6. Stringing

6.1 Material Supply

6.1.1 By the Employer

a) The **Employer** will provide all "free issue" material to the **Contractor** in order to complete construction of the project.

b) Quantities and delivery shall be as per the agreed schedules between **Employer** and **Contractor**.

6.1.2 By the Contractor

a) The **Contractor** is to establish the correct quantities of all stringing materials required to complete the Works.

b) The **Contractor** is to provide off-loading and secure storage facilities and shall be held responsible for the proper protection and safekeeping of all material like conductor, earth wire and OPGW until the completion date. The **Contractor** shall be held responsible for any loss or damage to material after delivery.

c) Special lay-down areas are to be made especially for wooden packaging (wooden drums and crates) to prevent direct contact with soil. The lay-down area must be on sufficient high ground to prevent any material standing in water after rain or other wet conditions.

d) If materials that are housed by wooden packaging are on site for longer than 6 months, a longer term solution to storage is noted below and must be implemented to safe guard the contents lifespan:

A solution, which can be proposed or adopted from the preferred below (with acceptance from LES), will require the wooden packaging be placed on a flat elevated position, with sufficient drainage to avoid the wood coming in direct contact with the soil. An elevation of the wooden packaging can be created by using concrete or wooden blocks.

Further, due to the unknown period as to when the contents of the wooden packaging will be re-used, all the wooden packages must be covered to avoid direct and continuous contact with sunlight. The covering should not be blanketing but rather shade creating and the space between individual packaging should be sufficient for air to flow between the packaging. An optional solution to this is to use Tarpaulin covering.

e) The **Contractor** is to verify and confirm the quantities of material supplied by the Employer. Conductor use is to be optimised to obviate excessive waste. A nominal amount (dependant on the terrain - max. 3%) of phase and earth conductor will be allowed for sags and jumpers. Off-cuts and waste shall be returned to the Employer upon completion of the works as scrap.

f) All other surplus material shall be returned to the **Employer** upon completion of the works.

6.2 Installation of Phase and Earth Conductors

All come-along clamps must be colour-coded to indicate the difference between clamps suitable for aluminium conductor and clamps suitable for steel wire. A **silver** colour is to be used for aluminium and **brown** for steel wires.

6.2.1 Changes in Phase Configuration

Where stringing through towers require changes between horizontal, vertical or delta phase configurations, the **Contractor** shall confirm the alignment of the phases with the **Design Engineer** to ensure that the minimum phase clearances are maintained as well as the correct phase orientation(s).

6.2.2 Crossings, Notices and Permits

a) Substantial temporary conductor supports shall be used, or equally effective measures taken, to prevent encroachment of statutory clearances, or other clearance requirements stated in the permits, between the conductor being strung and other power or communication lines, roads or railways being crossed.

b) Suitable structures under each phase will be erected to protect all fences and/or gates from conductor damage during stringing.

c) Temporary changes in poles, fixtures or conductors of lines being crossed will only be carried out if accepted by the **Eskom Site Representative**. The **Contractor** shall indicate any changes considered necessary and the **Eskom Site Representative** will co-ordinate any changes with the owner of the service.

d) The **Contractor** shall notify the **Eskom Site Representative**, at least 45 days in advance, of the time he intends to make crossings of power lines, communication lines, major roads or railways. This notification shall state the location of the crossing to be made, the approximate time of the permit, the length of time that will be required to affect the crossing, and the duration of permit requested. The **Eskom Site Representative** will endeavour to accommodate late changes to the stringing programme; however the **Employer** will not be liable for any time delays or costs resulting from the late programme changes.

e) The **Employer** will endeavour to arrange that all crossings be made with the crossed line de-energised. The time of line outages shall be kept to the absolute minimum. If line outages are not possible, alternative arrangements for live crossings should be made. A method statement of how this power line crossing is intended should be submitted to the **Design Engineer** for acceptance before work commences. All preparatory work shall be done prior to the work permit coming into effect. Upon completion of the work, the **Contractor** shall immediately notify the **Eskom Site Representative** that the lines are clear and release his working permit.

f) Suitable crossing support structures shall be used when obstacles like line, road, rail and other crossings are to be crossed. These support structures shall include but is not limited to prevent the conductors, earth wire or OPGW to be strung to come into contact with the obstacle to be crossed and at all times allow safe working distances, clearances to be maintained under live conditions and impact loads. Detailed safe work procedures indicating type of structures, methodology and material to be used are to be sent to the **Design Engineer** for acceptance prior to constructing the crossing.

g) The preferred live line crossing methodologies that can be used include:

1) Wooden H-poles "Rugby poles" with netting all suitably anchored. Typically used for 11 kV to 66 kV

2) Wooden Frame with netting and 2 cranes all suitably anchored. Typically used for 66 kV to 400 kV

3) Two cranes with running blocks and netting in between all suitably anchored. Typically used for 66 kV to 765 kV.

h) Alternatives to above methods should be submitted to the **Design Engineer** for acceptance.

i) Requirements for OPGW or E/W stringing over live conductors

1) Minimum load that needs to be supported by the proposed crossing systems to be provided by **Design Engineer**

2) Temporary Works Engineer to approve systems

3) Crossing systems to be accepted by Lines Engineering Services

6.2.3 Handling and Stringing of Conductors

a) All phase and earth conductors shall be tension strung using the accepted sag and tension tables for the relevant phase and earth conductor(s).

b) The equipment and methods used for stringing the conductors shall be such that the conductors will not be damaged. Particular care shall be taken at all times to ensure that the conductors do not become kinked, twisted or abraded in any manner.

c) Stringing shall be done in daylight hours only.

d) The **Contractor** shall make suitable arrangements for temporary staying of towers, and anchoring of conductors when necessary. Conductors may not be anchored to any portion of any tower, except strain towers, and then only at the points designed for conductor attachment. Temporary anchoring to footings and guy anchors will not be permitted. Where temporary anchoring is required, suitable temporary anchors shall be provided. Installation and removal of temporary anchors will be the **Contractor's** responsibility.

e) Matched conductor drums, marked with the same number followed by the suffix A, B, C etc., shall be used for each pull of multiple conductors per phase to ensure even sag characteristics and a minimum number of joints. The **Contractor** shall select the most suitable sets of matched conductor drums for each stringing position to minimise wastage of conductor. The **Contractor** shall keep an accurate record of the phase and earth conductor drum numbers and their position in the line. On Completion a copy of these records shall be supplied to the **Design Engineer** and **Eskom Site Representative**.

f) Where multiple conductors per phase are used, these shall be attached to a single running board and strung simultaneously to ensure matched sags. The individual conductors shall be attached to the running board by auxiliary clamps that will not allow relative movement of strands or layers of wire, and shall not over tension or deform individual wires.

g) Running boards shall pass through running blocks smoothly without hanging, catching or causing wide variations in pulling tensions, damage to the running blocks or over stressing of towers. The pulling line shall be a non-rotating type, which will not impart twist or torque to the running board or conductors. Swivels shall be used to attach the pulling line and conductors to the running board. Swivels shall be small enough to pass through the running blocks without damage to either, and shall have ball bearings and be free turning under load.

h) All conductors shall be strung by the controlled-tension method by means of rubber faced, double-bull wheel-type tension stringing equipment. This equipment shall be so designed that there shall be no conduction of the heat generated by the braking action, to the bull wheels. There shall be appropriate mechanical braking on the reels to prevent loose conductor between the reels and the bull wheels, but sufficient tension to pull the conductor in between layers remaining on the reel. Brake controls shall be positive and fail-safe in order to minimise the danger of brake failure.

i) The tension shall be controlled individually on each conductor, and when the desired tension is obtained, the same constant tension shall be held so long as the brakes are left at this setting. Tensions, while pulling, shall be sufficient to clear all obstacles safely without damage to the conductor. At no time shall the pulling tension exceed the tension shown on the sag charts. Pulling of more than one drum length of conductor shall be subject to the **Eskom Site Representative's** acceptance.

j) Adequate protection shall be provided where there is danger of conductors being damaged or scratched, in order to limit corona on conductors. Conductors shall not be left in contact with the ground, vegetable matter or any conducting or semi-conducting material. Wood lagging or similar material shall be used to protect the conductor when working at ground level. Ensure all materials in contact with the conductor are free of nails and other deleterious substances.

k) Radio communications shall be used to relay information and instructions between the conductor tensioning station, intermediate check points, mobile stations and the pulling station at all times during a stringing-tensioning operation. An outage of radio communications at any station will require immediate stopping of conductor pulling operations.

l) The placement of tensioning and pulling equipment shall be such that the vertical angle of pull on a cross arm during stringing operations shall not be more than 20° relative to the horizontal. Conductors shall not be pulled around angles that exceed 20° from the normal direction when pulling the conductor. With tandem-mounted running blocks, the pulling angle shall not exceed 40°. With triple mounted running blocks, the pulling angle shall not exceed 60°. The centre running block shall be adjustable and aligned so that all three running blocks contribute equally to reducing bending on the conductor.

m) The sheaves shall conform to the conductor manufacturer's recommendation as to diameter, and to size and shape of groove for the size of conductor used. Sheaves shall have a minimum diameter of fifteen times the conductor diameter at the base of the groove. Sheave surfaces that will be in contact with the conductor shall be coated with neoprene or rubber. This covering shall be kept clean and free of materials that might damage the conductor surface. The conductor sheaves shall have a separate groove for the pulling line. The pulling line shall not run on the rubber covered conductor grooves. The sheaves shall be inspected for damage or contamination before each usage. The **Contractor** shall not use any sheaves rejected by the Eskom Site Representative due to damage or excessive wear. The **Contractor** shall immediately remove such sheaves from the site.

n) During stringing operations and before regulating, if it becomes necessary to leave the conductor in the blocks for longer than eighteen hours, the conductor shall be left at a much reduced tension, and the **Eskom Site Representative** immediately notified. This reduced tension must be recorded in Newton or kg together with the ambient temperature. The percentage of sag, spans involved, time interval, and correction for creep shall be noted, and records forwarded to the **Eskom Site Representative.** In no case shall conductors be left with less than the following clearances:

1) Cultivated or open country: 6 metres,

2) Roads and rails: 8 metres,

3) Railroad tracks: 9 metres.

o) If it becomes necessary to leave the conductor during stringing for more than 72 hours in the running blocks prior to regulating and clamping in, the contractor shall recommend corrective action and submit to the **Design Engineer** for approval.

p) Bird caging of the conductor and/or earth conductor during stringing shall be avoided by the appropriate positioning of conductor drums relative to the tensioning equipment, as well as other means necessary to minimise conductor/earth conductor bird caging.

6.2.4 Joints

a) Before stringing commences, the **Contractor** will be required to compress sample phase and earth conductor mid span joints, as well as phase conductor dead/end assemblies on site in the presence of the **Eskom Site Representative**, using the matched and numbered dies and compressors intended to be used on the line during stringing. The length of conductor between any two fittings on the sample shall be not less than 100 times the overall diameter of the conductor. Note that for OPGW, the **Contractor** shall make a sample assembly and subject the assembly to the same test procedure as detailed in the next paragraph.

At an acceptable testing authority a tensile load of about 10% of the breaking load of the conductor shall be applied and the conductor/earth wire/OPGW shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily (as per the latest version of SANS IEC 61089) increased to 90% of the breaking load and maintained for 1 min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1 min and no failure of the fitting. The conductor/earth wire/OPGW shall then be loaded to failure, and the joint shall again withstand a minimum load of 95% of the minimum breaking strength of the conductor for it to be deemed acceptable. If the sample joint fails this test, a further three (3) sample joints shall be tested and will all be required to pass the above. If any one or more of these sample joints fail, no stringing shall commence until the **Design Engineer** is satisfied that the jointing equipment is acceptable. A copy of the test report shall be forwarded to the **Design Engineer** prior to stringing. The test report should include the project name and all relevant measurements such as "across-flat" widths, length of samples, suppliers of conductor and compression fittings, equipment used for crimping and dies used for crimping.

b) As far as possible, complete drum lengths of conductor and earth conductor shall be used to reduce the number of joints. Joints shall not be closer than 15 metres to the nearest suspension tower or 30 metres from the nearest strain tower. Joints shall not be installed in spans crossings railways, proclaimed roads, power or important communication lines. In no case shall more than one joint be installed in a given span, nor shall a joint be installed in a span dead-ended at both ends. The minimum distance between joints shall be 300 metres.

c) Whenever joints or dead-ends are made, auxiliary erection clamps and hauling devices shall not be placed closer than 8 m to the point of joint or dead-end. The auxiliary erection clamps shall not allow relative movement of strands or layers of wire, and shall not birdcage, over tension or deform individual wires.

d) When dead-ends are to be done on conductors, **Contractor** is to confirm the location of the new dead-end, by measuring of the full assembly length from the tower landing plate to dead-end location as per hardware and insulator supplier accepted drawings. The strain assembly must be assembled such that the extension links/ sag adjusters are in a midway position allowing adjustment either way. When the location of the dead-end is verified on the conductor, basic clearance checks to tower from that location must be done, using the live end exposed fittings and live end insulator corona ring positions. This will prevent any rework later on if clearances are incorrect. If clearances are not acceptable, the **Contractor** is to inform the **Design Engineer** so that technical options can be looked at to rectify issue. **Contractor** has to have a labelling philosophy in place when working with bundle conductor configurations, so that each conductor in that bundle is marked and cut as per allocated location in strain assembly. All dead-end flags must be orientated as per drawings accepted by **Eskom**.

e) The conductor shall be cut with a ratchet or guillotine cutter to produce a clean cut, retaining the normal strand lay and producing minimum burrs. The aluminium strands shall then be stripped from the steel core by using an acceptable stripper. Under no circumstances shall high tensile hacksaw blades be used to cut conductor.

f) The conductor shall be laid out for a distance of 15 metres and straightened at the ends before preparation for installation of joints or dead-ends. Compression jointing shall be carried out on a clean tarpaulin or jointing trailer. The lay of wires shall be tightened before the first compression is made. The conductor strands shall be cleaned by wire brushing and an accepted non-oxidising paste applied. Compression joints shall be carefully made so that the completed joint or dead-end is as straight as possible. To minimise distortion, the joint should be rotated 180° (rotation to be in the same direction as the lay of the wires) between each compression operation, with the joint and conductor being fully supported in the same plane as the compression jaws. If, required by the **Eskom Site Representative**, the completed joint or dead-end shall be straightened on a wooden block by using appropriate tools. Any damaged joints or dead-ends shall be replaced.

g) After compression joints have been completed, all corners, sharp projections and indentations resulting from compression shall be carefully rounded. All other edges and corners of the fitting that have been damaged shall be carefully rounded to their original radius. Nicked or abraded surfaces shall be carefully smoothed. Tape, tape residue and filler paste shall be removed from fittings and conductors.

h) Sufficient notification shall be given to **Eskom Site Representative** prior to the installation of compression fittings. Unless previously agreed all joints and dead-ends shall be installed in the presence of the **Eskom Site Representative**.

i) Under no circumstances shall compression joints be allowed to pass over the running blocks unprotected. Suitable exterior covering/protection must be applied over compression joint after crimping to allow safe movement over running blocks.

j) During the progress of the stringing, the **Contractor** shall keep an accurate record of the spans in which conductor and earth conductor joints are made, the date of assembly onto the conductor. A copy of these records shall be supplied to the **Design Engineer**.

6.2.5 Preparation of Metal to Metal Contact Surfaces

All current carrying connections, contact surfaces, clamps, conductor and terminals shall be prepared as follows:

a) wipe the mating surfaces free from grease and dirt (except the bores of compression sleeves);

b) apply 1 mm thick coating of approved jointing compound to the surfaces using a non-metallic spatula or similar tool;

c) scrub all the coated surfaces thoroughly with a wire brush which is new or which has been used solely for this purpose;

d) wipe off the jointing compound;

e) apply a fresh 1 mm thick coating of compound; and

f) After a period of not more than one minute make the connection in the normal manner and remove excess extruded compound.

Note: No jointing compound squeezed out by clamping pressure shall be used in making further joints. The Contractor shall apply such compound as necessary for making the connections by the method outlined above. On bolted connections care shall be taken during the tightening to avoid overstressing the bolts or components of the clamps. A torque wrench shall be used for tightening each bolt to the required torque.

g) Tighten all bolts and U-bolts to their specified torque on suspension clamps and other relevant hardware.

h) Leave clamps for 24 hours to allow aluminium conductor to expand and contract.

i) Check all bolts to ensure that they are still at the required torque as stipulated on the components or hardware assembly drawings.

j) Ensure Wedge Lock or Belleville washers are installed on all jumper flags.

6.2.6 Conductor Repairs

a) Damage caused by the **Contractor** shall be repaired in a manner determined by the **Eskom Site Representative.** Damage is any deformity on the surface of the conductor that can be detected by eye sight or by feel. Damage includes, but is not limited to nicks, scratches, abrasions, kinks, bird caging, and popped out and broken strands.

b) Depending upon the severity of the damage and the length of damaged section, the repair shall be made by careful smoothing the deformity with extra fine sandpaper, covering with preformed repair rods, installing a compression-type repair sleeve, or by cutting and splicing.

c) Kinked, bird caged or severely damaged sections of conductor shall be cut out. When there is repeated damage in the same span, or in consecutive spans, the entire conductor in such spans shall be replaced.

d) All damage caused by auxiliary erection clamps or other gripping devices shall be repaired or cut out, as instructed by the **Eskom Site Representative**, before the conductor is sagged.

e) Preformed repair rods shall be installed if no more than one strand is broken, or nicked deeper than one third of the strand diameter, or when a number of strands are reduced in area not exceeding the area of one strand. Not more than two sets of preformed repair rods shall be installed on any one conductor in any given span.

f) A compression-type repair sleeve shall be installed, if not more than one third of the outer strands of the conductor are damaged over a length of not more than 100 mm, or not more than three strands are broken in the outer layer of conductor and the area of any other damaged strands is not reduced by more than 25%.

g) Compression-type repair sleeves shall not be installed on one conductor in a given span if it already contains a conductor splice, conductor dead-end or another compression-type repair sleeve.

h) If damage exist in the outer and inner aluminium layers but no damage exist on the steel centre core for ACSR conductors, then a preformed type line splice can be considered. Details of the proposed repair should be provided to the **Design Engineer** for final acceptance.

i) Damage to the steel strands or aluminium strands, exceeding the stated limits for repair sleeves, shall be cut out and spliced by means of a compression type mid-span joint.

j) Any foreign matter such as pitch, paint and grease placed on the conductor and fittings by the **Contractor** shall be removed by methods accepted by the **Eskom Site Representative** prior to regulating.

6.2.7 Regulating

a) To have better quality control on stringing, the contractor must submit a schedule of how he intends stringing the strain sections and give locations of puller and tensioner used for the **Eskom Design Engineer** to review for acceptance. The tensioner must be behind the tower to be strained off. Should there be a deviation from this process, then the **Contractor** must supply a detailed method statement to demonstrate how he can safely execute the stringing operation. This deviation must be sent the **Eskom Design Engineer** for acceptance prior to commencement of any stringing operations. The **Contractor** is to ensure that appropriate equipment and accompanying hardware is selected for the specific application.

b) The **Contractor** shall string all conductors and earth conductors to the appropriate sags and tensions as determined from the conditions specified in the Works Information. The calculation of clamping offsets shall be the responsibility of the **Contractor**, based on sag tension charts supplied by the **Design Engineer**. Such calculations shall be submitted to, and accepted by the **Design Engineer** prior to regulating.

