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الشركة السعودية للكهرباء
Saudi Electricity Company

TCS-P-122.05

Revision no. 0

INSTALLATION OF

STEEL STRUCTURE FOUNDATIONS

ORIGINATED BY	CERTIFIED BY	APPROVED BY
Engr. GhazanfarA. Iqbal Division Manager, Transmission Lines Specifications	**Engr. Abdullah M. Al-Garni** Department Manager, Transmission Standards & Specifications	**Engr. Saleh N. Al-Sohaibani** Vice President, Engineering & Projects
Date of Approval: December 16, 2006		

TRANSMISSION CONSTRUCTION STANDARD

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1.0 SCOPE

This standard provides general recommendations for selection of methods and procedures that have been found practical for the installation of steel structure foundations with stub angles and anchor bolts for the overhead transmission line system of the Saudi Electricity Company (SEC), Saudi Arabia.

2.0 GENERAL REQUIREMENTS FOR FOUNDATIONS

2.1 It shall be the responsibility of the Contractor to locate underground facilities such as gas, water, sewer lines, drain lines, electric power and telephone cables, etc., which may be encountered in digging or drilling holes and to perform work in such a manner as to prevent damage to such facilities. In case of any damage, the Contractor shall repair immediately all such facilities, to the satisfaction of the facility Owners. If the facilities cannot be repaired immediately, the facility Owner shall be advised when repairs will be completed. The Contractor shall inform the SEC Representative as soon as possible after the repair works are completed but in no case, more than one week after the occurrence of any damage to such facilities.

When the damage is completely repaired, the Contractor shall secure and submit to SEC Representative one copy of a written release, signed by the Contractor and the facility Owners suffering the damages, within 30 days after completion of the repair work.

2.2 The footings for tangent structures shall be placed so that the longitudinal axis of the structure cross-arms will lie in a plane perpendicular to the centerline of the transmission line. The footings for angle structures except the terminal structures shall be placed so that the cross-arms will lie in a plane bisecting the interior angle formed by the two intersecting centerlines. The footings for terminal dead-end structures shall be placed so that the transverse axis of the structure cross-arms shall be parallel to the transverse axis of the gantry structures placed in the substation. If heavy angle structures are used as terminal dead-end, their footings shall be placed in the same way as that for the angle structures.

2.3 The center of the top of each drilled pier shall not vary from its designed center by more than four (4) percent of the pier diameter and pier shall be plumbed within one (1) percent of the total depth. The centerline of the completed foundations shall be centered within 30 mm of the specified location across the line and 150 mm along the line.

2.4 The transverse axis of the structure foundations shall not deviate from the bisector of the interior angle of the structure by more than 30 minutes of the arc due to rotation of the entire foundation.

2.5 Excavation of the structure foundations shall be to the elevations and dimensions indicated on the approved drawings or as required to permit

construction of the foundations, erection of forms and inspection of foundations.

2.6 The earth, rock, stumps and all other materials encountered shall be excavated as required for the construction of foundations in accordance with the approved drawings. All excavated materials suitable for backfill shall be placed in graded embank in the immediate area of the structure. Materials found to be unsuitable for backfill or grading shall be disposed off as directed by SEC Representative.

2.7 For excavation where the base is unstable or lies below the groundwater level, the water table shall be lowered and a layer of crushed stones or selected backfill or borrow shall be placed to stabilize the base before placement of the materials.

2.8 Foundations in earth shall be excavated to clean, level surfaces of undisturbed material of adequate bearing value. The quality of the soil and adequacy of its bearing value shall be approved by SEC Representative before placement of foundation. Materials unsuitable for sustaining the design loads shall be removed and disposed off as directed by SEC Representative. Where loose rock or boulders of a size equal to or less than the foundation diameter extend above the design elevation of the footing base, such loose rock or boulders shall be removed to a minimum depth of 150 mm below the footing base and the resulting depression shall be considered and treated as new footing base. Where over excavation occurs, the limit of such over excavation shall be considered and treated as the new limits of the footing.

2.9 Foundations shall be placed as soon as practicable after excavation and all excavations shall be maintained in a safe, clean and sound condition up to the time of placement of footings. Whenever necessary, all sand, mud, silt and other objectionable material, which may accumulate in the excavation, shall be re-excavated prior to the placement of the footings. All excavations shall be covered with strong covers or fenced as required until reinforcement and concrete have been placed. The bracing, sheeting and shoring shall be installed as required for safety. All excavations shall be kept dry by pumping or draining as required.

