
<td></td>
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<tr>
<td>6.</td>
<td>All tower members fitted correctly with correct size of bolts and nuts with spring washers and tightened. No bent or damaged members.</td>
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<tr>
<td>7.</td>
<td>Bolts and nuts provided on all blank holes.</td>
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<tr>
<td>9.</td>
<td>Number plates, phase plates and danger plates fitted. Also, circuit plates in case of double circuit towers.</td>
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<tr>
<td>10.</td>
<td>Anti – climbing device fitted. Barbed wire provided if applicable.</td>
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<tr>
<td>13.</td>
<td>Aviation obstruction fixtures / lights / painting provided where required.</td>
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<tr>
<td>14.</td>
<td>Condition of conductors. No loose strands or damage to the strands.</td>
<td></td>
<td></td>
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<tr>
<td>Sl. No.</td>
<td>Location No.</td>
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<td>Continue as required</td>
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<td>Span</td>
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<td>3-4</td>
<td>4-5</td>
<td>5-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Required number of spacers provided as per recommended chart. Spacers of all three phases in line. (For 400 kV lines)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>16.</td>
<td>Sub – conductor sag mismatch within the limit of 40 mm. (For 400 kV lines)</td>
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<tr>
<td>17.</td>
<td>Correct number and type of disc insulators provided. Insulators generally clean and not damaged. Damage to glazing within limits. All locking pins / clips provided and split open.</td>
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<tr>
<td>18.</td>
<td>Arcing horn, arcing ring &amp; corona control ring, as applicable, fitted correctly on suspension and tension strings.</td>
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<tr>
<td>19.</td>
<td>All required split pins fitted and opened on conductor hardware fittings.</td>
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<tr>
<td>20.</td>
<td>Armour rods / armour grips, as applicable, fitted in the suspension hardware.</td>
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<tr>
<td>21.</td>
<td>Vibration dampers fitted and at correct distances on the conductors.</td>
<td></td>
<td></td>
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<tr>
<td>22.</td>
<td>Proper shape and length of jumpers provided and required electrical clearance from tower body available. Lock nuts provided on the bolts of the jumper cones. Two rigid spacers provided on each conductor jumper in case of 400 kV lines.</td>
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<td>Sl. No.</td>
<td>Location No.</td>
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<td>Continue as required</td>
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<td>Span</td>
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<td>3-4</td>
<td>4-5</td>
<td>5-6</td>
<td></td>
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</tr>
<tr>
<td>23.</td>
<td>Condition of the earth wire. No loose strands or damage to the strands.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>24.</td>
<td>All required split pins fitted and opened on earth wire hardware fittings.</td>
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<tr>
<td>25.</td>
<td>Vibration dampers fitted and at correct distances on the earth wire.</td>
<td></td>
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<tr>
<td>26.</td>
<td>Earth bonds provided on earth wire suspension and tension hardwares. On angle / tension towers, provided on tension hardwares on both the sides.</td>
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<tr>
<td>27.</td>
<td>Proper shape and length of jumpers provided. Lock nuts provided on the bolts of the jumper cones.</td>
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<td>28.</td>
<td>Aviation warning markers / globules provided</td>
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<tr>
<td>29.</td>
<td>Required tree cutting done in the right of way.</td>
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<tr>
<td>30.</td>
<td>Required clearances available from the ground and roads.</td>
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<tr>
<td>31.</td>
<td>Clearance from power lines, telecommunication lines and railway tracks. (To be measured and recorded)</td>
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</tr>
</tbody>
</table>

**NOTE:** Details of defects / shortcomings are to be recorded separately in the proforma at Appendix – B for arranging rectification.

| Contractor's Representative | Junior Engineer | Assistant Engineer |
# DETAILS OF DEFECTS / SHORTCOMINGS AND THEIR RECTIFICATION

**FINAL CHECKING REPORT OF** [KV LINE FROM ] [TO ]

<table>
<thead>
<tr>
<th>Loc. No. or Span</th>
<th>Nature of defects / shortcomings</th>
<th>Remedial action to be taken</th>
<th>Remedial action taken</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
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Contractor’s Representative  Junior Engineer  Assistant Engineer

APPENDIX – B
CHAPTER 11
TESTING AND COMMISSIONING

1.0 TESTING:

1.1 After final checking is carried out and there are no defects / shortcomings in the work of the transmission line, the line is considered as having been completed and clear for energizing.

1.2 Pamphlets bearing the warning notice as shown in Appendix – A are got circulated in the area through which the transmission line is passing.

1.3 The concerning Executive Engineer shall be present at the time of charging the transmission line who shall ensure that all testing and checking has been done and approval of the relevant authorities has been obtained.