The appropriate conductor temperature to be used for sagging shall be determined by means of a Celsius thermometer inserted in the end of a suitable length of conductor or earth conductor from which a 150mm length has been removed from the centre strand, or other accepted method. The wire with the thermometer inserted shall be hung at cross arm level for at least two hours before the temperature is read.

c) The length of a section of phase and earth conductors to be regulated at any one time shall be limited to that length that will assure attainment of correct sag based upon terrain and obstructions.

d) Where there are a large number of suspension towers between strain towers, regulating of phase and earth conductors shall be done at intervals of 3 to 5 spans. In hilly country the conductors may require to be temporarily anchored one span away from the spans being regulated. The sag spans chosen shall be near each end of the section pulled for single conductor lengths, and near each end and at the middle for double conductor lengths. In addition, the sags shall be checked in all spans over 500 metres. In unusual situations, the **Eskom Site Representative** may require additional checks.

e) The **Contractor** shall provide, and maintain in good condition, suitable dynamometers, sag boards or other accepted apparatus for the proper checking of the work. Dynamometers shall read in Newton and shall be tested and recalibrated at regular intervals. The **Contractor** shall keep dynamometer calibration certificates at the site office.

f) The **Contractor** shall notify the **Eskom Site Representative** at least twenty-four hours prior to any planned regulating operation. No regulating shall be done except in his presence, unless otherwise authorised. The **Contractor** shall provide labour and equipment, for signalling and climbing purposes as requested by the **Eskom Site Representative**, to facilitate his inspection of the sag.

g) In pulling up the conductor, caution shall be used to avoid pulling the conductor above sag height.

h) The maximum elapsed time from the beginning of the pulling operation to the completion of the regulating operation shall not exceed seventy two hours, nor shall the maximum elapsed time between the completion of the regulating operation and the completion of the clamping operation exceed seventy two hours. Conductor remaining in the blocks longer than the established limits shall be subject to inspection and, if damaged, replaced. The **Contractor** shall provide labour and equipment as requested by the **Eskom Site Representative** for this purpose, as well as for inspection in the event of sudden windstorms.

i) No minus regulating tolerance will be allowed. A plus regulating tolerance of 0.01 times the theoretical sag, but not exceeding 150 mm will be allowed, provided all conductors in the regulating span assume the same relative position to true sag. Sags of conductors in the same bundle shall not vary more than 35 mm relative to one another. Sag variances between phases shall not be apparent to the naked eye.

j) When finally adjusting the sags of conductors and earth conductors, the sag shall be checked with sag boards, or other accepted methods in spans where the levels of the two towers are approximately the same, and the span length is approximately equal to the equivalent span length of the strain section. Upon completion of this regulating operation, as many successive spans as can be observed from the sag board position shall be checked for uniformity of sag.

k) All conductors, except for conductors in sag sections over flat terrain, shall be plumb-marked at each structure for the complete section regulated, before clamping-in or dead-ending of the conductor is begun. Conductors shall be marked with paint crayon or wax pencil - not with metal objects.

l) Insulator strings on three suspension towers adjacent to a new section to be regulated shall be clamped to the conductor before temporary anchors are removed and regulating of the new section begins. These insulators shall remain in the plumb position upon completion of regulating of the new section and during plumb-marking.

m) Regulating operations shall be conducted during daylight hours only. Regulating operations shall be suspended at any time, when in the opinion of the **Eskom Site Representative**, wind or other adverse weather conditions would prevent satisfactory regulating.

n) Records of temperature sag and tension for each section regulated shall be kept by the **Contractor**, and a copy supplied to the **Design Engineer.**

o) On completion of regulating of a section of the line, the **Contractor** shall measure and record all clearances over roads, power lines, communication lines, railways etc. along the route. A copy of these clearance records is to be submitted to the **Design Engineer**. The **Eskom Site Representative** is to be notified immediately of any discrepancy found between the actual clearance and that shown on the profiles.

6.2.8 Clamping of Conductors

a) The conductors and earth conductors shall be clamped-in by the **Contractor** after the **Eskom Site Representative** has accepted the regulating operation as being in full compliance with the standards and stringing data. Where offsets are required, the conductors shall be accurately adjusted in accordance with the offset clamping information developed by the **Contractor.**

b) All conductors in a sag section shall normally be clamped-in, beginning at the second structure from the forward end of the pull, and shall progress structure by structure, until the conductors at all structures are clamped-in.

c) The **Contractor** shall exercise extreme care in moving the phase and earth conductor from the stringing blocks to the suspension clamps.

d) Where armour rods or conductor clamps incorporating armour rods are called for, they shall be installed in strict accordance with the manufacturer's recommendations. Armour rods shall be centred in each suspension clamp in such a manner that the clamp is not more than 50 mm from the centre of the rods. Variations between the ends of the individual rods shall not exceed 12 mm. Aluminium rods shall be handled with the same care as the conductor.

e) Properly calibrated torque wrenches shall be used to tighten suspension clamp and dead-end bolts to the manufacturers' specified torque values. U-bolts shall be drawn up evenly to torque values. Bolts shall not be tightened excessively. Proof of calibration shall be submitted to the **Eskom Site Representative**.

f) All conductor support assemblies shall be installed such that the insulator string will hang in a vertical plane through points of insulator string attachment to structure, with the structure properly aligned.

6.2.9 Vibration Dampers for Single Conductors

a) Where vibration dampers are specified, these shall be installed at each suspension and strain point. The number of dampers to be installed per span shall be as recommended by the manufacturer. The spacing from the mouth of the strain clamp or the centre of the suspension clamp shall be in accordance with the manufacturer's recommendations.

b) If the use of armour rods makes it impossible to meet this spacing, the first damper shall be positioned at the end of the armour rods, and any additional dampers shall then be spaced from the first damper. Dampers shall be located within 25 mm of their correct position.

c) Vibration dampers shall be installed when clamping the conductor, but only after the conductor has been securely fastened in the conductor support assembly.

d) Stockbridge type vibration dampers shall be installed so that they hang directly under the conductor.

The installation of vibration dampers shall be in accordance with the manufacturers' recommendations.

6.2.10 Bundle Conductor Spacers and Spacer Dampers

a) On lines employing more than one conductor per phase, spacers or spacer-dampers, shall be installed to separate the individual conductors of each phase.

b) Conductor spacers or spacer dampers shall be installed immediately after clamping the conductors, but in no instance shall conductors be allowed to remain without spacers installed for longer than seventy-two hours after clamping.

c) Notwithstanding the allowed times between stringing, regulating, clamping and fitting of vibration dampers, spacers or spacer dampers, the overall time for these operations shall not exceed six days (144 hours).

d) Conductor spacers or spacer dampers shall be installed within 1 000 mm of the positions as specified by the manufacturer in a staggered (non-equal) spacing distance between spacer dampers, as per the manufacturers' installation instructions or spacing chart.

e) Conductor spacer carts used by the **Contractor** to move his men along the conductor shall be furnished with neoprene or rubber lined wheels to support the carts on the conductors. The carts shall be equipped with an odometer, which shall run on one sub-conductor and indicate distances in metres. The odometer shall be set in such a manner, as to give the distance from the suspension clamp to all cart positions along the span on the centre phase from which all the hardware on the three phases will be aligned perpendicular to the centre line of each span. Spacer-dampers will also be installed perpendicular to the sub-conductors of each phase along the catenary.

6.2.11 Aerial Warning Spheres and Bird Flight Diverters

a) Bird Flight Diverters should be installed on both the earth wires / OPGW, in the case of a line having two earth wires, in a staggered alternating configuration as indicated in the figure below.

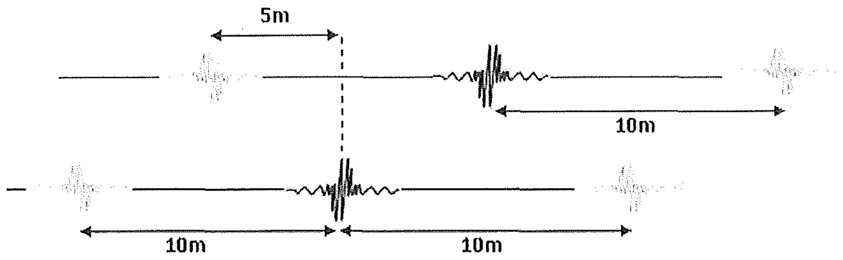

Figure 6: Installation of bird flight diverters

b) For the installation of Aerial Warning Spheres, it is recommended to use the following procedure:

1) Install the Aerial Warning Spheres on a single ground wire, but alternate the colours (white and red or orange)

2) The Aerial Warning Spheres have to be installed on the highest wire of the affected line spans, typically on the ground wires

3) They are to be located 30m from the tower, and 30m from each other along the span. White and Red/Orange Aerial Warning Spheres should alternate along the span, as shown in figure 7. This method will guarantee that the pilot sees the alternating affect from any approach angle.

4) If bird flight diverters are required on the same span, they will be installed as usual with the ones clashing with the position of the Aerial warning spheres omitted.

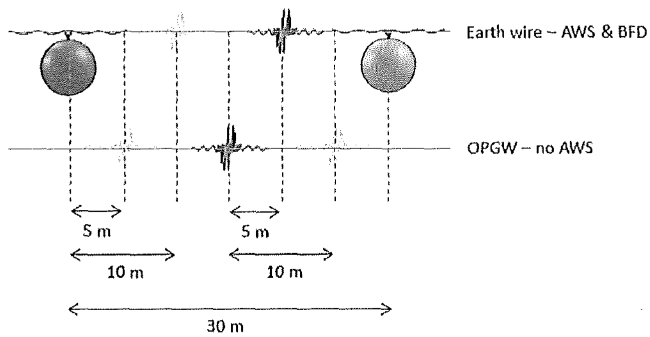

Figure 7: Installation of Aerial Warning Spheres

6.2.12 Jumpers

a) The jumpers shall be formed to provide the maximum amount of clearance from earthed hardware, and tower steelwork. Their positioning shall comply with the clearances stated under the specified displacements.

b) The **Contractor** shall supply labour and equipment to assist the **Eskom Site Representative** in measuring clearances from jumpers to earthed hardware if requested.

c) Jumpers not meeting the required clearances shall be removed and replaced.

6.3 Stringing of OPGW

In general the stringing of OPGW is the same as for the earth wire but the relevant installation standard for OPGW need to be adhered to.

7. Insulators

This section considers the handling, storage, transportation and installation practice of insulators.

The **Contractor** will adhere to the following guidelines regarding insulators.

7.1 Receiving

a) Inspect crates for damage upon delivery to site.

b) Open the crate carefully, ensuring that all tools used are kept well away from the insulators.

c) On removal of the lid and any internal battens, remove or flatten all exposed nails.

d) Any packaging damage must be:

1) Reported immediately to the **Eskom Site Representative**.

2) The supplier's representative must be immediately advised and the crate set aside for inspection by the manufacturer's representative, his insurance assessor or the relevant Eskom technical or quality assurance personnel.

3) Each insulator from the damaged crate must be visually inspected for damage.

4) Damaged insulator units must be marked to prevent inadvertent later use.

e) Check that the type numbers on the insulators agree with those on the order and the packing lists.

f) Sample and routine test reports must be included with the delivery.

g) Return the insulators to their original crates and re-seal.

7.2 Storage

a) Insulators must preferably be stored in their original crates.

b) Insulators in their crates must preferably be stored indoors.

c) Crates stored outdoors must be in pressure treated lumber rather than regular lumber or cardboard boxes.

d) Crates should be stored off the ground.

e) Stacking of boxes/crates must not cause squashing of lower boxes/crates. In the event of damage, point c) in the "Receiving" section 7.1 must be followed.

f) Heavy material must not be stored on top of boxes/crates due to potential damage.

g) If insulators are to be stored out of boxes/crates, care must be taken to protect them from damage:

1) They must not be stacked on top of each other.

2) Other material must not be placed on top of them.

3) Accepted storage methods include using designated bins, suspension hooks, PVC pipes or builders' tubes

h) Storage areas must:

1) Avoid water ingress into the boxes/crates or areas of standing water.

2) Be free of oils and petrochemical products.

3) Avoid possible rodent damage

7.3 Loading and off-Loading

a) Care must be exercised when using forklifts, so as not to penetrate boxes/crates and damage the insulators. Damaged boxes/crates will be subjected to point c) in the "Receiving" section 7.1.

b) Any nails or screws left exposed on removal of the box/crate lid, or internal batons, must be removed prior to removing insulators from the crate to prevent damage.

c) For polymer insulators shipped in plastic protective covers, the cover should be cut at the end only and not along its length.

7.4 Transport to site

a) Where possible, insulators must be transported in their original boxes/crates.

b) For the transport of unpacked insulators:

1) PVC pipes and builders' tubes can be used.

2) If protective coverings cannot be used, then the insulators should be stacked side-by-side.

3) Avoid placing objects on unprotected insulators.

4) Insulators should not be tied down using ropes, chains etc.

7.5 Visual Inspection of Insulators

a) Insulators must be visually inspected for damage prior to installation.

b) For polymer insulators, the following can be visually inspected:

1) Bonding of the rubber to the fibreglass rod and end fitting area.

2) Cracks or splits on the sheds and sheath.

3) Knife cuts.

4) Poor hot dip galvanizing or corrosion on the end fittings.

5) Mould accumulation. A method for mould removal should be suggested by the **Eskom Site Representative**. Preferably use water and a cloth to clean. Do NOT use solvent/oil-based detergents or abrasive materials to clean.

6) Unclipped sheath sections

7) Rodent damage

c) For glass insulators, the following can be visually inspected:

1) The clarity of the glass and streaks or cracks developing.

2) The porosity of the cement.

3) Poor hot dip galvanizing or corrosion of the end fittings

4) Split pin type and condition

7.6 Insulator Handling

a) Insulators must not be dragged on the ground.

b) Insulators must not be thrown on the ground or lie where inadvertent vehicle damage may occur.

c) Polymer insulators must not be bent or twisted.

d) A polymer insulator less than 2.5 m in length can be carried by one person holding the core at a central point.

e) A polymer insulator longer than 2.5 m in length must be carried by two persons, each holding the insulator 0.5 m from each end.

f) Bending must be kept to within a 30^0 angle from the horizontal when carrying long insulators.

g) For post insulators, slings must be placed around the end fittings for lifting and moving.

h) Under no circumstances must slings be attached to the shed areas of polymers.

7.7 Installation

a) Prior to raising the insulators must be inspected visually for damage.

b) For cap and pin units, the correct installation of cotter keys must be checked.

c) A ground sheet must be provided for the assembly of insulators and hardware.

d) Corona rings must be fitted correctly, according to the supplier's drawing and instruction sheets.

e) Sleeves can be used to prevent polymer shed or glass damage.

f) For polymer insulators, ropes or lifting lines must be attached around the metal end caps and not the shed areas. The ground line must be controlled by a ground-based lineman to prevent the insulator colliding with the structure.

g) For glass insulators, ropes and lifting lines must not be connected in between discs to prevent loading and damage to the split pins.

h) Working platforms, bucket trucks, tools etc., must not come into contact with the insulator during and after installation.

i) The climbing and walking on both insulators and corona rings are not permitted.

j) Insulators may not be used as anchoring points for pulleys, tools, safety belts and/or any other equipment.

k) No bending or twisting of the polymer insulator is permitted during attachment of hardware or during stringing. Do not try to rotate one end of a polymer insulator while the other end is fixed.

7.8 Post Installation

A final visual inspection on the installation should be done to determine:

a) Any signs of damage, including torsional loading.

b) Signs of bending or deflection.

c) Incorrectly applied insulators or hardware, including corona rings.

7.9 Marking, Labelling and Packaging

Where applicable, all marking, labelling and packaging must conform to the relevant standards.

7.10 Spares

Where spares-holding is a requirement, it must conform to the relevant standards.

8. Line Impedence Measurement

Line impedance measurements shall be carried out for all new transmission lines built. The measurement shall be carried out as per the latest revision of specification number 240-143268945, Transmission Line Impedance Measurement Specification. As per the requirements of the test, the measurements must be done **after construction completion but before the line is energised. One day must be set aside as a hold point on the project before commissioning.** Ideally, the test should be done after the line is inspected and any conductor, jumper and earth wire defects are repaired in order to not negatively affect the results of the test. The results of the test must be sent back to Lines Engineering Services, Eskom as soon as possible to verify. This is to allow for re-measurement, if there are any errors, before the line can be energised.

This activity must be performed by the **Contractor** however, if required, Lines Engineering Services can assist with this task (in such instance, the **Project manager** is to eliminate cost from BOQ).

For short lines; i.e. under 30 km; using differential protection, this test may not be required. The **Contractor** must confirm with Eskom Protection and Lines Engineering Services; via the **Project Manager**; before discarding this test on short lines.

9. As-Built Documentation

This section outlines the information that is required to be captured during and at the completion of construction of a new transmission line to form the as-built file. The **Contractor** must provide the as-built information in accordance with the format prescribed in the latest version of 240-72252925 (As-built document template) and outlined in **Annex E**. The template also specifies the standard format in which some of the data is required to be captured in.

The referenced template is also accompanied by an Excel spread sheet template which must be requested for from the **Design Engineer** for the **Contractor** to populate during construction.

10. Corrosion Protection

The corrosion protection system selection for all the various components on a transmission line is specified in the relevant line specification.

10.1 Hot Dip Galvansing

a) The **Contractor** shall include the number of the relevant standard i.e. SANS 121 (ISO 1461), in the instruction to the hot dip galvanizer.

b) Galvanising thickness requirements indicated in the relevant line specification shall be clearly communicated to the hot dip galvanizer.

c) The **Contractor**; before the material leave the hot dip galvanizer; should undertake acceptance inspections. Records of these inspections should be kept for auditing purposes and sent to the project manager for record keeping. The **Eskom quality inspector** should also be notified to verify the measurements obtained by the contractor. The number of articles that needs to be tested in a sample is specified in SANS 121. However, a lot in this instance is defined as a single delivery load and the control sample size is based on the number of each component type included in the delivery load. Each component classification forms its own control sample size within the lot e.g. 45x45x3, 50x50x4, etc.

d) The thickness of the hot dip galvanising on the components shall be inspected based on the thickness specified in the relevant line specification as well as making use of the table in Annex G

e) If the coating thickness on a control sample does not conform to the minimum requirements (stated above), twice the original number of articles shall be taken from the lot to be tested. If all the samples from the larger control sample passes, the complete component classification for that lot shall be accepted. If a sample from that larger control sample does not pass, the component classification for that lot shall not be accepted.

10.1.1 Tower Steel Members

a) The steel selected for manufacturing purposes of poles and lattice structures should be suitable for hot dip galvanizing. In general two steel types are acceptable namely "Aluminium Killed Steel" and "Silicon Killed Steel". Table 1 in SANS 14713-2 gives a guidance on steel composition and typical coating characteristics that can be expected.