3.0 STRUCTURE PADS

3.1 Prior to excavation or filling of structure pads, each structure site shall be verified based on plan and profile drawings to determine the structure centerline ground elevations.e. The top elevation of the concrete footings shall not be less than 450 mm above finished grade of the structure pads.

3.2 The structure centerline and location shall be established after the original ground has been scarified and prior to filling of the sub-base so that a minimum distance of 15 meters shall be maintained from any point of the structure foundations to the top edge of the structure pad. At locations, where

a minimum distance of 15 meters for structure pad is not met, SEC representative shall decide about the minimum requirements. The structure pad shall be graded with a slope of 1.5% to 2% to drain water away from the structure foundations. Structure pads shall be constructed in accordance with the requirements specified in TES-P-122.11.

4.0 SOIL PIER FOUNDATIONS

4.1 Soil pier holes shall be drilled with suitable types of drilling equipment to produce the required level of excavation. The methods and equipment used shall be such as to leave the sides of the excavation free from appreciable quantities of loose material, which would prevent intimate contact of concrete with firm soil and/or rock. The bottom of excavation shall be clean so that end bearing of the footings will be on the firm soil. The excavation shall be protected with a temporary casing of suitable thickness maintained at a height of 500 mm above existing ground line.

4.2 Temporary casings shall be required at all locations of high water table and layers of fine sand and, where workmen are required to work at the bottom of the excavation. Casings shall also be required at locations where the soil will not stand alone without support or where sloughing of the sides may endanger the satisfactory completion of the pier. Casings shall be of sufficient strength and rigidity to maintain the required excavation lines against the earth and water pressures that may be encountered, and shall be installed carefully to assure that soil around the casing is not disturbed. The method of holding casing in the pier hole shall be such that it will not allow the casing to sink in the ground. If casings are removed from the excavation, they shall be removed in a manner that shall not adversely affect the quality of concrete, disturb the surrounding soil, or reduce the amount of rebar cover.

4.3 When casing top is at the proper elevation and the vibrator-driving hammer is removed, the auger/digger shall be centered over the hole and the soil in the casing shall be removed. After vibrator is in position, the casing shall be checked for plumbness by using a transit on one side and at 90º to the first position check. The casing shall be driven until the top is about 500 mm above the structure pad.

If conditions permit and the steel casing is to be removed, the concrete shall be poured up to a construction joint. The steel casing shall be removed concurrently with the placement of concrete. However, in sandy areas, the casing may be left in place, if this is considered in the design. In such cases, the exposed portion and 500mm below the finished grade level of structure pad shall be coated with two (2) coats of coal tar epoxy.

4.4 In uncased foundations, where temporary casing used in excavation and concreting has to be removed, the following requirements shall be completed before removal of the casing:

4.4.1 Casing shall be fully plumbed in two position checks at 90º to each other.

4.4.2 It shall be ensured that concrete inside the temporary casing is sufficient to fill level up to the construction joint and the required concrete cover is maintained before removal of casing and tremie used in concreting.

4.5 If the pier does not require a steel casing or liner, the digger operator can set up the center of the cutting blades of the auger/digger so it is centered over the nail or tack of the foundation center hub and after checking that it is in plumb position both ways on the Kelly bar, digging can begin. If the soil is satisfactory and no caving occurs, the hole can be completed to the required depth and the other holes completed in a similar manner. The excavated soil shall be kept away from around the holes to permit working and shoring, as well as to keep the soil from slipping back into the hole. After completion of the hole, the steel-reinforcing cage shall be placed carefully. If a construction joint is to be provided, the concrete shall be poured and stopped at the level as indicated in the approved drawings. The construction joint key shall be installed as called for in the approved drawings.

5.0 ROCK PIER FOUNDATIONS

5.1 The procedures and methods for installing rock pier foundations are the same as for soil pier foundations except that they are partly embedded in the soft rock. They can be of uncased or cased type above the rock strata. The type, size and depth shall be as indicated in the approved drawings and the structure list.

5.2 When soft rock with Rock Quality Designation (RQD) of 26 to 50 and ultimate core strength of 1.4kPa to 2.8kPa is encountered at a depth of three (3) meters or less, the foundations shall be soil pier type. Rock pier type foundations shall be of bell-bottom or straight shaft piers type and shall be designed and constructed to resist the required design loads.

