CHAPTER – 6
STRINGING OF CONDUCTORS
AND EARTH WIRE

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: \( 0.5 + \left( \frac{D \times F}{20000} \right) \text{ sq. cm.} \)

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

where,  
\( D = \) Diameter of the disc in cm.  
\( F = \) 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.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>400 KV</td>
<td>Angle of V String: 100 Deg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of discs</td>
<td>1 × 23</td>
<td>2 × 24</td>
<td>2 × 23</td>
<td>2 × 2 × 23</td>
<td>1 × 23</td>
<td>2 × 23</td>
<td>1 × 23</td>
</tr>
<tr>
<td>E &amp; M strength (kN)</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>160</td>
<td>120</td>
</tr>
<tr>
<td>220 KV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of discs</td>
<td>1 × 13</td>
<td>2 × 13</td>
<td>N. A.</td>
<td>N. A.</td>
<td>1 × 14</td>
<td>2 × 14</td>
<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>132 KV</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 groundwires, 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</th>
<th>Maximum Sag*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Steel</td>
<td>Aluminium</td>
</tr>
<tr>
<td>1.</td>
<td>400 kV</td>
<td>ACSR “Moose”</td>
<td>2</td>
<td>7 / 3.53 mm</td>
<td>54 / 3.53 mm</td>
</tr>
<tr>
<td>2.</td>
<td>220 kV</td>
<td>ACSR “Zebra”</td>
<td>1</td>
<td>7 / 3.18 mm</td>
<td>54 / 3.18 mm</td>
</tr>
<tr>
<td>3.</td>
<td>132 kV</td>
<td>ACSR “Panther”</td>
<td>1</td>
<td>7 / 3.00 mm</td>
<td>30 / 3.00 mm</td>
</tr>
</tbody>
</table>

* Under conditions of maximum conductor temperature of 75°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 over run 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.
7.21 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.

7.22 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.

7.23 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.

7.24 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.

7.25 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.

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

8.0 REPAIRING OF CONDUCTOR & EARTH WIRE:

8.1 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.

8.2 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.

8.3 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:

   \[ \text{Equivalent Span} = \sqrt{\left(\frac{\sum l^3}{\sum l}\right)} \]
   
   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.
A typical sag tension chart showing how the tensions and sags are calculated as per site conditions is enclosed as Appendix – J.

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.

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.

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.

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.

The conductors and earth wire shall be pulled up to 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.

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.

DEAD ENDING OF CONDUCTOR:

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.

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.

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
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
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 → Conducter → Dynamometer → Pulley
Pulley
Pull

APPENDIX – C
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Single Conductor, Anchoring on Cross Arm, Pulling by Winch

Come along clamp
Lead
Conductor
Dynamometer
4 way pulley
Pulley
Winch
SAGGING WITH 2 WAY + 3 WAY OR 4 WAY + 4 WAY PULLEY ARRANGEMENT
Single Conductor, Ground Anchoring, Pulling by Tractor
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchoring on Cross Arm, Pulling by Winch
(Using Equalizing Pulley)

ELEVATION
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchoring on Cross Arm, Pulling by Winch
(Using Equalizing Pulley)

Conductors

Equalizing pulley

4 way + 4 way pulley system

Come along clamps

Dynamometer

P L A N
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchoring on Cross Arm, Pulling by Winch
(Using Two Pulley Systems)
SAGGING WITH 4 WAY + 4 WAY PULLEY ARRANGEMENT
Twin Conductor, Anchoring on Cross Arm, Pulling by Winch
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Come along clamps
Conductors

Dynamometer

4 way + 4 way pulley system

Come along clamps
Conductors

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4 way + 4 way pulley system
APPENDIX – J

SAG TENSION CHART FOR ACSR "PANTHER" CONDUCTOR

CONDUCTOR SPECIFICATIONS:

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ACSR</th>
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<tbody>
<tr>
<td>NOMINAL SIZE</td>
<td>&quot;PANTHER&quot;</td>
</tr>
<tr>
<td>TOTAL AREA</td>
<td>241.49 sq. mm</td>
</tr>
<tr>
<td>STRANDING</td>
<td>38 Al + 7 Steel / 3.00 mm</td>
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<tr>
<td>DIAMETER</td>
<td>21 mm</td>
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<tr>
<td>WEIGHT</td>
<td>0.970 kg / metre</td>
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<tr>
<td>ULTIMATE STRENGTH</td>
<td>9127 kg</td>
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<tr>
<td>MODULUS OF ELASTICITY (FINAL)</td>
<td>780 kN / sq. mm</td>
</tr>
<tr>
<td>COEFFICIENT OF LINEAR EXPANSION</td>
<td>17.75 x 10 ^ -6 per deg C</td>
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Use of SAG Tension Chart:
1) Calculate the Equivalent Span as given at para 10.8 of Chapter 6 of Section II.
2) Say, it is 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 up from point "A" until the line crosses the curve for 40 deg C at "B".
5) Move horizontally to the left from "B" 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 where it cuts the tension line at 2050 kg at "C".
7) Move vertically downward at this point (from the y-axis for the sag at "C". Read the sag. This is 7.25 M. This is the sag to be measured during the stringing.