   1) For Aluminium Killed Steel: **0.01 ≤ Silicon (Si) ≤ 0.03% and Phosphorous (P) < 0.015% maximum.**

   2) For Silicon Killed Steel: 0.**15 ≤ Silicon (Si) ≤ 0.25% and Phosphorous (P) < 0.02% maximum.**

b) Certified mill test reports of the chemical and mechanical properties of the steel for the full quantity required for fabrication shall be obtained from the steel supplier. These reports shall be supplied to the hot dip galvanizer to ensure thickness requirements specified in design documentation can be achieved.

c) Pre-treatment requirements, if necessary to achieve specified thickness, shall be discussed between the **Contractor** and the hot dip galvanizer and clearly communicated to the **Employer**.

d) **Contractor** to provide **Employer** with a certificate from the galvaniser with regards to work done (avg thickness achieved, surface preparation, etc.) as per acceptance process above.

e) All material shall be free from excessive white rust and black staining when it is handed over to **Employer**. To assist in meeting this requirement, close attention shall be paid to the manner in which the material is stacked and stored at the galvaniser's works and also during its subsequent handling until such time as it is handed over to **Employer**. Material which has been inspected at the galvaniser's or manufacturer's works and passed by appointed inspectors will still be liable to rejection if it has been found that excessive white rust has developed between the date of inspection and the date when the material is handed over to **Employer.** If the material is affected by excessive white rust the **Contractor** may clean it (using non-metallic brushes) before handing over and if thickness measurements of galvanised coating still meets the requirements specified in the appropriate tables in Annex G, the material will be accepted.

f) The preferred method of repair is by zinc metal thermal spraying, but due to the remoteness of sites and the unavailability of metals spraying equipment, repairs by a zinc-rich epoxy paint (of at least 100 µm or more than specified galvanising thickness) with at least 82% zinc in the dry film can be used. For convenience of application and accurate mixing of ingredients that make up the zinc rich epoxy, products in a "squish pack" form endorsed by the Hot Dip Galvanising Association (HDGASA) can be used.

g) These repairs should be limited to small coating defects not larger than 25mm diameter. Surface preparation is key and the affected area should be cleaned of contaminants (grease, oil, etc.) by means of approved solvents. The area should then be abraded with abrasive paper (80 grit roughness) or with a stainless steel brush. Dust and debris should be removed, and the area is adequate for repair using an approved product.

10.1.2 Bolts, Nuts and Washers

a) Bolts, nuts and washers shall be hot dip galvanised in compliance with the latest revision of SANS 10684.

b) As a general rule when hot dip galvanizing a threaded component or ISO metric fastener, the galvanizing of one thread either internal or external requires an extra clearance of four times the coating thickness. In practice it is normal for standard bolts from stock to be fully galvanized, but for nuts to be galvanized as blanks and then tapped up to 0.38-0.42 mm oversize with the threads lightly oiled. When assembled the nut thread is protected by contact with the coating on the bolt. The SANS 1700 standards on bolts and nuts do not make provision for this and hence all galvanized bolts and nuts should be manufactured according to Annex A.

c) Hot dip galvanising on fasteners that is applied using the centrifuged method should have a thickness specified in the relevant table in Annex G.

d) Further to the requirements as stated above, if protection of bolts, nuts and washers by means of an alternative metallic coating is specified in the relevant line specification, then additional clearances on the nut may be required as both bolt and nut threads will remain coated to the required coating thickness and easy fitment of nut and bolt must still be retained.

e) When use is made of a thermal zinc diffusion coating process (SANS 1471-3) the minimum coating thickness that will be achieved is 70 µm and the thread cut should accommodate this.

f) When use is made of a metallic electroplating process (ISO 4042) where the coating is specially developed for fasteners and hardware exposed to marine conditions, the minimum coating thickness that will be achieved is 35 µm and the thread cut should accommodate this.

10.2 Organic Coating System

If the design of a line calls for added corrosion protection in the form of an organic coating on top of the hot dip galvanised steel, the following shall be taken into consideration.

a) The **Contractor** is responsible to use the requirements provided in the relevant line specification and submit it to a paint supplier to be used for each activity specified.

b) The **Contractor** will ensure that all the necessary product documentation requested in the requirements section in the relevant design documentation are sufficient. The **Contractor** will submit these documents to the **Employer** for review and record keeping purposes.

c) The **Contractor** should follow the supplier application instructions on the system to ensure the best possible outcome. Coating thickness will be measured after application following supplier instructions.

d) **Employer** will require the **Contractor** to supply a guarantee certificate at the end of a project for the paint supplier, for each specific system supplied, including the product name, transmission line name, contractor name and guarantee period.

e) If the **Contractor** cannot provide the **Employer** with a certificate with the initial durability requirements with stated reason. The contractor should be held liable for maintenance on the system.

f) It is preferred that the coating system should be applied at the galvanising yard, alternatively it can be applied on site with a clear indication from the supplier in writing how it would affect the guarantee.

g) Care should be taken when transporting components to site that were coated at the galvanizing yard and suitable protection to sections should be provided.

h) Except where alternative application methods are mentioned, all coatings shall be applied by means of brush when on site.

i) Painting is a skilled process and shall only be carried out by capable and experienced personnel, as well as with equipment suitably designed for application of the coating.

j) All surfaces shall be inspected prior to coating, to ensure that the standard of cleaning complies with the criteria as stipulated in the suppliers surface preparation procedure.

11. Photographic and Video Records

Photographs shall be taken on all critical stages of the line construction. Where applicable, videos must be taken of the rigging and stringing activities.

12. Authorization

This document has been seen and accepted by Lines Engineering Services engineers and management.

13. Revisions

Date	Rev	Compiler	Remarks
March 2021	6.0	D Dukhan	Finalisation of document
January 2018	Draft 6.0	D Dukhan	Comments included from PDP, LES and Contractors
November 2014	5.2	D Dukhan/W Combrink	Include majority of comments

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15. Acknowledgements

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Annex A – Tolerances

1. Steel tolerances

Table A.1: Summary of main tolerances for the manufacturing of angles and plates generally used in tower fabrication

OPERATION	ANGLES		PLATES / FLATS	
Straightness (after manufacturing)	Length of member = L (mm) Leg length = h (mm) For h ≤ 150 : Straightness = 0.4% L For 150 < h ≤ 200 : Straightness = 0.2% L			
Dimensions	**Leg length = h (mm)**	**Permissible Variation (mm)**	**Flats**	
			Width = b (mm)	**Permissible Variation (mm)**
	h ≤ 50	-1.0 to +1.0		
	50 < h ≤ 100	-1.5 to +1.5		
	100 < h ≤ 150	-3.0 to +3.0	b ≤ 35	0.5 to +0.75
	150 < h ≤ 200	-3.0 to +3.0	35 < b ≤ 75	-0.8 to 1.0
			75 < b ≤ 100	-1.0 to +1.5
			100 < b ≤ 120	-2.0 to +2.5
			Thickness = t	
			t < 20	-0.5 to +0.5
			20 ≤ t ≤ 40	-1.0 to +1.0
			t > 40	-1.5 to +1.5
			Plates	
			Nominal Thickness (t) (mm)	**Permissible Variation (mm)**
				-0.3 to +0.9
			4.5 ≤ t < 5	-0.3 to +1.2
			5 ≤ t < 8	-0.3 to +1.4
			8 ≤ t < 15	-0.3 to +1.6
			15 ≤ t < 25	-0.3 to +1.9
Punching of holes	Allowed up to ≤ 18 mm thick for full size diameter of hole. More than 18 mm thick then sub-punch and ream or drill to full size. Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 10 and 11 below.		Allowed up to ≤ 18 mm thick for full size diameter of hole. More than 18 mm thick then sub-punch and ream or drill to full size. Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 10 and 11 below.	
OPERATION	ANGLES		PLATES / FLATS	
Drilling of holes	Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 10 and 11 below.		Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 10 and 11 below.	

OPERATION	ANGLES	PLATES / FLATS
Bending Angle	Only for open and closed flanges as per relevant tower drawing(s). No cold bending allowed. Tolerance on final bending angle = ±1°	Cold Bending Plate thickness = t (mm) t ≤ 12 : Max angle = 14° 12 < t < 22 : Max angle = 7° Hot Bending Plate thickness = t (mm) For t > 22 mm Tolerance on final bending angle = ±1°
Backmark	Allowable offset from backmark = ±1 mm.	Allowable offset from backmark = ±1 mm.

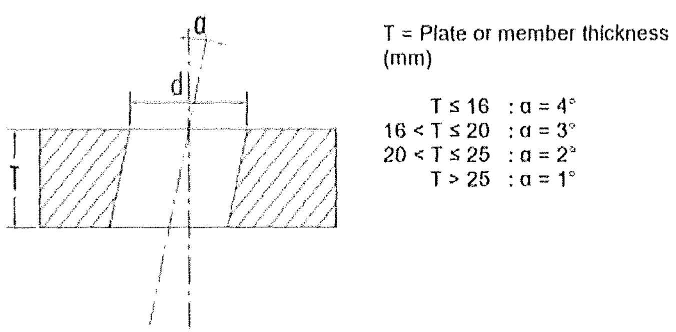


Figure A.1: Tolerance requirement on holes (a)

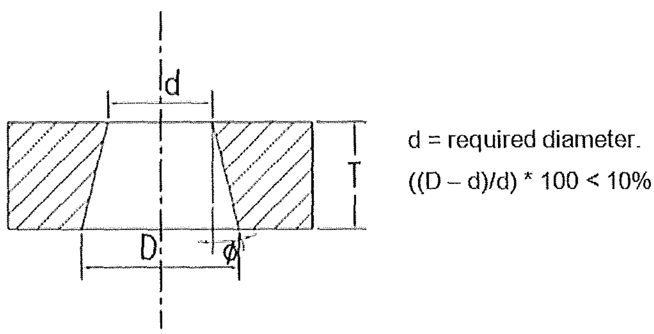


Figure A.2: Tolerance requirement on holes (b)

2. Bolt tolerances

Inspecting of the bolts on site by measurement of the outside diameter of the thread will clearly indicate if bolts were undercut prior to hot dip galvanizing. The following table is an extract from the SANS 1556-1: ISO Metric screw threads, with the addition of the galvanizing thickness on bolts and oversize tapping of nuts, and can be used on site to measure pitch diameters to check if bolts are cut undersize.

Table A.2: Details of Bolt and Nut Tolerances

Bolts (All dimensions in mm)									With Hot dip galvanizing	
d/D	Toll	Pitch	M	es	Td	d_max	d_min	Galv	d_max	d_min
M16	6g	2	16	0.038	0.280	15.962	15.682	0.045	16.052	15.772
M18	6g	2.5	18	0.042	0.335	17.958	17.623	0.045	18.048	17.713
M20	6g	2.5	20	0.042	0.335	19.958	19.623	0.055	20.068	19.733
M22	6g	2.5	22	0.042	0.335	21.958	21.623	0.055	22.068	21.733
M24	6g	3	24	0.048	0.375	23.952	23.577	0.055	24.062	23.687
M30	6g	3.5	30	0.053	0.425	29.947	29.522	0.055	30.057	29.632
M36	6g	4	36	0.060	0.475	35.940	35.465	0.055	36.050	35.575
Nuts (All dimensions in mm)									Oversize Thread	
d/D	Toll	Pitch	M	EI	Td	D_1	D1_min	D1_max	D1_min	D1_max
M16	6H	2	16	0.000	0.375	13.835	13.835	14.210	14.255	14.630
M18	6H	2.5	18	0.000	0.450	15.294	15.294	15.744	15.714	16.164
M20	6H	2.5	20	0.000	0.450	17.294	17.294	17.744	17.824	18.274
M22	6H	2.5	22	0.000	0.450	19.294	19.294	19.744	19.824	20.274
M24	6H	3	24	0.000	0.500	20.753	20.753	21.253	21.393	21.893
M30	6H	3.5	30	0.000	0.560	26.211	26.211	26.771	26.961	27.521
M36	6H	4	36	0.000	0.600	31.670	31.670	32.270	32.530	33.130

Annex B – Details of fall Arrest Anchor

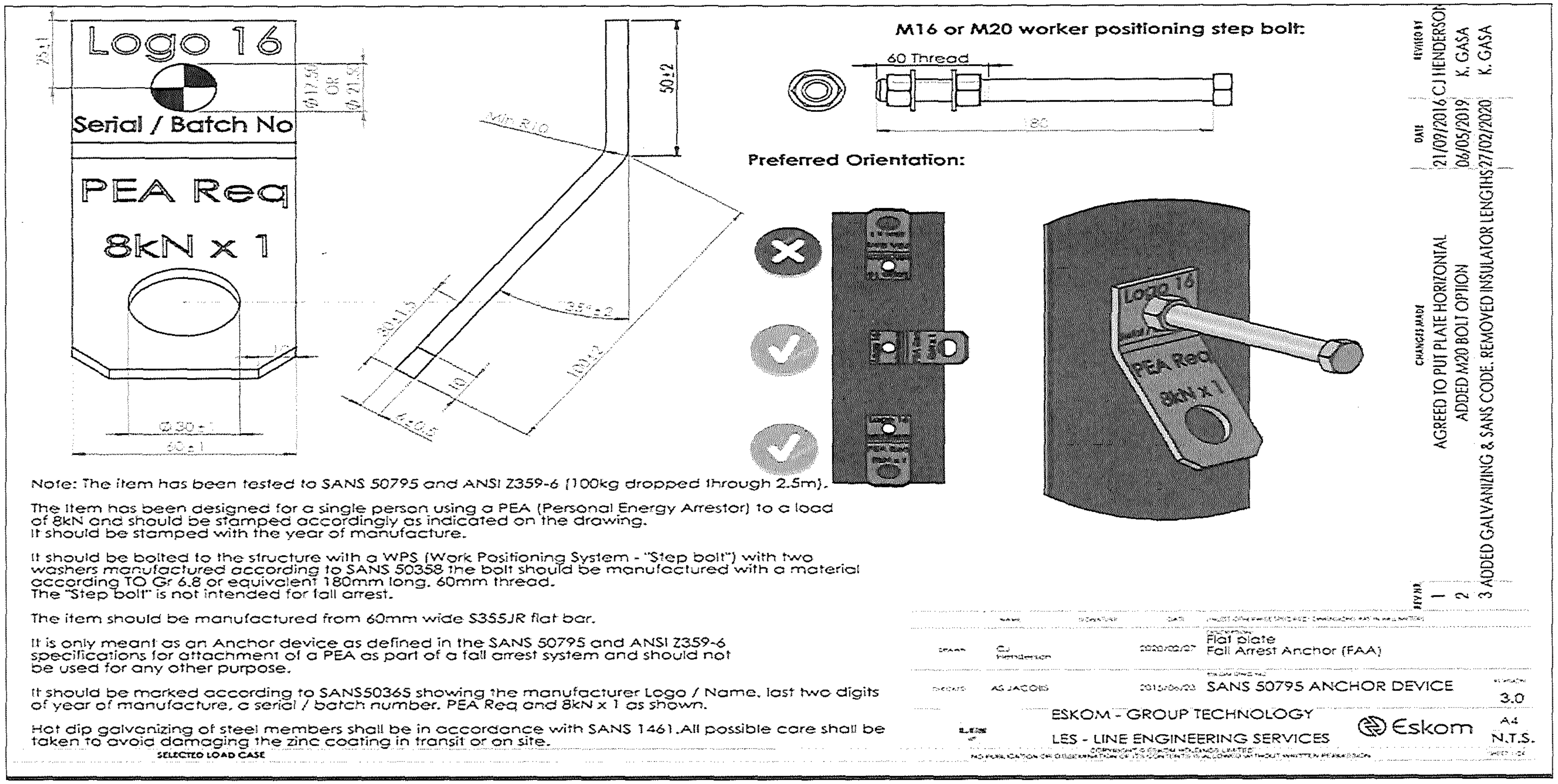


Figure B.1: Fall Arrest Anchor Details

Annex C – Electrical Safety Earthing during Construction

Introduction to Safety Earthing

It is the responsibility of the **Contractor** to ensure compliance with all the requirements contained in the ORHVS (Operating Regulations for High Voltage Systems) as well as in the OHSA when working on the power system. The **Contractor** needs to ensure that all staff is adequately trained and authorized to the requirements contained in the ORHVS as well as the OHSA.

1. Close Proximity to Live Conductors or Apparatus (Ref Table C.1)

If work is of such a nature that a person, machine or object could inadvertently encroach on the minimum safe working clearance then this is interpreted as close proximity.

The following precautions shall be taken prior to the commencement of work that could inadvertently encroach on the minimum safe working clearance to a live line or apparatus:

a) The auto-reclose features on all breakers controlling the supply to the live line shall be made inoperative.

b) The relevant prohibitory signs shall be displayed on the control panels. Where the auto-reclose function of a line is made inoperative via supervisory, it will not be necessary to apply a prohibitory sign to the control panel. If the auto-reclose is rendered inoperative manually, a prohibitory sign shall be applied. Tags shall be displayed on all Supervisory Control and Data Acquisition systems irrespective of the method used to render the auto-reclose inoperative

c) The live line or apparatus shall be handed over to the appointed operator responsible for supervising the work

d) The control officer shall attach the names of the appointed operators to the apparatus on the operating diagram.

e) No breaker controlling the supply to the apparatus shall be reclosed after a breaker trip until the control officer has confirmed with the appointed operators, to whom the live line has been handed over, that it is safe to do so.

f) All work shall be supervised by an appointed operator who shall ensure that minimum safe working clearances are maintained at all times.

When the minimum safe working clearance between persons, machinery or objects and live apparatus or lines cannot be maintained such live apparatus or lines shall be isolated and earthed at a safety panel.

Table C.1: Minimum Safe Working Clearances

SAFE WORKING CLEARANCE				
AC VOLTAGES	MINIMUM CLEARANCE		DC VOLTAGES	MINIMUM CLEARANCE
765kV	6.0m		600kV	5.0m
400kV	4.0m		450kV	4.0m
275kV	3.0m		300kV	3.0m
220kV	2.5m		150kV	2.0m
132kV	2.0m			
88kV	1.5m			
66kV	1.3m			
1kV-44kV	1.0m			

2. Stringing and Regulating

When stringing and regulating conductors close to a parallel energized line(s), and when transferring conductor onto suspension and strain hardware and when fitting jumpers at strain towers, there is a real risk for workers to get injured or killed as a result of induced voltage and current.

This risk can be avoided by applying safety earthing in two levels, namely 1 set of working earths on either side of the work sites, and an additional set of earth's further away (master earth). It is also assumed that proper earthing tools are used, and that earthing will always be applied and be removed using an insulated earth stick.

The main aim of the earthing described above is to create a preferred path for induced energy (described in engineering terms as electrostatic and electromagnetic induction which leads to measurable voltage and current levels). It is further implied that the worker should never become part of the electrical circuit through the rigorous application of the working earths.

Note that the earthing system that is designed and intended to be part of the operation of the line during its lifecycle is to be seen as a separate earthing system.

Internationally, line construction contractors are required to apply the safety earthing principles as laid down in in the following standards, including the adherence to earthing equipment specifications:

- IEC 61328-2017 : Live Working - Guidelines For The Installation Of Transmission Line Conductors And Earthwires - Stringing Equipment And Accessory Items,
- IEC 61230-2008 : Live working - Portable equipment for earthing or earthing and short-circuiting
- IEEE STD 524- 2016 : IEEE Guide for the Installation of Overhead Transmission Line Conductors
- IEEE STD 524a- 1993 : Guide to Grounding During the Installation of Overhead Transmission Line Conductors

Of particular interest is the IEEE Standard 524 which explains how safety earthing practices should be applied during the installation of overhead conductors and how the **Contractor** should proceed to do the various activities from the stringing phase until the conductor installation work is finished.

For the application of working earths at least a 20 mm squared copper cable must be used or an aluminium equivalent. For the application of control earths at least a 70 mm squared copper cable must be used or an aluminium equivalent.