6.0 ROCK ANCHOR FOUNDATIONS

6.1 Where sound hard rock is encountered at a depth of three (3) meters or less, the hard rock shall be drilled and the reinforcing bars (or tendons) shall be grouted into the rock. All holes shall be protected as soon as drilled with plugs at the collars of the holes to prevent the entrance of sand, silt and other objectionable materials. The bottom of the drilled hole shall be at least 100 mm lower than the tip of the tendons. The minimum center-to-center distance between rock anchor holes shall be 300 mm. Prior to grouting, each grout hole, including the area immediately around the collar of the hole, shall be thoroughly cleaned by air or other satisfactory means to provide clean contact surfaces against which to place the grout. Water entering the excavation shall be removed by

pumping from a sump provided at the bottom of the excavation so as to keep the excavation reasonably dry during the grouting operations. The grout hole shall be completely filled with grout prior to inserting the rebars. The grout forced out from the hole by insertion of the reinforcing dowel shall be left in a mound around the dowel (tendon) to form a raised crown above the adjacent rock surface.

6.2 If entry of groundwater prevents the complete dewatering of a grout hole, the grout shall be pumped through a small diameter pipe lowered to the bottom of the hole. Grout shall be pumped slowly into the hole until all water is displaced and clean grout overflows the hole.

6.3 After insertion, the reinforcing dowel (tendon) shall be subjected to vibration to ensure intimate contact with the grout. After the dowel (tendon) has been properly positioned in the freshly placed grout, special care shall be taken to prevent it from being moved out of position or otherwise disturbed by subsequent operations. A centering device shall be used to ensure the rod (tendon) is centered in the hole and completely surrounded by the grout.

7.0 SPREAD FOUNDATIONS

7.1 Spread foundations have large rectangular or square plan dimensions. These are placed in shallow excavations and are then backfilled. One foundation commonly is used for each structure leg. Spread foundations typically consist of a buried rectangular or square pad with a leg-stub or column connecting the foundation to the tower body. The typicall foundation depth–to-width ratio is between 1 and 3, with the maximum depth often limited to 4-6 m because of construction equipment limitations. The foundation usually is set horizontally, with a leg-stub battered to the same slope as the tower legs. Steel or concrete, or a combination of both, usually are used for the foundation.

7.2 The tower foundation construction survey shall establish the foundation center hub, reference hubs, elevations and the required depth of excavation. Before excavation, the tower foundations shall be marked (staked), and the depth of excavation shall be computed. Ground staking shall include establishing a reference point (RP) hub to the pit center (PC) for each foundation. The elevation of the RP hub shall be esatblished and the depth of cut from this hub shall be computed. This hub shall be used during excavation to control the depth of excavation. During staking process, a PC stake and depth of cut at PC shall be esatablished. The four corners of large excavations shall also be staked according to the foundation excavation dimensions.

7.3 The equipent and techniques to be used for excavation shall depend on the type of material encountered at the excavation site. When soil, loose or fractured rock, boulders, or any combinations thereof are encountered, the excavation shall be done with a track-mounted or rubber-tired backhoe. When the terrain is steep and the backhoe equipment can not be used, other specialized digging machines shall be used.

Drilling and blasting may be rquired whenever machine digging alone cannot proceed because of hardness of the material being excavated. A rock-drilling machines shall be used to drill holes for blasting. If rock is encountered during hand excavation on steep hillsides, small portable compressors and jackhammers shall be used to loosen the rock material. Excavated material shall be removed from hand–dug excavations using a bucket and rope.

7.4 High water table shall require dewatering of the excavations. Depending on the site-specific conditions, open pumping, cutoff trenches, or predrainage with wells shall be required to remove the water. If water continues to run into or seep in from the walls or bottom of the excavation after the initial dewatering, a sump hole shale be dug at one or more corners of the foundation bottom, and small portable suction pumps shall be used in these pumping points to keep the excavation dry during foundation installation.

7.5 After excavation, the stability of foundation bottom shall be checked to ensure adequate bearing capacity. If soil conditions exist that lead to inadequate load bearing capacity caused by water or poor soil properties, additional excavation below the foundation, to a depth of 230-1200mm (depending on the subgrade soil), shall be required to remove the soils. The excavation shall be backfilled with select soil or rock materials to improve the bearing capacity of the foundation bottom. After compaction of such material and subgrade preparation, the excavation shall be made ready for foundation placement. Care shall be taken to avoid saturation of the foundation bottom during periods of heavy rains. Whenever the water table is at or above foundation bottom elevations, the excavation shall be kept free of water. The recommendations of the Soil Investigation Agency shall be followed for poor soil conditions.