1.4 Before commissioning the line, the tests given below are to be carried out.

2.0 INSULATION RESISTANCE TEST:

2.1 This test is carried with a motor driven megger / insulation tester of at least 5 kV rating. This test is carried out to ascertain the insulation condition of the line.

2.2 Measures for ensuring safety from induced high voltages in the lines should be taken before carrying out this test.

2.3 The line is kept open at the other end. The insulation resistance is measured between each phase and ground, and between the phases. The ambient temperature and weather conditions are noted for future reference.

2.4 The insulation resistance values are dependent on the ambient temperature and weather conditions prevailing at the time when these are measured. Therefore no comparable values are prescribed. However, the values should not be ZERO. The observed values are recorded.

3.0 Conductor Continuity Test:

3.1 The electrical resistance of the conductors is to be measured with a Wheatstone Bridge or other suitable instrument. This test is carried out to verify that each conductor of the transmission line is properly connected electrically. This is verified by comparing with the electrical resistance of a continuous conductor of the same size and length after correcting it to the temperature at which measurement has been made.

3.2 Measures for ensuring safety from induced high voltages in the lines should be taken before carrying out this test.

3.3 For measurement of the resistance, the line is got earthed at the other end. The resistance of each phase to ground is measured. The ambient temperature is noted for reference. The observed values are recorded and compared as given at para 3.4.

3.4 The maximum values of electrical resistance at 20°C of the conductors used in the transmission lines are given below as per IS 398 (Part 2) – 1996 / IS 398 (Part 5) – 1992.
<table>
<thead>
<tr>
<th>No.</th>
<th>Transmission Line Voltage</th>
<th>Code name of Conductor</th>
<th>Resistance in ohms per km</th>
<th>Resistance in ohms per km per phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>400 kV</td>
<td>ACSR Moose</td>
<td>0.05552</td>
<td>0.02776</td>
</tr>
<tr>
<td>2.</td>
<td>220 kV</td>
<td>ACSR Zebra</td>
<td>0.06868</td>
<td>0.06868</td>
</tr>
<tr>
<td>3.</td>
<td>132 kV</td>
<td>ACSR Panther</td>
<td>0.13900</td>
<td>0.13900</td>
</tr>
</tbody>
</table>

4.0 APPROVALS:

4.1 Check and ensure that the approvals have been received from the following authorities.
   a) Power & Telecommunication Coordination Committee.
   b) Railway Authorities.
   c) Electrical Inspector.

5.0 Verify that testing of the control & relay panels including the line protection has been carried out by the Protection Wing.

6.0 The clearance for charging the line, certifying that all men, material, T &P and earthing have been removed from the line, is obtained from the Contractor / Officer – In – Charge of constructing the line.

7.0 The permission for energizing the line is obtained from Load Despatch along with the charging code.

8.0 Clearance is obtained from the sub station at the other end of the line for energizing the line.

9.0 The line is then charged. The following points are checked.
   a) The leakage current meters on the three Lightning Arresters of the line should indicate the leakage current.
   b) In case of 220 kV and 400 kV lines, the line voltage of all the three phases and between the three phases is read in the voltmeter on the control panel of the line.
   c) The checking given above at (b) is also got carried out at the other end of the line.
सर्व साधारण को सूचित किया जाता है कि ............ कंटी का एकल / द्वि परिपथ विद्युत प्रसारण लाइन ......... कंटी की जी.सी.एस.एस. से ........ कंटी की जी.सी.एस.एस. से सब स्टेशन तक का निर्माण कार्य पूरा हो चुका है, एवं लाइन में दिनांक ............ को तक फ़स्काव किसी भी समय उच्च शक्ति का विद्युत प्रसारण प्राप्त किया जा सकता है।

यह नवनिर्मित विद्युत प्रसारण लाइन निम्नलिखित गाँवों से या इनके समीप से होकर गुजर सकता है से या इनके समीप से होकर गुजर सकता है :-

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<thead>
<tr>
<th>क्रं. सं.</th>
<th>गाँव का नाम</th>
<th>क्रं. सं.</th>
<th>गाँव का नाम</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>13</td>
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</tr>
</tbody>
</table>

अतः सर्वसाधारण को सूचित किया जाता है कि उपरोक्त विद्युत प्रसारण लाइन के टावरों (खम्भों), तार, इत्यादि पर चढ़ने या उन्हें छुपने का प्रयत्न न करें, क्योंकि ऐसा करने से जीवन की हानि होने की संभावना है। उपरोक्त सूचना हिदायत के विरुद्ध यदि किसी ने कोई कार्यवाही की, जिसके फलस्वरूप किसी प्रकार कोई हानि हुई तो इसके लिए राजस्थान राज्य विद्युत प्रसारण निगम किसी नी प्रकार का उत्तरदायी / जिम्मेदार नहीं होगा।

अभियंता ( )
राज्यविधान, .................