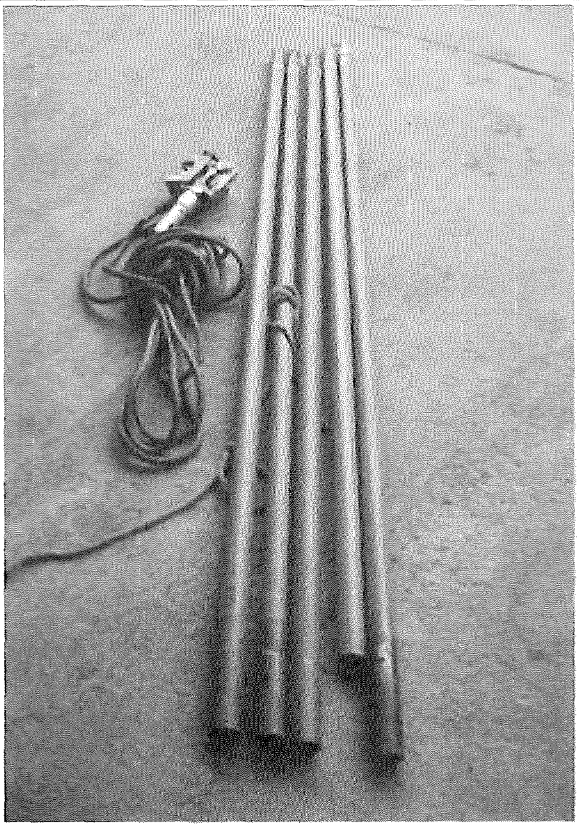


Figure C.1: Example of insulated earth sticks

Induced Voltages and Currents that pose a risk

There are several potentially hazardous conditions routinely found on equipment connected to the electrical network including earthing conductors and interconnected structures. These hazardous conditions can cause a fatal electric shock and include:

- Induced voltages from electromagnetic induction and capacitance coupling
- Transient voltages from lightning and some high voltage (HV) switching surges
- Earth potential rise (EPR) and the resulting step and touch potential

While these conditions are more likely to be found during a fault somewhere on the electrical network or during storm conditions, they can also occur during normal working conditions.

Factors affecting the level of induced voltage are:

- Strength of the electromagnetic field being produced around the energised conductors
- Distance that the lines/cables runs parallel to each other, and
- Proximity (closeness) of the lines/cables to each other.

The value of an **Electrostatic** induced voltage depends on the voltage of the inducing conductor/line (energised apparatus) or changes in voltage due to switching or faults.

The value of an **Electromagnetic** induced voltage depends on the:

- Distance that new or isolated aerial conductors run parallel to an inducing conductor/line that can considerably increase the amount of induced voltage.
- Separation distance between the inducing conductor/line and the new or isolated apparatus.
- Amount of current flowing in the inducing conductor/line due to load or faults.

In some cases, an inducing conductor/line crossing at right angles to a new or isolated line can create induced voltages.

Electrical apparatus such as transformers and cables, including the associated metalwork, which is close to live HV apparatus, can have a voltage induced into it.

The value of an induced voltage will influence the number of working earths required and the proximity of the working earths to a person's working position.

Job Risk Assessments (JRA) must take into consideration the effects of induced voltages for all tasks that involve working on new or isolated electrical apparatus.

If either the master earths or the working earths cannot be connected to a tower's steel (to use the tower's earthing system), it is specified that rod earths be driven into the ground and tested to see that a low enough resistance is achieved for it to be effective. This is an area where contractors should be strictly monitored to make sure that the correct technique and equipment is used to verify the effectiveness of drive rod temporary earth electrodes. Although it will not always be possible to achieve low ohm values, it is suggested that a value below 25 ohms be achieved. If this value is not achieved by the first driven rod, it implies that more rods be driven in a crow's foot arrangement and interconnected with leads.

The two figures C.2 and C.3 below demonstrate the capacitive coupling and magnetic coupling situations. In practice, a mix of the two coupling mechanisms will be present. The magnetic coupling mechanism can be more dangerous especially if the workers on site do not understand how it actually manifests itself. A single earth applied to a conductor which is subjected to magnetic coupling phenomena is a death-trap waiting for the worker to touch it to complete and set the circuit up to conduct electrical current.

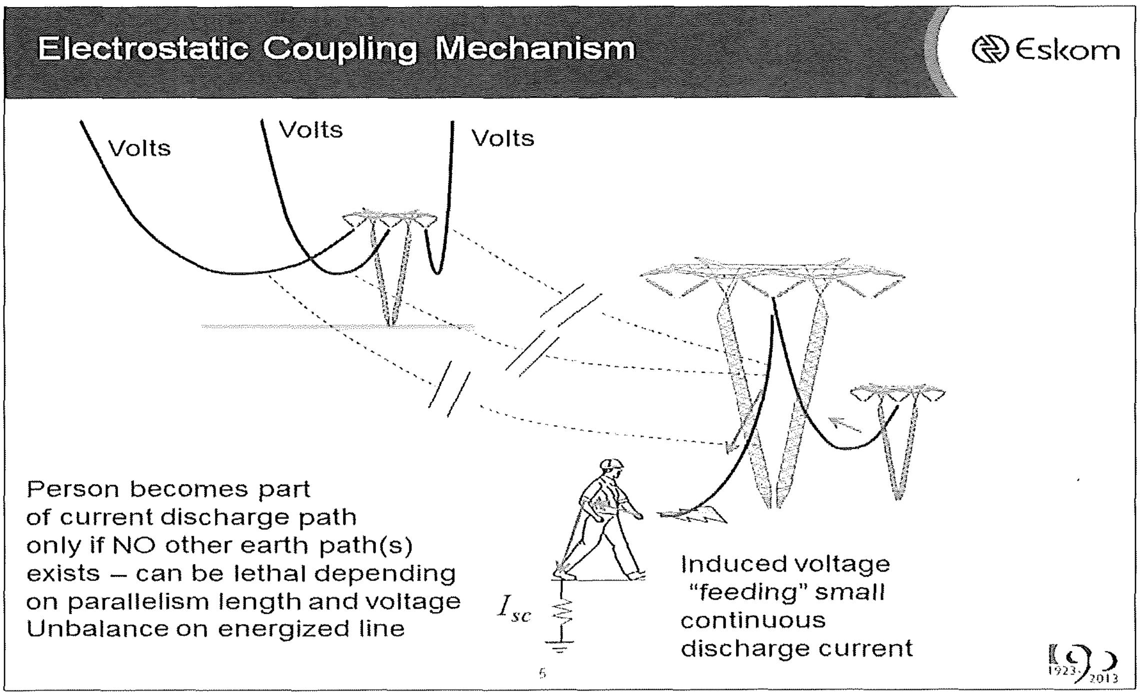


Figure C.2: Electrostatic Coupling Mechanism

With a single earth in place, the electrostatic induction (which would be present if energized parallel lines are energized but not carrying current) can be dealt with quite effectively using only 1 earth (instead of the worker providing that path to earth).

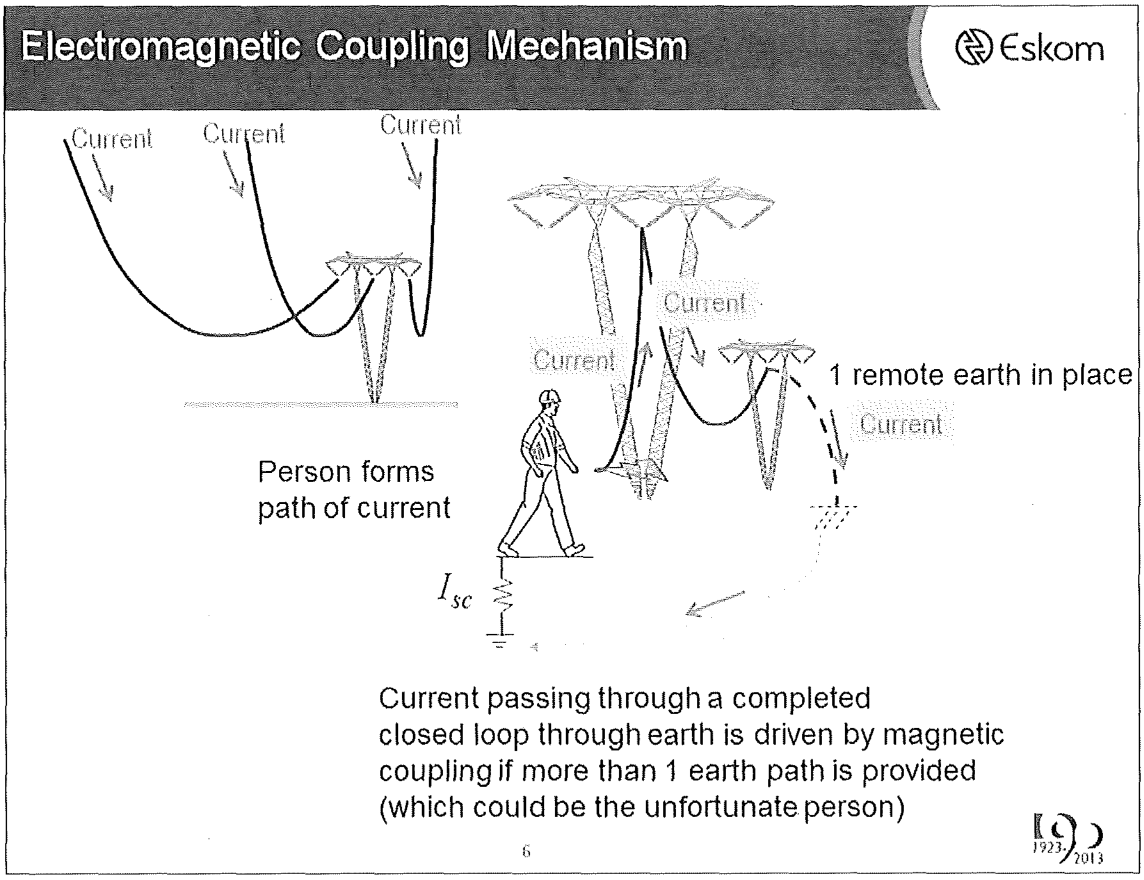
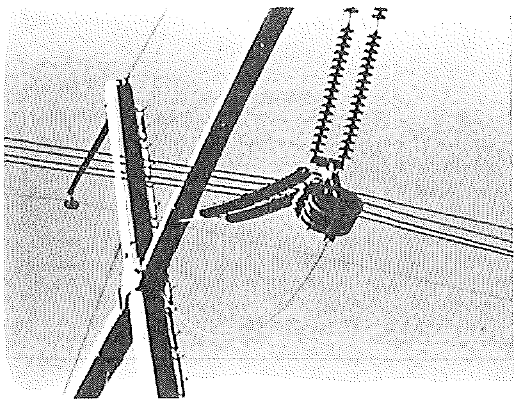


Figure C.3: Electromagnetic Coupling Mechanism

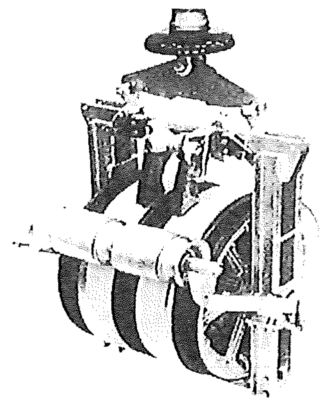
When there is no voltage on the parallel energized lines but if they carry current, which is admittedly an unlikely scenario but used here for explanatory purposes, the worker is facing a lower risk when no earths are applied than when 1 earth is applied. If only 1 earth is in place, the worker becomes the second earth which completes the electrical circuit for current to be conducted.

As soon as more than 2 earths are applied, the chances of the worker becoming a preferred path for electrical current is reduced. When two working earths are applied on both sides of the work site, and two master earths further away, redundancy in the temporary earthing system is provided and the risk to the worker is reduced to a very low level.

Avoiding induced voltage and current effects during construction activities



a) Application of traveler ground



b) Individual traveler ground

The use of running blocks with a traveller ground is suggested by the IEEE 524 standard and provides a very good security system against accidental electrocution when transferring conductors from running blocks onto insulator assemblies. These devices also provide an additional remote earth connection at each suspension tower.

In summary, the following activities and procedures are potentially risky in terms of steady state (50Hz) induced electrocution:

- Stringing a new line close to parallel energized lines or when crossing them
- Regulating and fitting of dead-ends, and transferring conductors from running blocks on suspension towers to the insulator hardware
- Fitting of jumpers on strain towers
- Dismantling of conductor from an old line that runs in parallel or crossing existing energized lines

Transient coupling, from lightning or switching impulses, although far less likely to occur at a critical moment in time, will also be limited to a large extent if the 50Hz steady state induction risk is properly eliminated.

As shown, Figure C.4 is a suggested retro-fit to convert standard running blocks so that traveler grounds are added.

3. Handling of Conductive Tools

Tools will develop a dangerous potential when being hoisted in a high electric field. Tools must be discharged before any worker makes contact with it.

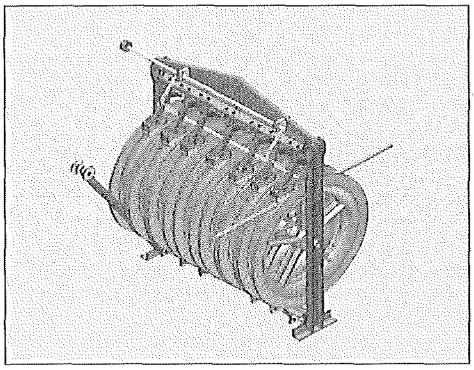


Figure C.4: Conversion of Standard Running Blocks

4. Crossings

Before work commences:

- The installation being crossed must be inspected to ensure that it conforms to design standards and that no existing clearances (phase-phase, phase-earth, phase-stay wires) are compromised.
- Arc should be switched off.

It is of particular importance when working close to energized infrastructure that the minimum safe approach distances are maintained at all times. It should also be noted that the minimum safe approach distance only ensures that a flashover will not occur. It does not stop induction from occurring - be it electrostatic or electromagnetic.

It is important to note when crossing live infrastructure that there is a huge risk that the installation may become live in the event of mechanical failure. This will lead to dangerous step, touch potentials and transferred potentials which can be partially mitigated by installing an earthmat at the site location.

Annex D – Foundation Nominations

IDENTIFICATION AND CLASSIFICATION OF SOILS

PURPOSE: To identify strength, compressibility and permeability characteristics.
CRITERIA: MOISTURE, COLOUR, CONSISTENCY, STRUCTURE, SOIL TYPE, ORIGIN (MCCSSO)
SOIL PROFILE: A soil profile is composed of 4 categories of material. **1) Rock**- weathered to fresh Cu= 700 KPa; **2) Residual Soil** – insitu decomposed rock; **3) Transported Soil** – in waterborne or windblown deposits; **4) Pedogenic Material** – cemented soils eg. Ferricrete.
Frequently the profile displays a "pebble marker" located between transported and residual soils.
Note: Not all four soil categories are necessarily developed on any particular site.

Soil Moisture

1. Dry (powdery): } Below optimum moisture content for compaction.
2. Slightly Moist: }
3. Moist: Near optimum moisture content for compaction.
4. Very Moist: } Above optimum moisture content for compaction
5. Wet: } Comes from below the water table.

NOTES:
1) **Consistency is largely dependent on the moisture content.**
2) **Sand with a moisture content of 5–10% will appear wet, while clay at the same moisture content may be dry or slightly moist.**
3) **Clays are usually saturated or partially saturated. Only clays from close to the surfaces will be dry or slightly moist in which case their structure will frequently be micro-shattered or shattered.**

Soil Colour

Use a Burland Colour Disc
Describe the soil colour in two ways
a) Take a small sample and mix it with water to form a creamy paste in the palm of your hand.
b) Describe the colour of the natural soil "in profile".
Use terms such as mottled (blotched if mottling is large scale), speckled, banded or streaked.

NOTES:
1. **Colour is more an aid to identification than of geotechnical significance**
2. **Reference should be made in the soils report to the colour standard used.**
3. **Be consistent.**
4. **Colour zoning on a particular site and in a particular weather rock profile may reflect the degree of weathering.**

Soil Structure

When referring to cohesive soils indicates presence or absence and nature of joints. When referring to granular soils, describes bedding thickness and type and grain characteristics.

Cohesive Soils
Intact: No joint or fissures.
Fissured: Closed joint frequently stained with iron or manganese oxides.
Slickensided: Fissures are polished or glossy and may be striated. Indicates movement.
Shattered: Open fissures or joints which may or may not be slickensided. Soil fragments are usually stiff to very stiff and do not easily absorb water. Often associated with having soils.
Micro-Shattered: Intact fragments are very small and soil appears to be granular.

Stratified laminated foliated. Various terms for bedding.

Granular Soils
Beddings: Thick or thin, give dimensions and indicate presence of cross-bedding.
Particle Shapes: Rounded, sub-rounded, sub-angular, angular.
Surface Features: Polished, pitted, striated.
Compostion: Cemented, Nodular, concretions etc.

Soil Type

A soil may be composed of the types mentioned below leading to sub- classifications such as clayey sand or sandy clay depending on relative proportions.

Cohesive Soils:
Clay - Particle size <0.002mm. Soapy or greasy feel when mixed with water. If mixed with water in a glass, remains in suspension for longer than 1 hour. Can be rolled into threads approximately 2.5mm thick. No feel of grittiness when placed between tongue and teeth.
Silt - Particles 0.002 – 0.05mm. Graininess barely felt when rubbed with water in the palm of the hand but can be felt on the teeth. Settles from suspension in a glass of water in 15 to 50 minutes. Exhibits dilatancy. If a saucer with the wet paste in it is gently tapped, surface will appear shiny. LL <35%

Granular Soils:
Sand - Particle size 0.05 – 2.0mm; fine 0.06 – 0.2mm, medium 0.2 – 0.6mm or coarse 0.6 – 2.0mm. Particles visible to the naked eye. Settles from suspension in 15 to 60 seconds.
Gravel - Particle size 2.0 – 200mm; fine 2.0 - 12mm, medium 12- 50mm or coarse 50 – 200mm. Composition and shape of particles is important as is proportion and composition of matrix.
Boulders - Rock fragments larger than 200mm. Describe as for gravel.
Granular Soils may be well, poorly or uniformly graded.

Cemented Soils:
Ferricrete, Silcrete, Calcrete frequently incorrectly called "laterite".

Soil Consistency

GRANULAR SOILS	Ø	SPT 'N'	Dry γ = KN/m³	Dutch Probe Point Res	Field Identification
1. Very Loose	25 - 30	0 – 4	<14,2	< 1,3 MPa	Almost no resistance to shoveling. Crumbles.
2. Loose	27 – 35	4 – 10	14,2 – 15,7	1,9 – 3,8	12 mm Ø bar easily pushed in by hand. Small resistance to shoveling and geological pick.
3. Medium Dense	30 - 40	10 – 30	15,7 – 17,2	3,8 – 8,6	Easy penetration by 12mm Ø bar using 2 kg hammer. Considerable resistance to shoveling. Considerable resistance to penetration by geological pick.
4. Dense	35 – 43	30 – 50	17,2 – 18,6	8,6 - 12,5	Considerable resistance to penetration to 300mm by using 12mm Ø bar driven with 2 kg hammer. Very high resistance to penetration by geological pick. Hand pick required for excavation.
5. Very Dense	40 – 45	50 – 80	>0,6	>12,5	Penetration by 12mm Ø bar only up to 25mm using 2 kg hammer. Power tools required for excavation.
6. Refusal		>80			

COHESIVE SOILS	SPT 'N'	Natural γ – KN/m³	qu – KN/m²	Field Identification
1. Very Soft	0 – 2	15,1	<35	Easily moulded by fingers. Pick easily pushed in up to the shaft of the handle. Distinct heel mark left on exposed surface.
2. Soft	2 – 4	16,7	35 – 75	Easily penetrated by the thumb. Sharp end of pick pushed in 30 to 40 mm. Moulded by strong finger pressure. Faint heel marks left on the exposed surface.
3. Firm	4 – 8	18,0	75 – 150	Indented by thumb effort. Pick pushed in by only 10mm very difficult to mould with fingers. Slight penetration by spade.
4. Stiff	8 – 15	19,6	150 – 300	Penetration by thumb nail. Slight indentation by pick. Cannot be moulded by fingers. Pick required for excavation.
5. Very Stiff	15 – 40	21,2	>303	Indentation by thumbnail with difficulty. Slight indentation produced by blow with pick. Requires power tools for excavation.
6. Hard	>40			(Usually a dry or a slightly moist very stiff clay)

Notes: 1) With regard to the strength of cohesive soils, the soil structure is very important as is the possibility of moisture content changes.
2) qu = unconfined compressive strength = 2 Cu

Soil Origin

Transported Soils:
Talus - Unsorted angular gravel and boulders that have fallen from a rock outcrop. "Coarse colluvium". occurs on hillsides and below cliffs.
Hillwash – Mixed soils derived from weathering of rocks making hills. Found on hillslopes and sides of valleys below hills. "Fine Colluvium".
Alluvial or Gully Wash – Frequently gravels and sands with cohesive strata. Found in valleys and deposited during floods.
Lacustrine – Mixed soils deposited at river mouth into lakes or dams.
Estuarine – Mixed soils occurring in estuaries.
Aeolian – Usually sands, deposited by wind.
Littoral – Beach sediments.
Except for colluvium most granular transported soils have rounded particles.