7.6 After all the foundations have been excavated and their subgrade elevations have been established to be within allowable tolerances, the excavation with the highest elevation shall be set first. The remaining foundations shall be set using the first foundation as a reference for elevation and angular placement. For setting of foundations, position of the tower center hub for the alignment and the line angle, if any, shall be checked. Templates shall be used to ensure correct setting dimensions.

7.7 For placement of foundations, following major items shall be considered. Generally these items shall be considered in order:

- Batter

- Working Point Elevation

- Back to Back (Transverse) Distance

- Diagonal Distance

- Twist

In case, the distance between the center of tower and center of foundation at the bottom of the excavation is esatablished, the foundation shall be set to this distance first and then the above items shall be considered in order.

8.0 REINFORCING STEEL CAGE

8.1 The steel reinforcing bar cage shall either be assembled at the storage yard and hauled to the job site or the proper steel bars be hauled and assembled at the job site. Both of these methods shall be acceptable and satisfactory. The vertical reinforcing bars and ties shall be spaced and assembled as shown on the approved construction drawings.

8.2 The reinforcing bar cage shall be properly located and held in position by using concrete blocks of proper dimensions and wired into place at about 75 mm to 100 mm intervals on the outside of the cage. Concrete blocks shall have the same compressive strength as concrete to be used for the foundation. They shall be placed in several locations around the cage to position the cage in the center of the hole. The reinforcing steel shall be bonded to the stub angle/anchor bolts by using suitable size of steel wire in accordance with the procedures described in TCS-P-122.21.

8.3 Steel reinforcement, before being positioned, shall be thoroughly cleaned of mill scales and of all coatings that may destroy or reduce the bonding. Loose mil scale, dirt, grease and heavy flaky rust shall be removed and cleaned. Reinforcement bars (rebars) shall be carefully formed to the dimensions indicated on the approved construction drawings. All rebars shall be bent cold before being placed in the forms. Rebars with kinks and bends shall not be used. No heating of rebars shall be permitted. Rebars shall be accurately positioned and secured against displacement by using annealed iron wires of suitable size or clips at all intersections, and shall be supported by concrete or metal chairs or spacers, or by metal hangers. Vertical column bars shall be rigidly tied to binders at every intersection.

8.4 Pier cages shall be made, as described in the approved construction drawings. No visible deformation of the cage shall be allowed. Splicing of vertical bars shall not be permissible unless shown in the approved drawings. The cages shall be accurately positioned and secured against displacement during the placement of concrete. The method of securing pier cages shall be such that it will not allow the reinforcement to sink in the ground.

The tops of the reinforcement cages in piers shall neither extend more than 12mm above the specified elevation nor more than 25mm below this elevation.

The center of the cage at the top shall not deviate horizontally by more than 12mm from the specified center of the pier. Fabrication and bending, where required, shall be in accordance with the approved drawings and within the tolerances specified in the latest edition of ACI-315, “Details and Detailing of Concrete Reinforcement”.

9.0 STUB ANGLES

9.1 Stub angles shall be placed in the tower footings as shown on the approved drawings, and shall be supported in proper position by means of a rigid frame (setting template) or an equivalent device. The stub angles shall be held rigidly in a manner to prevent displacement during placing of the concrete. All stub angles shall be set accurately to the grade and alignment indicated on the approved drawings, and within the following limits:

9.1.1 The center (punch mark) of the four stub angles of a tower shall be within 30mm of its theoretical position across the line and within 150mm along the line.

9.1.2 The faces of each stub angle shall not deviate from the corresponding faces of the tower by more than one part in 300 horizontally and the batter of each face of the stub angle shall be within 5mm per meter of the specified batter in the part exposed.

9.1.3 The relative elevations between the punch marks on the heel of the stub angles for each set of the tower footings shall not differ by more than 6 mm.

9.1.4 The actual elevation of any set of the stub angles shall be within 60mm of the specified elevations.

9.1.5 The actual horizontal distance between adjacent stub angles of a tower shall be within 6mm of the specified distance (back to back) and the actual distance between the diagonally opposite stub angles shall be within 12mm of the specified distance (diagonal distance).

9.1.6 The transverse axis of each angle tower shall not deviate from the bisector of the interior line angle at that tower by more than 30minutes of arc.

9.2 The stub angles and the setting template shall be assembled together into place to obtain proper setting location for each stub angle. The stub angle setting template shall be furnished as part of the steel furnished by the steel supplier or shall be fabricated separately for the intended purpose. The templates shall be adjustable for different spacing and batter as required for tower type under construction.

9.3 The concrete shall be poured after all the adjustments and checks have been made as required. The top surface shall be crowned and given trowel finish. After three days (72 hours) of curing, the templates and the forms may be removed. Waterproof elastomeric coatings and coal tar epoxy coatings, etc., shall be applied as shown in the approved drawings and/or Scope of Work & Technical Specifications.

10.0 ANCHOR BOLTS

10.1 Anchor bolts shall be placed in the steel pole footings as shown on the approved drawings, and shall be supported in proper position by means of a rigid template. The anchor bolts and the template shall be held rigidly in a manner to prevent displacement during concrete pouring. If required, anchor bolts may be tack-welded with the foundation reinforcing bars to avoid their dispalcement. The vertical reinforcing bars and the anchor bolts shall be bonded electrically. Anchor bolts shall be set accurately to the grade and alignment indicated on the drawings, and within the following limits:

10.1.1 The center of the circle of the anchor bolts shall be within 25mm of its theoretical position.

10.1.2 The angular variations in the specified location of the anchor bolt group shall not exceed one (1) degree for a single pole.

10.1.3 The actual elevation of any set of anchor bolts shall be within 25mm of the specified elevation.

10.2 The anchor bolts and the setting template shall be assembled together into place to obtain proper setting location for each anchor bolt. The anchor bolt-setting template shall be furnished as part of the steel poles furnished by the manufacturer or fabricated separately for the purpose. The location of each anchor bolt shall be accurately set by measuring from top of the bolt to the required length of anchor bolt to be exposed at the top of the concrete.

10.3 The concrete shall be poured after all the adjustments and checks have been made as required. The top surface shall be crowned and given trowel finish. After three days (72 hours) of curing, the templates and the forms may be removed. Waterproof elastomeric coatings and coal tar epoxy coatings, etc., shall be applied as shown in the approved drawings.

11.0 CONCRETE

11.1 General

The measuring, mixing and placing of concrete shall conform to the latest requirements of 70-TMSS-03, TCS-Q-113.03, ACI 318 and ACI 304. In cases of conflicting specifications, the provisions of 70-TMSS-03 shall prevail. Concrete shall have a minimum 28-day compressive strength based on degree of exposure required in 70-TMSS-03. The concrete mix design including test report on materials by an Independent Testing Laboratory and samples of all materials (fine and coarse aggregates, water, cement, etc.) shall be submitted for review and acceptance to SEC Representative a minimum of 45 days prior to the start of concrete work. Frequency of testing for concrete materials shall be as per 70-TMSS-03.

11.2 Preparation for Concrete Placement

11.2.1 Prior to placement of concrete, excavations and formed areas for the footings shall be cleaned. All water at the bottom of excavations shall be removed or absorbed. Hoppers and elephant trunks shall be used for directing the flow of concrete down the center. For initial pours, sacked cement shall be used at the bottom of the pumped-out excavations. Concrete shall not be placed until SEC Representative inspects the excavations and/or forms and embedded items. The holes shall be kept in acceptable condition until placement of concrete is completed. The placing of concrete shall be accomplished in such a manner as to prevent segregation of the aggregates. Concrete shall be consolidated by the use of vibrators with just sufficient vibration being done to ensure compaction of the concrete into a dense homogeneous mass without honeycombs. Where concrete for pier is deposited against formed surfaces or earth, the contact surfaces shall be wetted prior to the placement of the concrete unless the surface treatment of the forms or moisture in the earth is sufficient to make this requirement unnecessary.

11.2.2 If the amount of groundwater present will result in having concrete of unacceptable quality, tremie or other pumping methods shall be used for placing the concrete in accordance with ACI 304R, “Guide for Measuring, Mixing, Transporting and Placing Concrete”.

11.3 Placement of Concrete

11.3.1 Except as shown in the approved drawings, construction joints in foundations shall be avoided. The use of such joints shall require approval from SEC Representative. In cases, where such joints are permitted, the first lift which is to be placed as soon as practicable after excavation is completed, is to be made to an elevation approximately 150 mm below the bottom of the stub angle. The second lift shall then be placed to meet the requirements indicated on the drawings. Joints not indicated on the drawings shall be designed and located to least impair the strength and appearance of the structure, and shall be approved by SEC Representative. The surface of the previously placed concrete shall be thoroughly cleaned of all laitance and foreign matter before placing the next lift of concrete. Prior to placing the next lift of concrete, the surface of the poured joint shall be covered with a brushed coat of grout. The grout shall be introduced into the holes or formed area in the space between the reinforcement cage and the sides of the excavation or forms, and the grout brushed over the concrete surfaces to ensure thorough coverage, particularly between the bars of the reinforcement cage and the sides of excavation or forms. The whole of a showing face between prescribed construction joints shall be cast in one continuous operation. Concrete that is to have an exposed surface, whether any particular finish is called for or not, shall be placed and worked as