Residual Soils:
Derived from in-situ weathering of bedrock. Depending on degree of weathering may retain the parent fabric and texture from which the parent rock may be identified. Grade downwards to "rock".

Pedogenic materials may develop in both transported and residual soils.

Figure D.1: MCCSSO: Soils Identification

Eskom

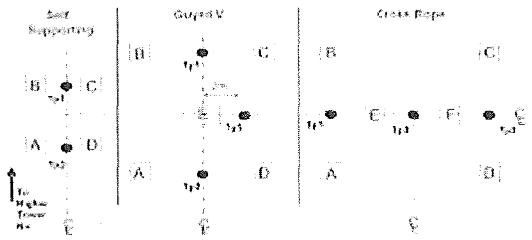
Power Delivery Engineering
Line Engineering Services

Unique Identifier: 240-87292251

Contractor's Soil Profile Sheet

NO CONSESSION SHALL BE GRANTED BY ESKOM WITH A VIEW TO REDUCE THE NUMBER OF TEST PITS AS ILLUSTRATED BELOW.

Contractor:	
Project:	
Date Tested:	
Test Pit No.	
Tower Type	
NOMINATION	



Tick the applicable box above and indicate the test pit position.

Pit Depth (mm)	Layer Thickness (mm)	General Description (MCCSSO) Moisture, Colour, Consistency, Structure, Soil type, Origin
0		
1000		
2000		
3000		
3500		
Profile Notes:		1.
		2.
		3.

Insert Photograph of Soil Test Pit profile HERE

NB:

(Photograph should be of good quality of at least 5megapixels, and must clearly illustrate the entire depth of the profile with the following test pit information on a board, above the soil test pit)

Test Pit Info:

- Tower Type and Number
- Test pit number and tower leg letter

Soil Profile done by:	
Name of Registered Person:	
Institute: (Eg. ECSA/SAIEG)	
Registration Number:	

NB: The results of this soil profile must be captured in the Eskom's Contractor's Soil Nomination List (Unique Identifier: 240-87292229)

Figure D.2: Contractors Soil Profile Sheet

Eskom

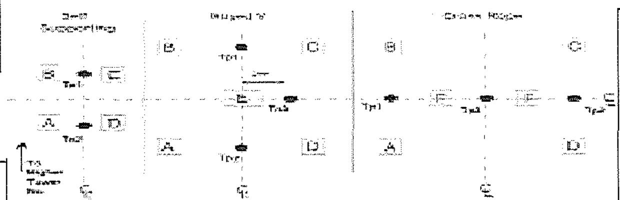
Power Delivery Engineering
Line Engineering Services

Unique Identifier: 240-87292229
Revision: 2.0

Contractor's Soil Nominations List

Tower/ Test Pit No.	Tower Type	Leg A		Leg B		Leg C		Leg D		Leg E		Leg F		Comments
		*Foundation System	*Soil Type	*Foundation System	*Soil Type	*Foundation System	*Soil Type	*Foundation System	*Soil Type	*Foundation System	*Soil Type	*Foundation System	*Soil Type	

Project:
Contractor:
Date Compiled:
Batch No.:
Profiled by:
Accepted by :



*Foundation System	*Examples:* Pad-and-pier, pad-and-plinth(center mast), Rock Anchor, Deadman(guy-anchor), Micro-pile(grout injected), Concrete piles.
*Soil Types	1, 2, 3, 4, Soft Rock (SR), Hard Rock (HR)

Contractor Company Logo

Figure D.3: Contractors Soil Nomination List

QUALITY AND INSPECTION PLAN - GROUT INJECTION ANCHOR CONSTRUCTION

Project No:	Project description														Revision 1
Quality preformed by - Signature / Activity No and description	Instruction / Procedure / Drawing /Inspection /Template or Specification or Reference	DOCUMENT	ACTION	MEASUREMENT ,CHECK, INSPECTION.	CONTRACTOR			ESKOM			TOWER AND FOUNDATION NUMBER				Remarks, Deficiency or Non-conformance Report numbers
											LEG A	LEG B	LEG C	LEG D	Mast E
ANCHOR FOUNDATIONS	Method Statements (MS) and Specification: 240-47172520 (TRMSCAAC5 3)	Type of control				Signature	Date		Signature	Date					
Tower setting out. Centre peg position. Foundations setting out positions	Foundation set out drawings (clear of any objects, roads, water courses-dongas, fences, embankments slope edges etc.)	X	X	X	I			W							
Profile hole drilled and flushed with water. (not part of foundation)	Profile hole's log (as to M S) with all the following: (a) Contractor's nomination. soil type 1or 3 or soft or hard rock. (b) drill depths to layers etc.	X	X	X	I+T			I							
Anchor setting out	Anchor setting out. Cap stub /link and anchor positions adequate space between stub and anchor plates	X	X	X	I			W							
Installation of anchors. As to M S Logging of drill profiles	Profile Anchor hole's logs with all the following: (a) drill depths layers-soil type 1or 2 or soft or hard rock. (b) drill rates (c) grout pressure (d) grout mix (e) anchor type (f) sleeve tubes top of anchor (g) drawing No's	X	X	X	I+T			I							
Excavation Barricading	M S and TRMSCAAC5 cl 6.5.1 h)	X	X	X	I			I							
Cap Installation	Check stub/link position, Check rebar, Shuttering, Remove grout around top end of anchor and leave 150mm for construction joint into cap and install anchor plates and nuts. Photographs must be taken beforecasting of concrete. foundation anchors rake/angle to be in 10 degrees and single guy anchor and link to be in 3 degrees of requied angle.	X	X	X	I+T+H			I							
Concrete casting compaction(vibration) of cap	Check concrete delivery time, do slump tests and take concrete cube samples. M S. Works information and TRMSCAAC5 cl 6.6.10.	X	X	X	I			I							
Concrete finishing and curing	Cap top sloped and edges chamfered. M S and TRMSCAAC5 cl 6.6.13 and 6.6.5	X	X	X	I			I							
Clean tower site	(Environmental requirements for line completion check)	X	X	X	H+W			I							
Test cube results 7 and 21 day results	M S and TRMSCAAC5 cl 6.6.6	X	X	X	I+T			W							
Construction proof load test on Guy anchors	M S and TRMSCAAC5 cl 6.7.5	X	X	X	I+T			W							
Ultimate Load test -block anchor(deadman), pile or rock anchor	M S and TRMSCAAC5 cl 6.7.1	X	X	X	I+T			W							
Review all relevant inspection and test records		X	X	X	I			I							

Definitions:

H - Hold Point: A predetermined stage beyond which work shall not proceed without the attendance of and written authorization of a Eskom representative and photographs must be taken at

I - Inspection Point: A predetermined stage in the Quality product/process plan where a inspection or check or measurement must be preform to verify parameters and specification requirements.

T - Test / measurement check or action to be preformed	W - Witness point	S - Surveillance - general observation
S - Surveillance - general observation	M S - Method Statement	

Figure D.4: Quality & Inspection Plan – Grout Injected Anchor Construction

Project: Project Title				Doc Number: as per project allocation			
Contractor: Contractor Name Representive: Contractor Site Rep/Construction Manager Role: Site Agent Address: Contractor Address Contact number: Contractor Rep Contact Number				Date: date initiated Title: Engineering Change Notification – reason for change notification			
Contract No: XXXX				Reference:			
Early Notice of Field Change	**Early Notice of Engineering Change**	**Drawing error/ommision**	**Value Engineering**	**Information**	**Instruction**	**Safety**	**Other**
X							
Details of Instruction: Soil Nomination Amendment Date Received: DD/MM/YYYY Date Required: DD/MM/YYYY Affected drawings/documentation: This is affected drawing or documentation that would be affected by this change							
2 Technical Details **2.1 Details Of Technical Changes** What has changed? Include photgraphs (annotated where necessary). **2.2 Additional Quantities** Does the repair/correct require additional quantities as per established BoQ? **2.3 Cost Impacts** What is the cost impact?							

3 Additional Considerations Of Technical Change

3.1 Motivation and Benefits Of Change

Should proposed method for correction deviate from standard works, Contractor must highlight the benefits of proposing deviation.

3.2 Potential impact on Schedule and Procurement Plan

Imapct to schedule and/or procurement plan if extra materials are needed.

3.3 Safety Considerations

Are there any safety concerns.

3.4 Associated Risk

Does Contractor foresee any other risks?

4 Conclusion

Summary of request

Change Proposed By: Designation: Contact No:	Estimated quantity: R XXXXXX Estimated Schedule Impact: XXX months
Site Manager:	Cost Code: Where Applicable
Contractor	Contractor Signature
Documentation reviewed and accepted by Eskom Design Representative	
Documentation reviewed and accepted by Design Engineer (where applicable)	
Change accepted by Project Manager	

Figure D.5: Guideline for Notification of Engineering Change

Annex E – As Built Documentation Format

As built Documentation Format

The latest As Built Specification should be adhered to.

On completion of construction the contractor, in conjunction with the project manager, is required to compile the final as built document as per the requirements outlined in Table E.1 and E.2 and in full in 240-72252925 (latest version).

Outline of Requirements

General Line Data

Project Name, Client, Eskom Contract No., Contractor Name.

Table E.1: Outline of General As-Built Data

Data Category	Line
Line Voltage	
Circuits	
Configuration	
Phase Conductor	
Jumper Conductor	
Earth Conductor	
OPGW	
OPAC (Optical Approach Cable)	
Insulators	
Route Length	
Tower supplier and tower steel grade	
Tower Types	
Guyed Suspension Tower	
Self-supporting Suspension Tower (0° to 3°)	
Self-supporting Tension Tower (0° to 15°)	
Self-supporting Tension Tower (15° to 35°)	
Self-supporting Tension Tower (35° to 60° / 0° Terminal)	
Self-supporting Transposition Tower	

Table E.2: Project As-Built Requirements

ITEM REFERENCE AS PER AS-BUILT TEMPLATE	DATA	INFORMATION SUPPLIED BY:
A.	General Line Data	Project Manager
B.	Contractor Details	
B.1.	Main Contractor	Contractor
B.2.	List of Sub-Contractors	Contractor
C.	Summary of Project (Towers, Foundations and Earthing Specification	Contractor
D.	Earth Resistance Measurements	Contractor
E.	OPGW Installation	OPGW Contractor
E.1.	OPGW Schematic Layout	
E.2.	Colour Coding and Numbering	
E.3.	Power Meter Results and OTDR Reports	
E.4.	Splice Performance Summary	
E.5.	Power Line Carrier Frequencies	
E.6	Joint Box Positions	
E.7.	Assembly Drawings	
E.8.	OPGW Specification (As-built)	
F.	Electrical Line Parameters	Contractor
G.	Drawings	
G.1.	Tower Outline Drawings	Contractor
G.2.	Hardware drawings and OPGW Hardware	Supplier/Contractor
G.3.	Manufacturers Insulator Drawings	Supplier/Contractor
G.4.	Grading Rings	Supplier/Contractor
G.5	Tower Schedule (Including leg and body extensions)	Contractor
H.	Foundations	
H.1.	Foundation Drawings	Contractor
H.2.	Setting Out Drawings	Contractor
H.3.	Excavation Photos	Contractor
H.4.	Soil Nominations (including any amendment forms)	Contractor
I.	Hardware	
I.1.	Insulators	Supplier/Contractor
I.2.	Confirmation of equipment used for compression fittings	Letter of confirmation from contractor
I.3	Midspan Joints	Contractor
I.4.	Spacers/Spacer Dampers	Contractor

ITEM REFERENCE AS PER AS-BUILT TEMPLATE	DATA	INFORMATION SUPPLIED BY:
I.5.	Insulated Earth Wire Assemblies and Non-Standard Assemblies	Contractor
I.6.	Damping Devices	Contractor
I.7.	Miscellaneous Items (Aircraft warning spheres, bird diverters, warning lights, etc.)	Contractor
I.8.	Hardware Type/Sample Test Records	Supplier/Contractor
I.9.	*Hardware Problems and Non-*Conformances during Construction (Fitment Issues, Failures, etc.)	Contractor
I.10.	On-Site conversions to cater for Special Requirements	Contractor
J.	Free Issue Material Control Sheet	Contractor
K.	Line Profiles	Contractor
L.	Landowner Details	Project Manager
M.	Aerial Laser Scan (as-built)	Eskom Survey
N.	HD Visuals and Corona Checks from Flyover	Contractor
N.1.	HD Visuals	Contractor
N.2.	Corona Checks	Contractor
N.3.	Tripod Camera Records	Contractor
N.4.	Helmet Mounted Camera Records	Contractor
N.5.	Drone Inspections	Contractor
O.	Line Walkdown and Line Audit	Contractor
O.1.	Line Walkdown and Line Audit Findings	Contractor/Eskom
O.2.	Tower Top Inspection Sheets	Eskom
P.	Handover Certificates	Project Manager
P.1.	Galavanising certificates	
P.2.	Tower member paint specification	
P.3.	Steel mill certificates	
P.4.	Hardware release documentation	Eskom Quality
P.5.	Conductor certificates	
P.6.	OPGW and earth wire certificates	
P.7.	Insulator test certificates	
Q.	Permits	
Q.1.	Statutory Permits	Project Manager
R.	Incident Reports	Contractor

ITEM REFERENCE AS PER AS-BUILT TEMPLATE	DATA	INFORMATION SUPPLIED BY:
R.1.	Incident, Injury and Fatality Reports Related to Hardware/Mechanical Failure	
R.2.	Non-Conformance Reports	
R.3.	Concessions	
S.	Orange Site File Inspection Reports	Contractor
T.	TxSIS	
T.1.	TxSIS Upload Form	Project Manager
T.2.	TxSIS Input from Contractor	Contractor
T.3.	TxSIS Data	Project Manager
U.	Learning Points	Design Leader

Annex F – Access and Ground Erosion Protection for Overhead Line Construction

1. Scope and Purpose

This design specification deals with the construction of access routes, soil erosion rehabilitation and prevention, as applied during overhead line construction lines with operating voltages of 66kV and above.

Requirements are provided to enable appropriate design and construction in the following areas:

- Servitude access road water runoff control and drainage.
- Slopes, roads, embankments, cuttings and fillings.
- Positioning and construction of water diversion berms
- Drift or water course crossings.
- Low level bridge or culvert crossings.
- Tower erection platforms in sloping terrain
- Erosion rehabilitation

Where deviations to applicable standards are suggested in this guideline, these are subject to approval by the **Employer's** environmental representative.

2. Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this specification. In cases of conflict, the provisions of this specification shall take precedence. Unless otherwise stated, the latest revisions, editions and amendments shall apply.

TRMSCAAC 6: Eskom Transmission Line Towers and Line Construction Specification

3. Compliance statement

A statement of compliance and/or deviation from this standard is required as a tender returnable.

Refer to Volume 7 Section 2 for the Compliance / Deviation Form relevant to this standard.

4. Access planning

4.1 Parties and inputs to access planning

Access to each structure location should be planned by the following parties:

- **Contractors** Environmental Officer
- **Contractors** Surveyor or Representative experienced in line construction
- **Employers** Environmental Representative

Access should be planned with reference to the following input information:

- **Environmental Management Plan (EMP)**
- **Suggested Access Plan (if available)**
- ***Landowner Restrictions***

4.1.1 Basic Access Philosophy

The following basic access principles shall apply:

a) The preferred access route will follow a "least impact" course along the line within the servitude boundary.

b) As per Standard 240-47172520 maximum use of existing roads and tracks should be made, as far as practicable, and the condition of private roads recorded prior to use by the **Contractor's** Environmental officer.

c) Where this is not possible due to potential erosion risks, environmental concerns, or landowner restrictions, access to each tower or series of towers should follow a "least impact" course from the closest practical location.

d) All such roads should be aligned as far as possible to avoid the need for any "cut or fill" to the existing ground level. Any road construction work requiring the cutting of natural ground level shall require prior approval and participation from the **Employer's** appointed environmental control officer.

e) Where the least impact route traverses terrain with a side slope of more than 8.5% (0,45m over 3m or 1:6.5) road construction requiring cut and fill may be undertaken. This guideline may be adjusted where it can be demonstrated that a potentially unsafe access route or increased erosion could result.

f) Where it is not deemed practical or desirable to construct any roads, access by a suitable footpath can be made to ensure safe passage on foot. Preferably, vehicular access to within 200m to such "inaccessible" tower sites should be made to allow concrete to be pumped to site. In such cases, maximum use of hand excavation and erection can be pursued.

g) Where the above methods are not possible, helicopter assisted construction techniques could be considered. This is the least favoured construction access option from a cost perspective.

h) Where roads requiring cut or fill have been constructed, these should not be closed after construction, unless precluded by environmental, erosion or landowner restrictions. Rehabilitation and erosion protection of such roads must be completed at the completion of construction.

i) The installation requirements for berms may be relaxed during the construction period to facilitate easier access to tower positions, provided that a moderate erosion potential has been verified by the Environmental officer.

5. Access roads

Roads should be planned according to principles of water runoff and should ideally be positioned on a watershed or ridge, and along contours. The overall slope of a road should not exceed 7% and may over short distances be increased but should never exceed 18%. Sensitive soils may cause a change in route.

All access routes are to be flagged to enable visitors and suppliers to reach specific tower locations on the accepted access route.

5.1 Positioning and construction of water diversion beams

Berms are to be constructed with the primary purpose of preventing erosion of access roads, however the profile of the berm is to be shaped with due consideration to both the resulting ride quality of the access track.

The **Contractor** may elect to delay the construction of berms to the end of the contract in areas where a moderate erosion potential exists, provided that erosion developing along the access road during the construction activities shall be rehabilitated promptly, and that existing drainage systems shall not be blocked or altered in any way by construction activity.

A lower average berm spacing is suggested by this specification: Berms spacing (in meters) = 300m / Slope of the road (%). See Figure F.1 below.

In very flat areas with a low erosion potential, this implies that berms may not be required at all.

The inclusion of erosion control measures and berm spacing may be adjusted as directed by the **Employer's** environmental officer.