may be necessary to secure, at the face, a uniform distribution of the aggregates, freedom from void spaces, and uniform in texture. For exposed surfaces, the forms shall be smooth and watertight. The top of the foundation shall be sloped to prevent the accumulation of water. The slope shall start at the heel of the stub angles and shall have a minimum rise of 6 mm in 300mm to form a level plane at the edge of the foundation. At the periphery, an edging tool shall be used to form a bevel at the edge approximately 12mm. Exposed uniform surfaces shall be wood float finished.

11.3.2 During hot weather, or under conditions contributing to rapid setting of concrete, the mixing and delivery time shall not exceed the following limits:

a.	Air temperature below 29ºC	90 minutes
b.	Air temperature above 29ºC but less than 32ºC	75 minutes
c.	Air temperature above 32ºC	60 minutes

All concrete**,** which has not been placed within 90 minutes after all the ingredients have been introduced into the mixer, shall be rejected. The temperature of the mixed concrete shall not exceed 32ºC.

11.4 Curing and Testing

11.4.1 All exposed surfaces shall be cured for a period of at least seven (7) days except as required by 70-TMSS-03. Curing shall be accomplished by the continuous application of water of similar quality as that used for mixing, either through ponding, sprays, or saturated cover materials such as burlap or cotton mats. If saturated cover materials are used, they shall not be allowed to dry out.

11.4.2 Concrete cylinders shall be made under the supervision of SEC Representative, and testing shall be made by SEC approved Independent Testing Laboratory in accordance with ASTM C39, 'Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens". Test cylinders shall be kept in a similar environment as that of the foundations concrete until testing.

11.4.3 Sixteen (16) concrete cylinders shall be made (four per tower leg) for every strain tower. Four (4) concrete cylinders shall be made for every tangent tower foundation for the first thirty (30) tangent towers. One additional cylinder for each tower shall be taken for chloride permeability test. If the cylinders pass the following evaluation and acceptance criteria, the requirement may be reduced to four (4) cylinders for every fourth tangent tower. Whenever the sample fails to meet the evaluation and acceptance criteria, the cycle shall begin

again with four (4) cylinders taken for each of the next thirty (30) tangent towers.

11.4.4 One set of four (4) cylinders shall be made for every angle pole and one set of four (4) cylinders for every tangent steel monopole foundation for the first thirty (30) tangent monopole structures. One additional cylinder for each tower shall be taken for chloride permeability test. If the cylinders pass the evaluation and acceptance criteria specified in clause 11.4.6, the requirement may be reduced to four (4) cylinders for every fourth tangent monopole. Whenever the sample fails to meet the evaluation and acceptance criteria, the cycle shall begin again with four (4) cylinders taken for each of the next thirty (30) tangent steel monopole.

11.4.5 SEC representative may require additional cylinders to be taken whenever there is a just cause, such as change in batching procedures, change in concrete materials, breaking of batching, etc.

11.4.6 Concrete shall be considered acceptable if the following criteria are met:

a. The average of any three (3) consecutive strength tests shall be equal to or greater than the specified compressive strength.

b. No individual strength test (average of two cylinders) shall be less than the specified compressive strength by more than 3.50MPa.

11.4.7 In the event that the concrete fails to meet the strength requirements, in-place testing for concrete strength shall be conducted under the supervision of SEC Representative. In-place testing shall be conducted by one or a combination of the following methods:

a. ASTM C42, “Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete”

b. ASTM C803, Test Method for Penetration Resistance of Hardened Concrete”

c. ASTM C805, Test Method for Rebound Number of Hardened Concrete”

11.5 Protection of Concrete

11.5.1 On above grade surfaces a asingle component, liquid applied, moisture cure, polyurethane waterproofing membrane with the following properties shall be applied in accordance with TCS-P-122.21 and/or Scope of Work & Technical Specifications:

a. Chemically resistant to alkalies, acids, chlorides and sulfates, and can withstand service temperature up to 90°C.

b. Priming Coat and Subsequent Coats (except Top Coats), Aromatic formulation, 700 microns dft (dry film thickness):

- Color	Black
- Modulus at break	3 MPa
- Tear resistance	25 kN/m
- Ultimate elongation	400%
- Tensile set recovery	95%
- Adhesion to mortar	3000 N/m
- Shore "A" hardness	45
- Permeability to water vapor	0.4 metric perms
- Re-coatability	Excellent

c. Top coats, aliphatic formulation, 300 microns dft:

- Color	White
- Ultimate elongation	130%
- Tensile strength	22 Mpa
- Shore "A" hardness	85 ± 5
- Tear resistance	17.5 kN/m
- Total solids (by weight & volume)	60%

11.5.2 On below grade surfaces a two-component, high-build, high-solids (at least 90%) coal tar and epoxy resin with the following properties shall be applied in accordance with TCS-P-122.21 and/or Scope of Work & Technical Specifications:

- Bond strength to concrete	3 Mpa
- Bond strength to steel (sandblast prepared)	7.5 Mpa

- Heat deflection temperature (as per ASTM D468) 60% or above

- Potential health hazard (during application and in-service) None

12.0 BACKFILL

12.1 Excavated material, that is suitable for backfill around the foundations, shall be stockpiled separately for use as backfill. The stockpiles of backfill material shall be sloped to drain water and shall be protected from other elements, which may render the material unsuitable for backfill. The quality of backfill material shall be approved by SEC representative for each foundation.

12.2 Backfill shall be placed in layers not greater than 200 mm before compaction. Each layer shall be thoroughly compacted before the next lift is placed. Steel-wheeled roller compactors shall be used on cohesive materials; vibratory compactors shall be used on non-cohesive materials. Each layer of non-cohesive material shall be thoroughly compacted to 85% of the relative density at optimum moisture content. Relative density for non-cohesive compacted material shall be determined in accordance with ASTM D4253. Each layer of marl or cohesive materials shall be compacted to 95% modified proctor density. Maximum density for marl and other cohesive compacted materials shall be determined in accordance with ASTM D1557, modified proctor densities. The terms “maximum density” and “optimum moisture content” shall be as defined in ASTM D1557. When backfill material is too dry for proper compaction, water shall be applied to obtain relatively uniform moisture content throughout the backfill. Stone and rock fragments may be used in the backfill provided they do not interfere with proper compaction. Rock particles larger than 100 mm shall not be in contact with the concrete.

12.3 All locations that settle below the surface of the surrounding ground shall be refilled. Final grade after backfill shall be sloped and ditched to direct drainage away from the foundations.

13.0 SAND STABILIZATION

13.1 At structure locations where, as determined by SEC Representative, a potential for shifting sand exists, the sand shall be stabilized with crude oil. The crude oil shall be applied with metered spray nozzle. An average of 4.5 liters of crude oil shall be applied for every square meter of sand to be stabilized. The amount of crude oil per square meter shall be increased if the minimum oil penetration is less than 13mm. The composition of crude oil shall be as approved by SEC Representative.

13.2 The area of sand to be stabilized shall be determined on a structure-by-structure basis by SEC Representative, but in all cases, the minimum amount

of area to be stabilized shall consist of an area within a minimum distance of three (3) meters or more from the edge of the structure pad. Based on actual site conditions, SEC representative shall decide whether a minimum distance of three (3) meters is sufficient for sand stabilization or needs to be increased. Sand stabilization shall also be done on opposite sides of the access roads as necessary.

14.0 SURFACE EXCAVATION

14.1 For erosion control, grading shall be performed to produce more uniform or level surface at structure sites and other locations. Excavation in earth and rock shall be made at approved areas on the site, and the resulting materials wasted or placed in embankment at designated locations.

14.2 Areas to be filled shall be stripped of topsoil and organic material before forming embankments thereon. Stripped materials shall not be incorporated in embankments except when permitted at topsoil. Material not permitted shall be wasted. Fill materials shall be placed in 200mm layers and compacted.

15.0 EROSION CONTROL

15.1 The slopes adjacent to structures, which may be washed or otherwise eroded, shall be protected. Where erosion control is required, no slope or excavation shall be steeper than one and a half (1 1/2)) horizontal to one (1) vertical without erosion protection. Structure site slopes shall have contour trenches, for each 2-meter change in elevation, constructed by hand 0.4 meter deep. The trenches shall drain to the sides of the cleared area, i.e., the area shall be high in the middle and slope down each side at about 2% from the high point. Where structure sites are so located that trenching is inadequate to carry water from the cleared area, drains shall be installed to carry water away from the area. Such drains and their locations shall be approved by SEC Representative.