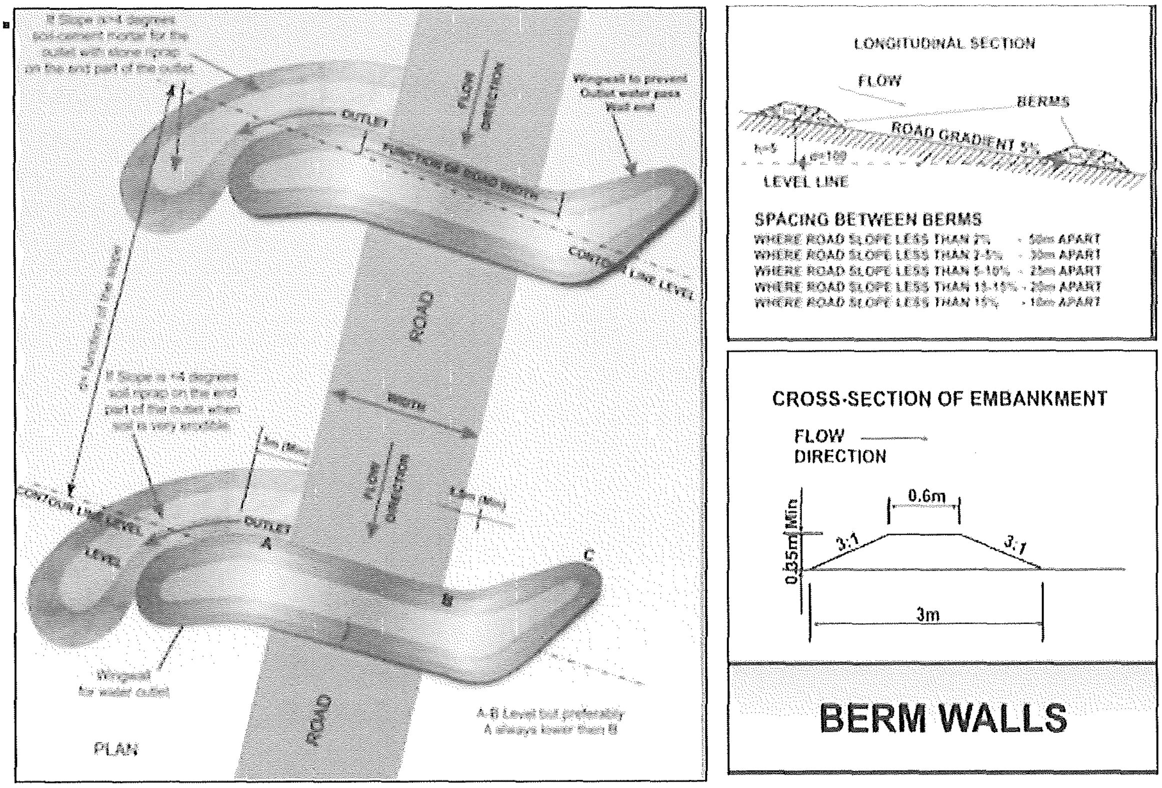


Figure F.1: Alignment of water diversion beams

5.2 Constructon of new roads in sloping terrain

The maximum riding surface width for newly constructed roads is 3.5m, provided that road widening may be required to enable passing of vehicles at appropriate intervals.

The cross fall slope of roads requiring cut to fill shall be 1-2%, against the natural ground slope to avoid erosion of filled material. Fill material must be compacted by vibrating roller in 150 mm layers.

Runoff is drained via a 300mm deep channel (See Figure F.2) and directed off the riding surface at regular intervals via diagonal berms sloped downhill at 10-40m spacing (lined with stone or precast strips). Such berms may require soil stabilisation in steep access roads (See Figure F.1 and Figure F.2).

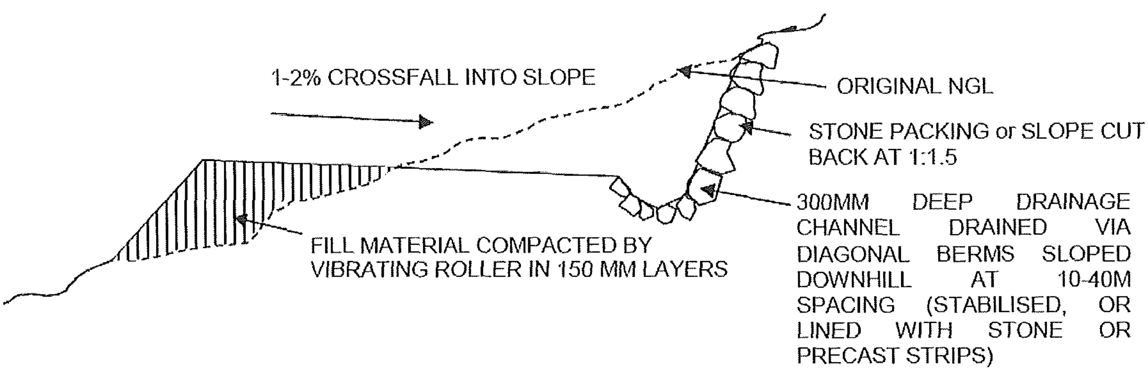


Figure F.2: Typical cross-section of access road requiring cut and fill

5.3 Drainage on roads in sloping terrain

5.3.1 Stabilised Outlet Berms

Where significant erosion potential exists on sloping roads constructed with cut and fill, additional erosion protection will be required on the berm itself, and the outlet of the berm.

In moderately sloping areas, the berm may be stabilised and compacted with 1:8 cement soil mixture. For stabilisation to be effective, it is imperative to mix and moisten the stabilised soil before compacting the berm with a mechanical hand operated compacting roller. Failure to effect proper stabilisation as per the preceding method will result in the gradual disintegration of the berm.

In areas with steeper slopes, berms may be lined with stone pitching (Figure F.3) or an "Amorflex" type interlocking system (Figure F.5).

Alternatively, the approach of berms may be strengthened by the casting of 600mm x 175mm deep concrete strips.

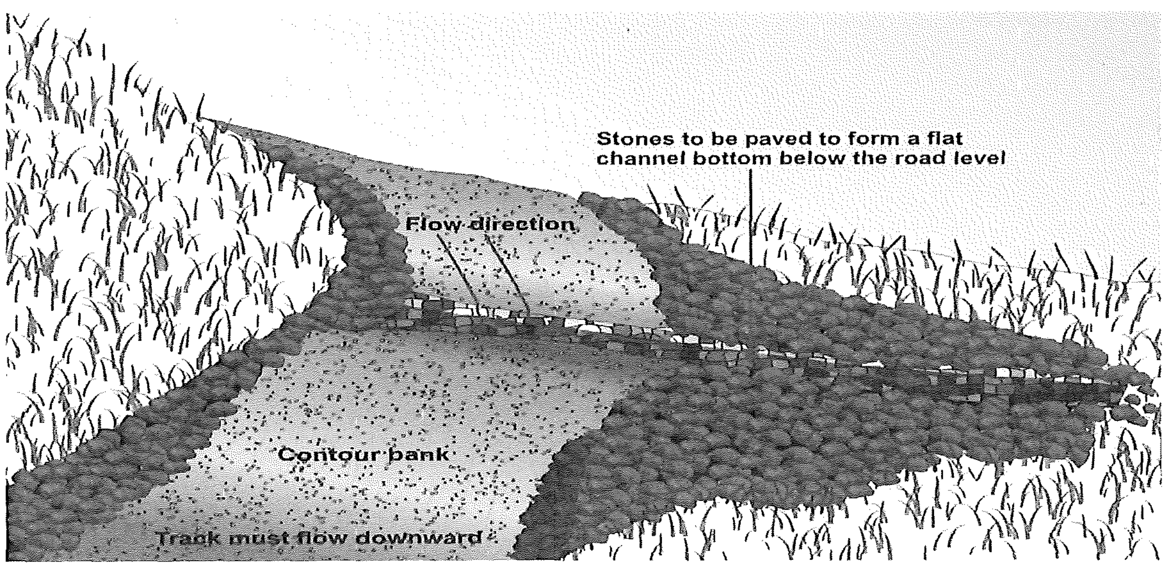


Figure F.3: Stone pitched outlet berm

5.3.2 Gabion Outlet Drains

Where there is a risk that water run-off from berms in sloping roads could erode the fill material or outlet area, it is preferable to construct a protected outlet area with stone rip – rap as illustrated in Figure F.4. However, in steeper terrains, a gabion outlet drain may be specified, based on the erosion potential at the outlet.

Outlet drains will refer to positions where the road forms a dip, water then accumulate and flood the road service causing the water to flow out at the shoulder of the road (or lowest point on road shoulder) causing eroding of the road shoulder.

These drains consist of 600mm high, 1m long and 600mm wide gabion walls with a reno mattress outlet. The gabions are set 300mm deep at the road surface. Measurements may be adjusted by the supervisor depending on the road condition.

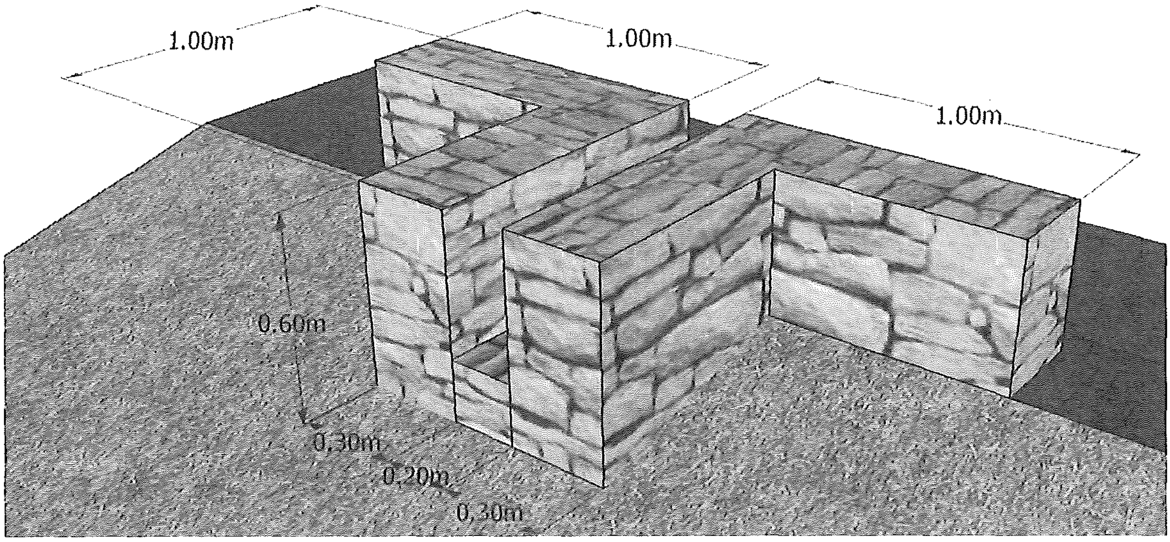


Figure F.4: Gabion Outlet Drain

5.4 Armorflex strip roads

The maximum longitudinal slope for a road ascending sloping terrain shall not average more than 1:10, with a maximum for short lengths being 1:16, provided such lengths are constructed with Armorflex or similar approved continuous precast erosion protection, as shown in Figure 24 or with concrete strip roads as specified in 0.

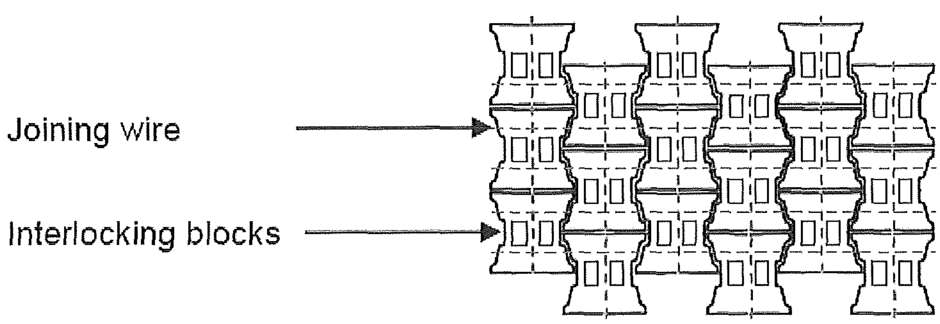


Figure F.5: "Armorflex" type interlocking system for steep access of up to 1:16

5.5 Concrete strip roads

Strip roads are constructed on the steep sections of the access road only. Concrete strips will be cast 600mm wide and 900mm apart, centre to centre. Minimum thickness of the concrete will be 175mm.

Grooved joints are used where the strips are placed in a continuous operation in lengths considerably greater than 1.5m. Keyed joints are to be used in the so called alternate-panel method of construction, i.e. the first, third and fifth panels, etc. are placed on the first day, and the in-fill second, fourth and sixth panels on the second day, etc. Where continuous placing with grooved joints is interrupted for more than an hour, a keyed joint is required. Each strip must be divided into panels by transverse grooved or keyed joints. For very steep slopes it is preferable to use keyed joints.

The water content of the concrete must be reduced to prevent the concrete from flowing downhill during compaction. The target slump for strip road concrete is 60mm.

Panel anchor blocks must be incorporated in the construction of the concrete strips at bottom end of the slope.

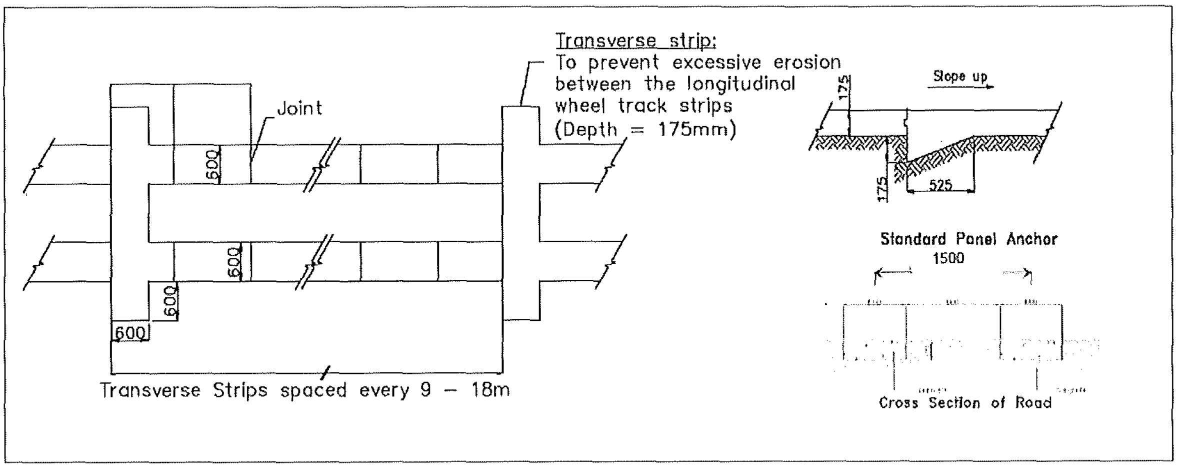


Figure F.6: Concrete strip road for steep access of up to 1:16

5.6 Closure of roads for erosion control

While the utility should attempt to maintain access to all tower sites on the servitude, there are situations where road closures will be required. These locations are usually in environmentally sensitive sites and should be flagged for closure in the EMP. The closure of a road may also be specifically requested by the landowner.

In areas of 30 % slope and less, the fill of the road should be placed back into the roadway, to restore the natural ground slope as indicated in Figure F.6. Here it is important to use equipment that does not work outside of the road it is closing. (For example a Tractor Loader Back-actor may be used and should operate from the cut portion of the road, working backwards and closing the road as it retreats.)

On steeper slopes (greater than 30 % slope), the equipment should break the road shoulder down, so that the slope nearly approximates to the original slope of the ground. The cut banks should be pushed down into the road, and a terraced side slope should be re-established with an erosion control system and re-vegetated.

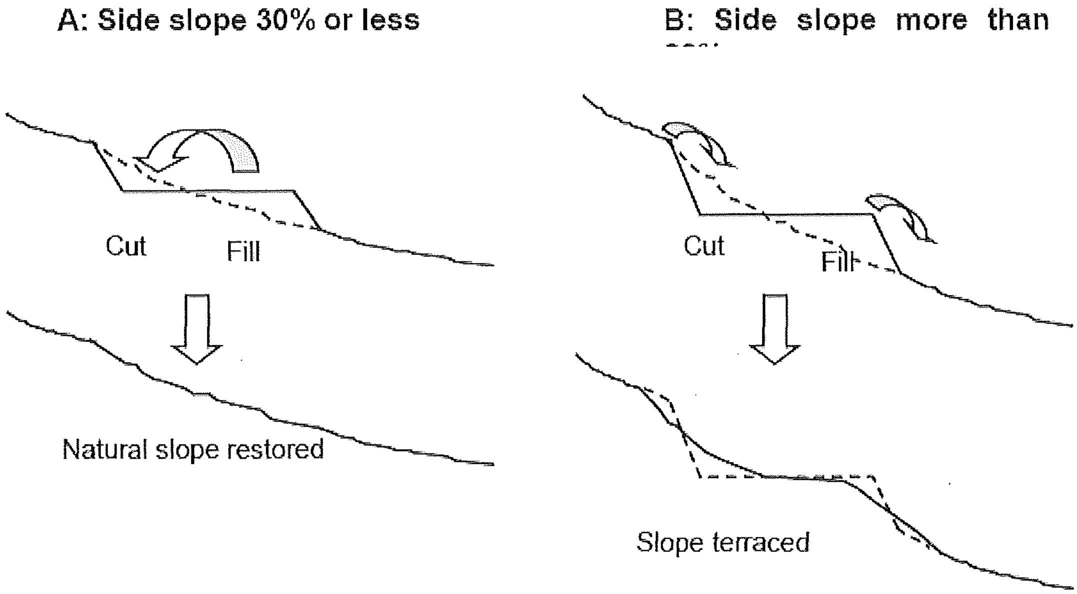


Figure F.7: Road Closure in steep terrain

Replacement of earth should be at a slope less than the normal angle of repose (the natural angle of soil spill) for the soil type involved.

Rehabilitation can be done by using Geo grids (Geotex) or Geo cells (Hysan or Multi cells) with topsoil and re-seeding. Note that Hysan cells and such like grids merely contain topsoil on a temporary basis to allow the re-growth of natural vegetation, and are not suitable to carry traffic or for use in the presence of larger amounts of flowing water.

Where towers are placed on steep slopes resulting in disturbed surfaces, or loose ground, the slopes should be rehabilitated or refurbished by one of the following methods:

- Steep slopes: use retaining systems such as Gabion basket systems, retaining blocks or stone masonry.
- Moderate slopes: use Geo grids (Geotex) or Geo cells (Hyson or Multi cells) with topsoil and re-seeding.

Where access roads have crossed cultivated farmlands, the lands should be rehabilitated by ripping to a minimum depth of 600mm.

6. Water crossings

The construction of permanent stream crossings will only be undertaken where no alternative access to tower position is possible.

The construction of temporary accesses for the purposes of construction is subject to the **Employer's** environmental representative and environmental restrictions.

6.1 Water courses and small river crossings

If access is across running water, precautions should be taken not to impede the natural flow of water.

The banks of small rivers and water courses upstream and downstream of crossings are environmentally sensitive areas which need to be protected from erosion. When cutting through the embankments of watercourses and small rivers, the road cuttings should likewise be protected to prevent erosion from spreading in the direction of the servitude road.

No soil should be pushed into the watercourse, as this will impede the natural flow of water. Rather, the banks of the watercourse should be cut as illustrated in F.8. Watercourse crossings should be designed and maintained to withstand a 1 in 20 year flood.

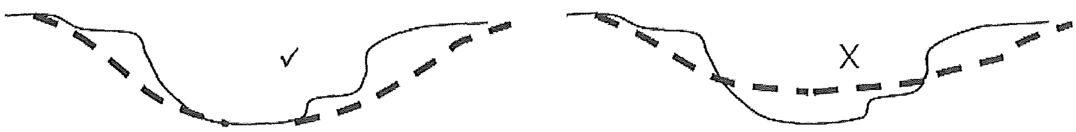


Figure F.8: Correct and Incorrect methods of cutting stream crossings

6.2 Temporary dry bed/marsh crossings

Where sandy river beds, moderately marshy or soft soil areas are to be crossed which cannot support construction vehicles, a temporary crossing surface may be constructed using a 300mm layer of primary crusher run (150mm stone), topped with 26.5mm stone and crusher dust.

Alternatively, Cellular Confinement Systems (CCS, also known as geocells), may be used in conjunction with a graded stone mix (5-19mm) or gravel. See figure F.9.

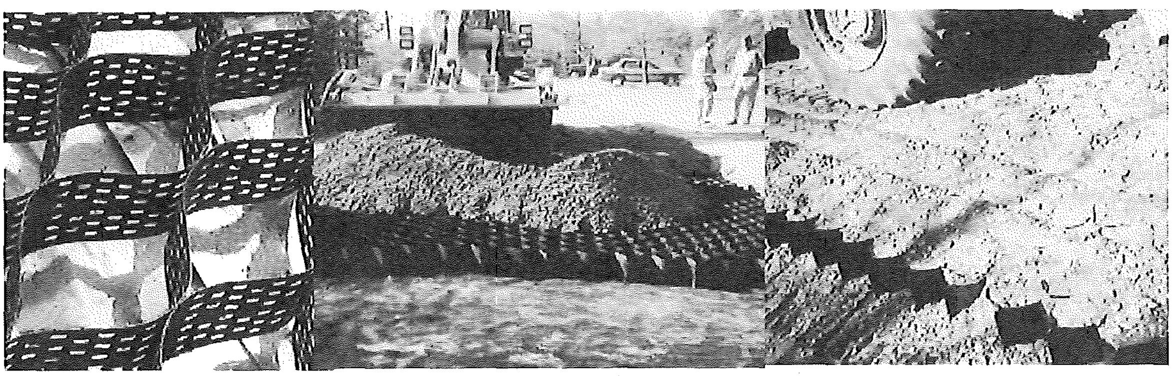


Figure F.9: Increasing load bearing capacity using a cellular confinement system (Sources: Elmich.com and Geoproducts.org)

6.3 Drift water course crossings

The construction of drifts must be aligned with stream bottoms as shown in Figure F.8. Experience has shown that failure to execute this will result in the tilting or breakup of the drift.

Drifts may be constructed on Reno mattresses, as shown in Figure F.10.

For faster flowing water velocities (>2m/s), "Armorflex" type paving (illustrated in Figure F.5) should be used.

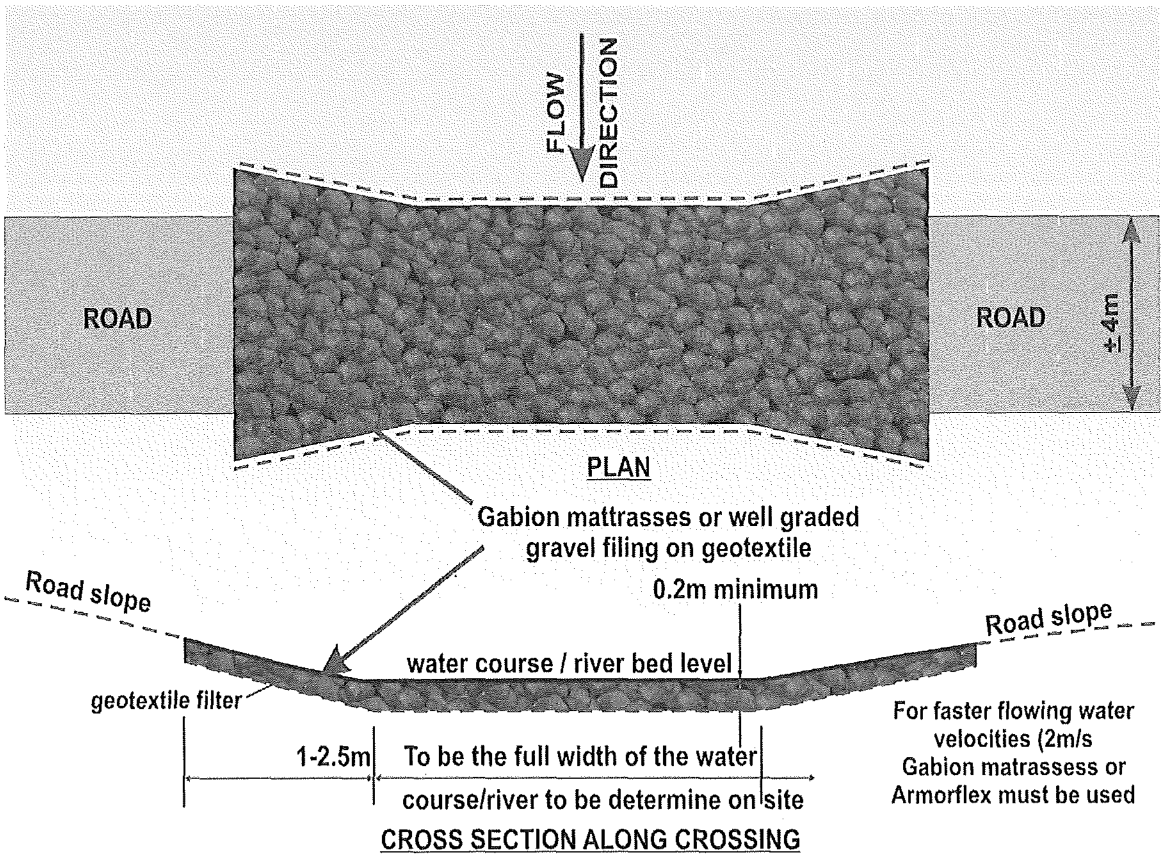


Figure F.10: Water course crossing with Gabion mattresses or rock/gravel filling on Geotextile Filter Material

6.4 Low level bridge or culvert crossings (pipes with concrete slabs)

Low level bridge or culvert crossings should be constructed and maintained bearing in mind the following:

The combined diameters of the pipes in the bed stream should be equal to the width of the water course, that is, the distance from one embankment to the opposite embankment, and have a diameter of approximately the depth of the 1 in 5 to10 year flood level.

The pipes should be laid with a cross-fall of 2 to 5 % on a 150mm+ thick concrete blinding layer. They should be built-in at the ends with rock mortar walls (or gabions) and an in-between fill of rock or gravel mortar should be used. The rock mortar walls and fill should extend well into the embankments (1to 2 m).

For higher water flow volumes and velocities, the top layer over the pipes should be a reinforced concrete slab of ± 350mmthick.

Embankments should be built up with stone and mortar (or cells with gravel and mortar or other means for example, gabions etc.) to about ± 0.3 m above the 5-year flood levels.

The riverbed should be protected for about ±1 m upstream and ± 2 to 3 m down-stream with mortar stone rip rap or Hyson cells with stone. Refer to Figure F.11 for the design layout.

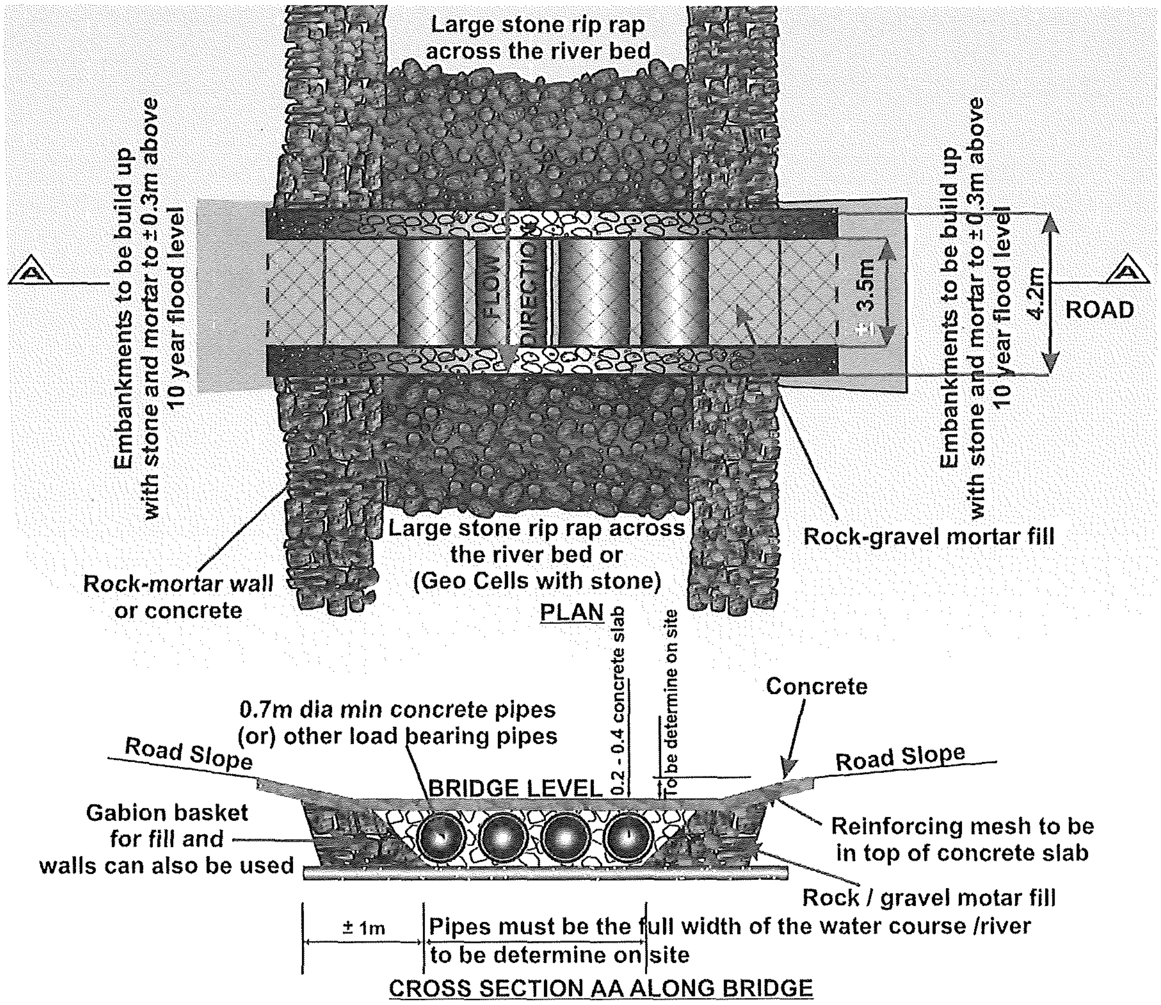


Figure F.11: River/Water course crossing with pipes, rock/gravel mortar filling and concrete slab

7. Tower sites in sloping terrain

The majority of tower sites should be positioned such that access is possible with the minimum effort. While due care and effort should be undertaken in the finalisation of tower locations, the presence of more suitable tower positions may be made possible by minor adjustment in tower locations during construction. Where relevant, this option is considered preferable over the construction of special access roads and platforms.

7.1 Alignment of access to tower sites

The alignment of access roads in towers in sloping terrain must be planned by all relevant parties.

The alignment must suit access requirements for foundation construction and tower erection. Unless precluded by environmental restrictions, the alignment must aim to provide access for a rough terrain crane, rough terrain trucks, and 6-wheel drive concrete trucks.

The access alignment must also be suited to the tower footprint, as shown below. For guyed structures, access may be aligned within the footprint of tower legs, while self-supporting towers may be suited to the construction of access roads around the tower legs.

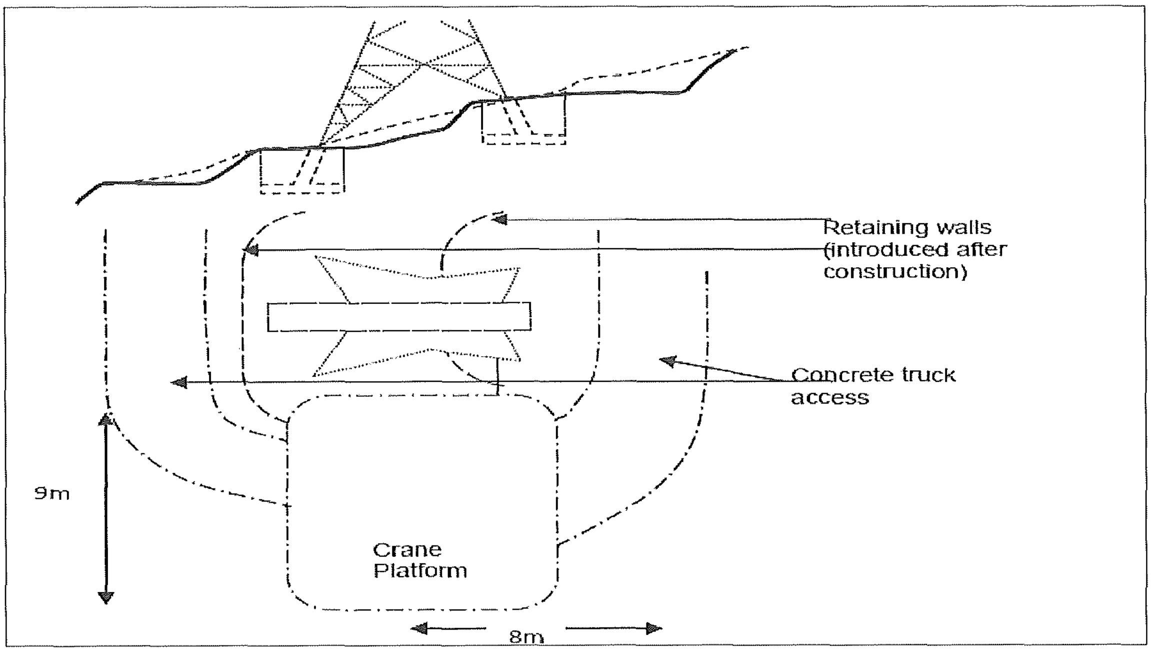


Figure F.12: Typical access of self-supporting lattice tower

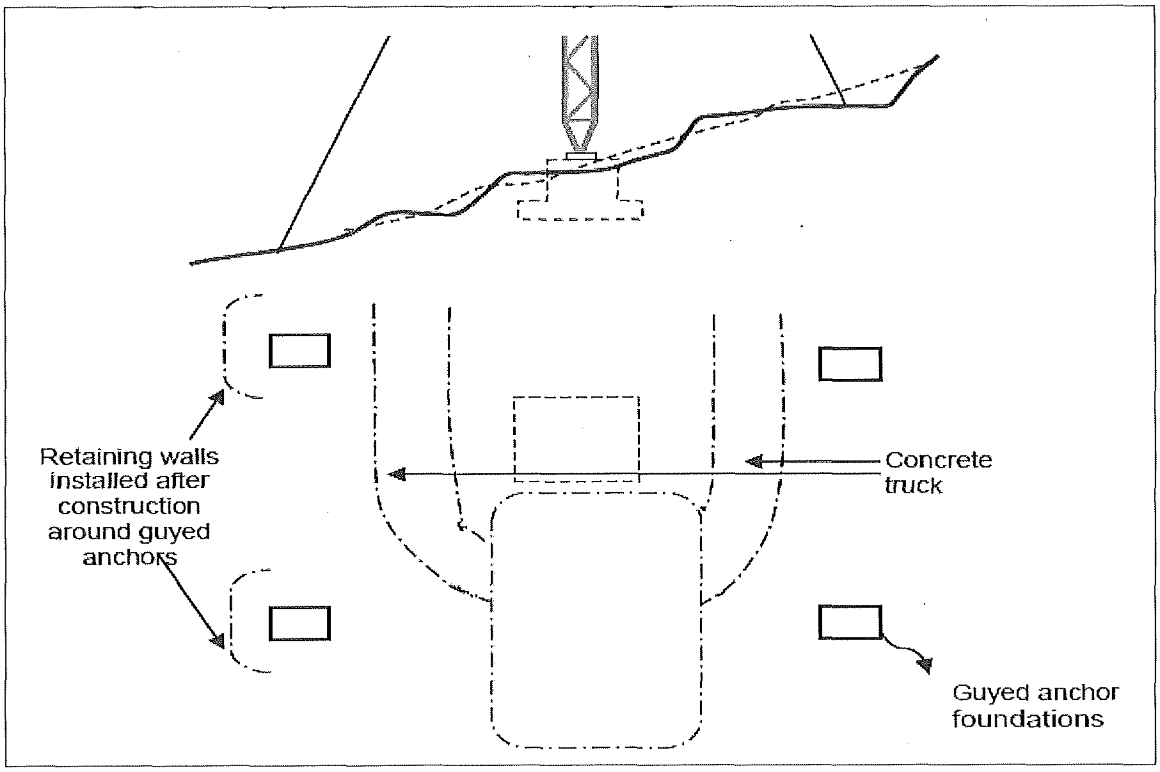


Figure F.13: Typical access to guyed tower

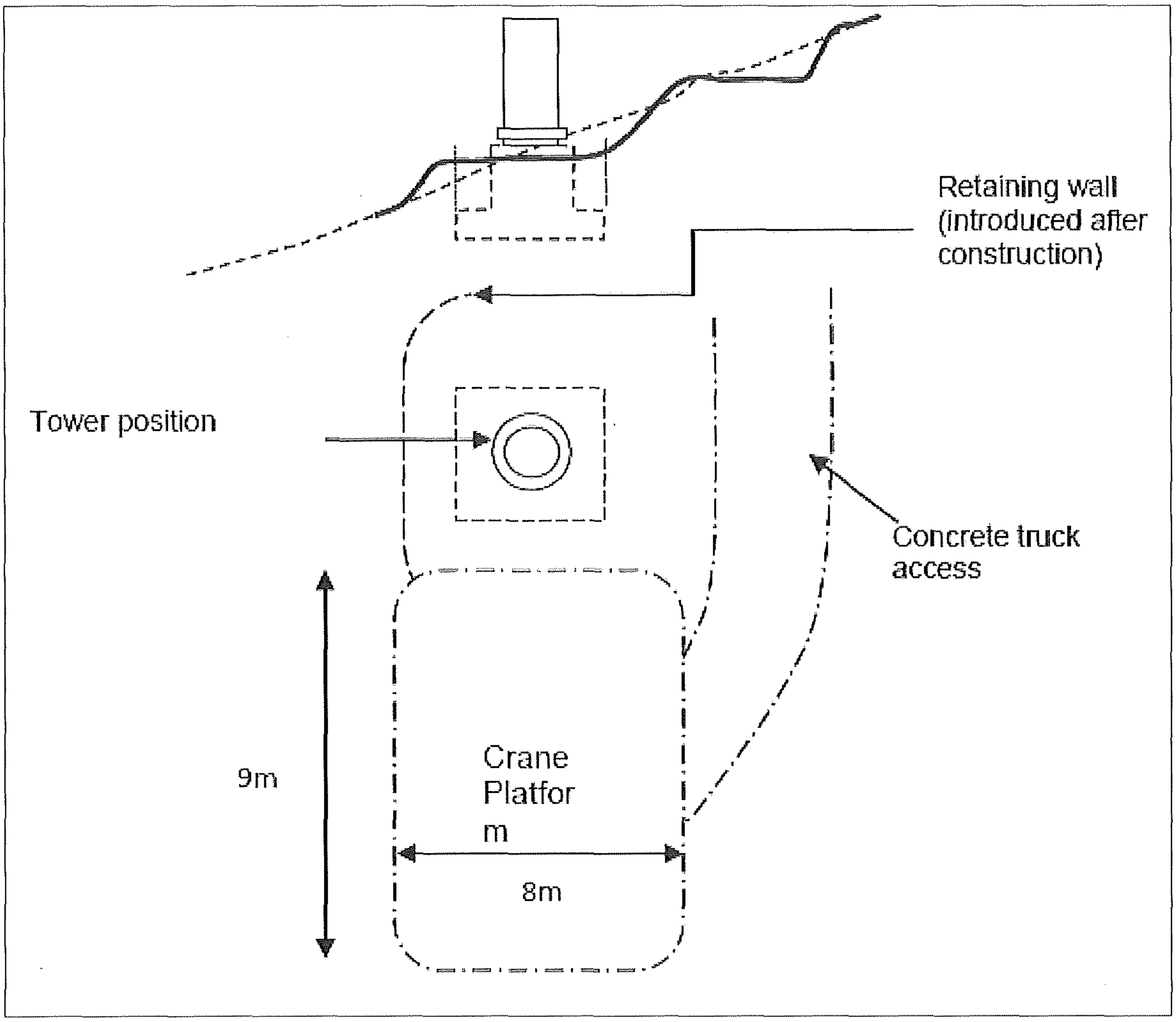


Figure F.14: Typical Access to Self-Supporting pole

7.2 Access for cranes

The footprint for outriggers of a typical 80 ton crane is about 8 x 9m, however the outriggers need not be placed of a completely level platform. The maximum crossfall slope for a rough terrain crane suited to overhead line construction is about 5% or 1:20.