15.2 All foundations located in wadi areas shall be designed to resist a two (2) meter flood running at a velocity of 20km per hour.

15.3 In wadi areas, where a water level of 300mm or more above the existing bed may be expected, concrete barriers shall be installed to protect the structure pads against erosion. The design of the concrete barriers shall be approved by SEC Representative. Erosion control shall be completed at each structure site as soon as practicable after installation of the structure. If required the concrete barriers shall be made of concrete slabs.

15.4 When transmission line structures are located on a sloping terrain in the hilly areas, gravel blanket/retaining walls may be required for the erosion protection of foundations/structure pads against water current. Gravel blankets shall be placed in such a way that they do not flow away with water current. The placement of gravel blanket or construction of retaining wall shall be as

approved by SEC Representative. The gravel shall contain stones not larger than 610 mm and shall be reasonably clean and free from other foreign matter, and shall be distributed and graded evenly over the required areas. No compaction shall be required.

15.5 Riprap shall be placed on the slopes of the structure pads and in such places along the right-of-way or access roads, which in the opinion of SEC Representative, is required to control erosion.

15.6 Riprap shall be of durable stones or broken concrete without projecting reinforcement bars. Riprap shall be well graded and shall be individually placed in a manner that larger pieces are uniformly distributed and the smaller pieces are filled in the spaces between the larger pieces, to produce a compact uniform layer of Riprap at least 300mm thick.

15.7 Where, in the opinion of SEC Representative, gabions are required for the protection of foundations against erosion, these shall be installed as per following specifications:

15.7.1 The box gabion shall be mesh type 8 x 10 with a 27 mm diameter wire diaphragms. The sizes of boxes shall be 1.5m x 1.0m x 1.0m, 2.0m x 1.0m x 1.0m and 4.0m x 1.0m x 1.0m as required.

15.7.2 The box gabion shall be rectangular basket fabricated from a double twist, hexagonal mesh of soft annealed heavily galvanized wire, It shall be filled with rounded river or quarried stone of suitable size.

15.7.3 All the edges of the main base and end panels shall be reinforced with galvanized wire of greater diameter. The selvedges wires, in addition to strengthening basket facilitate its assembly and assist in keeping it square.

15.7.4 Where there is more than one course of gabions, the ones in the upper course shall be securely laced to those below.

15.7.5 The stone must be hard to withstand the abrasion, non-friable and resistant to weather. Its packing inside the compartment shall as tight as practicable.

15.7.6 After filling the gabions slightly over-full, to allow for subsequent settlement, the lid shall be laced down with binding wire to the tops of all sides and diaphragms panels.

15.7.7 The steel wire shall be in accordance with the United States Federal Specifications 00-W-461 Soft and shall be hot-dip galvanized conforming to furnish 5-Class 3.

16.0 QUALITY ASSURANCE

SEC representative shall inspect both materials and workmanship at each stage of the work, focusing attention on such items as:

Establishment of correct location for the structure (span length, radial distance, elevation, etc.)

Type of structure, height of basic body and leg/body extensions, etc.

Suitability of location for the proposed type of foundation

Suitability of excavated material for backfill

Excavation depth

Setting of templates and placement of stub angles/anchor bolts

Distance between adjacent and diagonally opposite stub angles

Stub angle slope/batter

Quality of concrete

Sand stabilization

Typical Proforma for keeping the record of monitoring, inspection and installation of steel structure foundations is enclosed in Appendix-1. This Proforma shall be signed by the Contractor as well as by SEC representative.

APPENDIX-1

STRUCTURE FOUNDATION INSTALLATION REPORT

Project:_____ Foundation Type:_____

Contractor:_____ Reference Drawing No.:_____

Structure No. and Type:_____ Makeup (leg, body extension):_____

Station (R.D):_____ Span Length:_____

Weather:_____ Air Temperature:_____

Ground Resistance:_____ Concrete Mix Ratio (by volume):_____

DESCRIPTION	Leg 1	Leg 2	Leg 3	Leg 4
Date and Time of Concreting:				
Excavation depth actual, mm:				
Water Table depth, mm:				
Rebars, Size and No.:				
Earthing Material used: (Number of rods & length of wire)				
Concrete Slump, mm:				
Test Cylinders taken:				

STUB SETTING DIMENSIONS

Distance between adjacent stubs (specified/actual), mm:_____

Distance between diagonally opposite stubs (specified/actual), mm:_____

Stub Slope (batter), degrees: _____

Remarks:_____

_____

_____

_____

_____ _____

SEC Representative Contractor's Representative