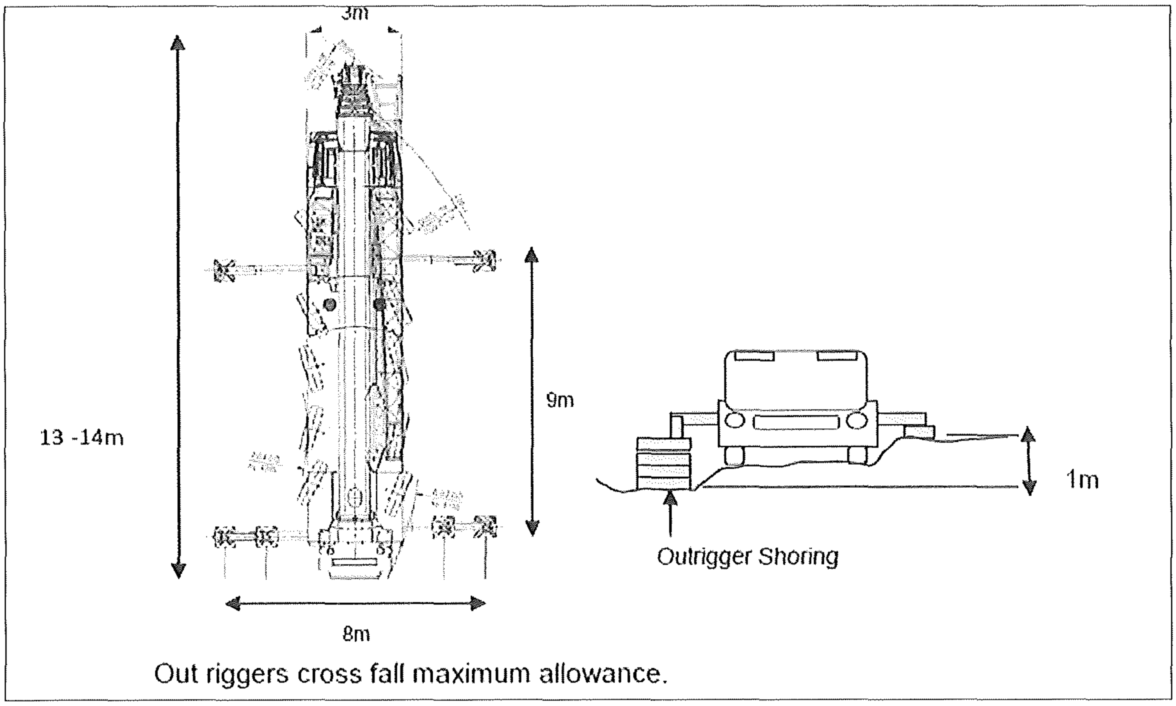


Figure F.15: Typical 80 ton crane plan dimensions

Outrigger shoring, using railway sleepers or thick timber boarding will usually be required in areas with significant crossfall.

8. *Rehabilitation of tower sites and access roads*

At the completion of construction, repairs may be required on access roads to restore them to their original condition.

Where berms have been eroded or worn away because they were constructed using unsuitable localised material, alternative material for refurbishment and maintenance should be used. The following methods may be considered:

Where the local material has high clay content or consists of a sandy soil with little variation in particle size, the soil needs to be improved. The properties of the soil can be improved by the addition of stabilising agents such as slaked lime in the case of clayey soils or cement in the case of sandy soils. The berm material stabilised in this way should be mixed in the ratio of one part cement or lime to eight or ten parts of soil. This material should be properly mixed, moistened, placed and compacted.

Borrow pits may be utilised to source more suitable material. The location of borrow pits, and their rehabilitation should be specified in the EMP.

Under normal circumstances, the majority of tower sites, being located on relatively even terrain, will not require extensive rehabilitation or mitigatory measures. If the top-soil is replaced in the final layer of backfill, natural ground cover vegetation will usually grow back in spite of extensive removal of surface vegetation during construction.

Any soil removed by erosion, must be evenly filled back and, graded to conform to the surrounding terrain. During foundation excavation, care must be taken to replace top-soil to the final layer of foundation backfill. Failure to replace topsoil in the final layer will leave infertile sub-grade soil on the surface, thus impeding re-growth. The EMP may in certain instances also call for the re-planting or re-seeding of certain sites. All tower sites should be rehabilitated (slope areas to be stabilized) and maintained by methods applicable to the situation. Maintenance should be in accordance with the requirements of the EMP.

The following environments however, can constitute sensitive sites:

8.1 Arid environments or sparse vegetation

These sites are typically located in areas of the Karoo and Namibian desert. The ground vegetation, when disturbed, can take years to recuperate, and there is not sufficient natural moisture to permit re-planting of natural flora.

The principle mitigatory measure is to limit the destruction of vegetation, by strict adherence to minimizing the extent of damage. This includes limiting the available working area and avoiding the creation of multiple tracks.

8.2 Sloping terrain

These tower sites require various forms of terracing. This not only ensures that erosion is limited but aids in maintaining the uplift capacity of foundations, which is invariably compromised in sloping terrain.

The terraced soil requires the construction of soil retaining systems, which include the use of:

- Stone walls, consisting of natural stone which are either loosely packed (adequate in mildly sloping terrain), or laid using mortar.
- Stone pitching, entailing the use of natural stone which is overlaid on the side slopes of terraces and then cemented by mortar.
- Pre-cast retaining systems, generally consisting of interlocking pre-cast concrete blocks.
- Gabion Mattresses, consisting of wire baskets which are filled with natural stone.

The use of natural materials is favourable not only from an aesthetic, but also from a cost efficiency point of view, and should be utilised where availability permits.

8.3 Proximity to flowing or still water

Erosion of river banks have resulted in compromised tower foundations in a number of instances. In these cases, it is preferable to utilise resilient systems, such as gabion mattresses. Gabion mattresses have the added benefit that they are flexible, and continue to provide protection even after surrounding material has been eroded (in contrast to other retaining systems, which can topple after heavy flooding).

9. Post construction inspections

The first post construction inspection should be conducted upon hand-over, and should be conducted jointly by regional staff, project managers and engineers responsible for design.

The second (and most important) should take place 11 months after hand over, in order to asses:

- the extent to which natural re-growth is possible
- the erosion resulting from the preceding season, taking into consideration the amount of rainfall
- the need for additional erosion protection or re-vegetation

10. Erosion prevention structures

These structures or systems are used in eroded areas and aim to control the flow of water, halt active erosion and re-establish vegetation. Three categories of solutions are suggested by Suthers (2002). They are:

10.1 Heavy systems

These solutions include concrete or brick structures and gabions and reno mattresses, etc.

10.2 Gabion mattress walls

Soils or up slope embankments which are subjected to dynamic or static loading must be stabilised to ensure equilibrium of the surrounding environment. When soils is confined or loaded, distributing forces are set up that may give rise to sliding, overturning and bearing failures. To counteract these effects slope reinforcements may be required.

The specifications as referred to in SANS 1200DK should be taken in consideration when building Gabion Mattress Retaining Walls.

The specifications and sketches in this document will refer to the protection of service roads against up-slope rock and soil sliding which might damage the access / service road or prevent access along the service road.

The following schematic sketch will illustrate the layout of a Gabion wall. Dimensions will need to be calculated according to the slope gradient, erosion risk and composition of the soil.

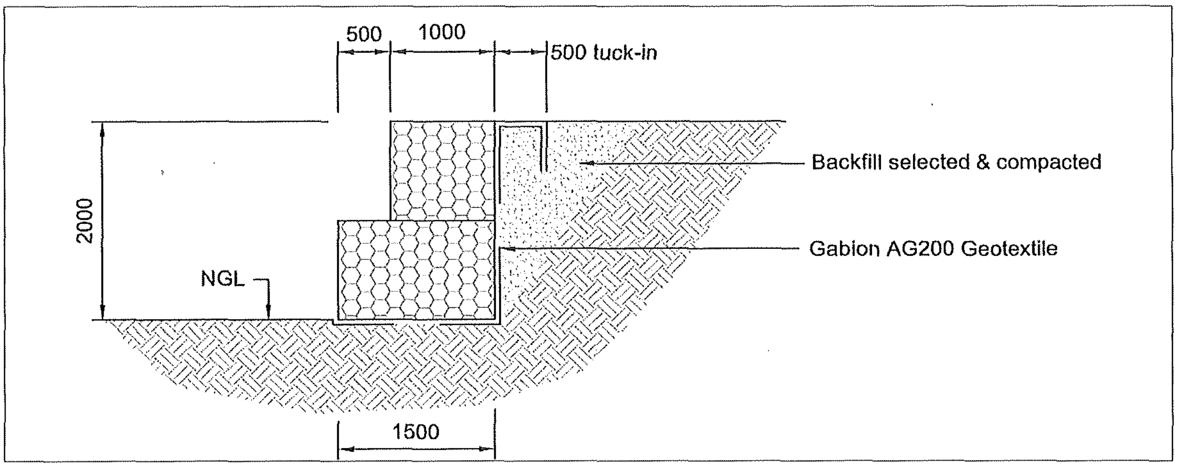


Figure F.16: Schematic sketch for layout of gabion wall

Note: No single gabion cage will be longer than 4m.

Use double twist hexagonal woven mesh according to SANS 1580 specifications: use galvanised mild steel wire.

Stone filling can be rock from the surrounding environment, primary crusher run, or obtained from an approved source as indicated by the Employer or Technical Specification related to the specific project.

Backfill material behind structures and below structures to be compacted to a minimum of 98% MOD AASHTO. A G200 geotextile to be used at all mesh / soil interfaces.

10.3 Light systems

These systems include silk screens (van Heerden 2000) erosion control blankets, turf reinforcement mats and geocells. The re-establishment of vegetation is also encouraged by using soil reclamation rolls (SRR), EcoLogs or seeded coir mats.

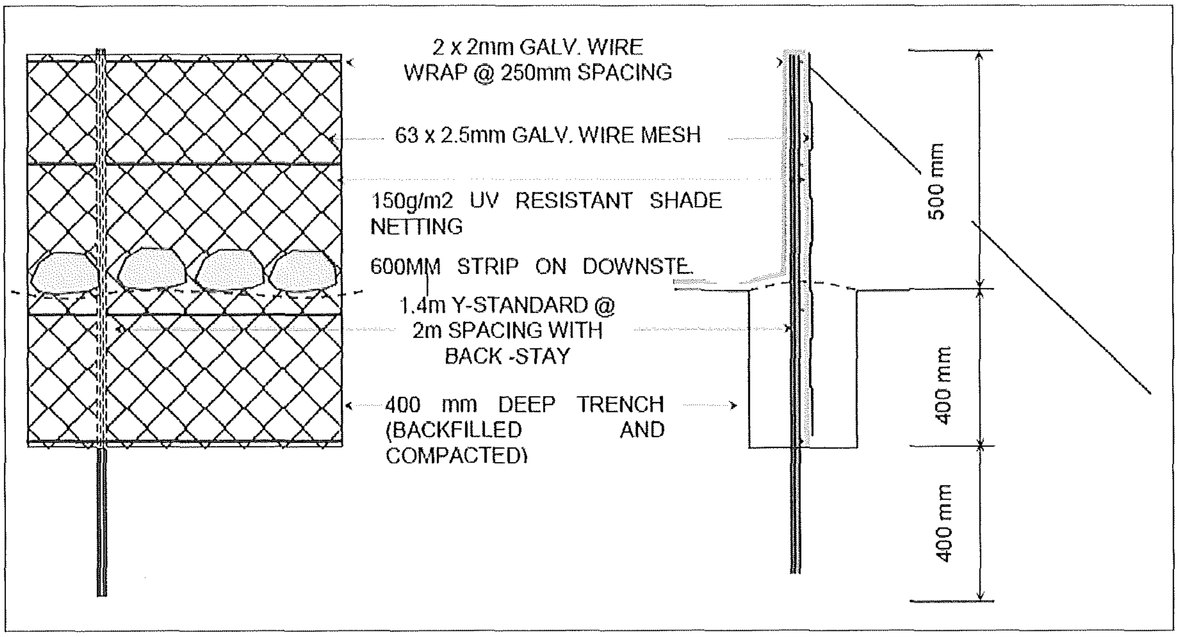


Figure F.17: Silt Screen used for rehabilitation of eroded areas

11. References

- Matthee, J F and Van Schalkwyk, C J, A Primer on soil conservation - Department of Agriculture publication- 2001
- Eskom Specification, Environmental Impact Control (EIC/385) , Eskom-Transmission , March 1985
- Eskom Specification, Environmental Impact Management Program (ESKPVAAZ1), Eskom-Transmission , Jan 2000
- Eskom Specification, Transmission Line Towers and Line Construction (TRMSCAAC1 rev.3) , Eskom-Transmission , March 2001
- Eskom Publication, The fundamentals and practice of Overhead line Maintenance, Power series vol.2, 2002
- Determination of longitudinal grades on rural roads, Polus, et. al., Israel Institude of technology, 1995
- Eskom Transmission Guideline -Soil Erosion Guideline, 41-337, 2010

Annex G – Corrosion coating classifications for hot drop galvanising

Coating classifications (CC) indicate the mean coating thickness described in SANS 121 (ISO 1461). The table below expands on SANS 121 to include medium and heavy-duty coatings and their requirements. This table should be used in the same manner as table 3 in SANS 121 (ISO 1461) when inspecting coating thickness. The thickness description next to the coating classification describes the mean coating thickness expected on members > 6mm and is used to refer to a certain coating classification.

Light Duty - 85 µm

Medium Duty - 105 µm

Heavy Duty - 140 µm

Table G.1: Minimum coating thickness and mass specified in the design of the steel members too be

Article and its thickness	CC	Local coating thickness (µm)	Local coating mass (g/m^2)	Mean coating thickness (µm)	Mean coating mass (g/m^2)
Steel > 6mm	Light	70	505	85	610
	Medium	90	648	105	755
	Heavy	125	900	140	1008
Steel > 3 mm to ≤ 6 mm	Light	55	395	70	505
	Medium	73	525	88	633
	Heavy	110	792	125	900
Steel ≥ 1.5 mm to ≤ 3 mm	Light	45	325	55	395
	Medium	54	389	69	497
	Heavy	95	684	110	792
Coatings ≥ 6 mm	Light	70	505	80	575

Table G.2: Minimum coating thickness and mass specified for fasteners to be achieved

Article and its thickness	Local coating thickness (µm)	Local coating mass (g/m^2)	Mean coating thickness (µm)	Mean coating mass (g/m^2)
Articles with threads:				
> 6mm diameter	40	285	50	360
Other articles (Including castings)				
≥ 3 mm	45	325	55	395

Annex H – Guy foundation Link Plates

Guy anchor links shall be manufactured with filleted edges in the hole for the guy attachment if a U-bolt attachment is used and a straight hole if a shackle is used. The rounded fillet radius should match the radius of the U-bolt to ensure no point contacts. Chamfered edges will create multiple point contacts and is not allowed.

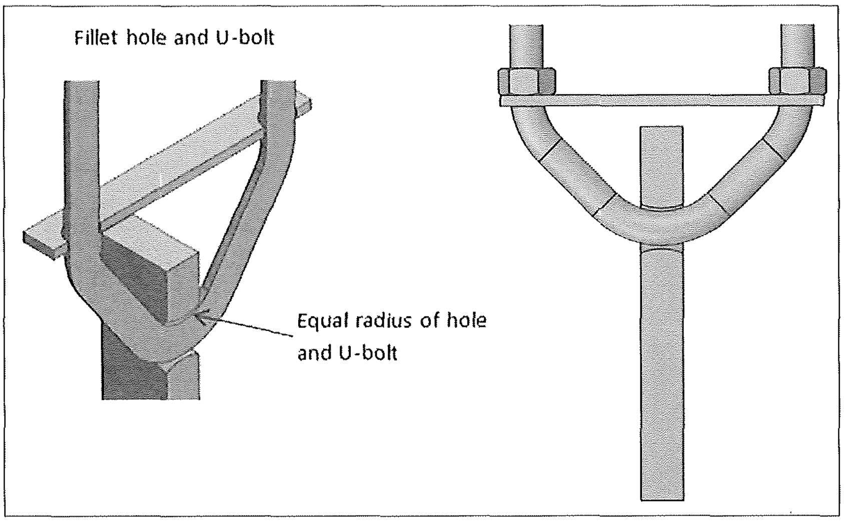


Figure H.1: Guy Foundation Link Plates - Fillet Hole and U-Bolt

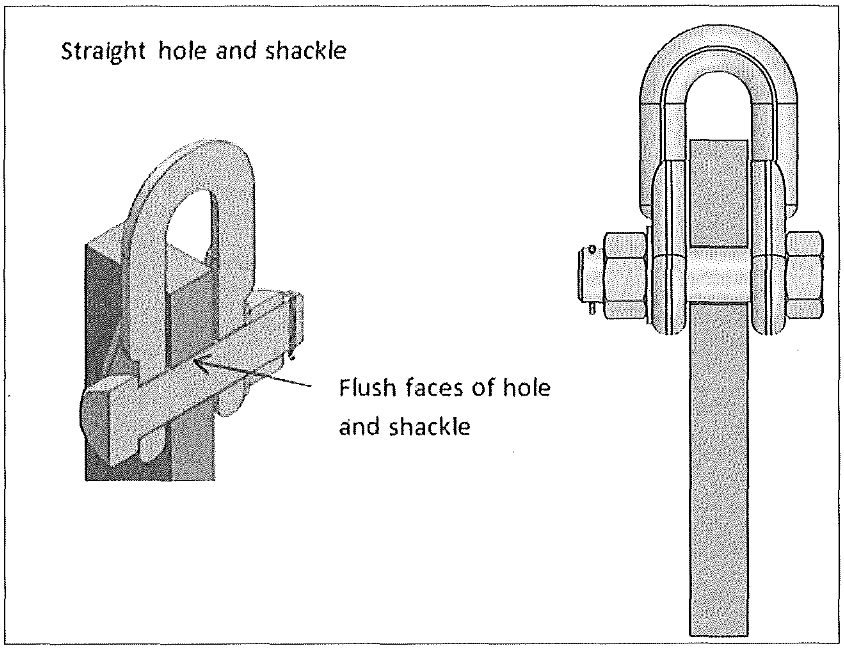


Figure H.2: Guy Foundation Link Plates - Straight Hole and U-Bolt