Eskom	Standard	Technology

Title: **NEW TOWERS : GENERAL TOWER SPECIFICATION FOR NEW INSTALLATIONS OF ESKOM TELECOMMUNICATIONS RADIO TOWERS**

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Content

1. Introduction

The following document provides a detail specification for Eskom Telecommunication new towers to be used as a guide when going out on tender.

2. Supporting Clauses

2.1 Scope

2.1.1 Overview

This specification provides for the design, manufacture, delivery to site and erection of newly installed Radio Towers.

2.1.2 Purpose

The purpose of this specification is to provide the operational and technical requirements for radio towers or masts to be used in the tender specifications for Eskom. This is a specification to be used to establish a contract to design, supply, deliver, install and commission for a period of five years.

2.1.3 Applicability

This specification is applicable to radio towers for use within Eskom by Eskom Telecommunications Business Unit. This specification caters for towers/masts of heights between (and inclusive of) 3m and 80m.

This specification shall apply throughout Eskom Holdings Limited, its divisions, subsidiaries and entities wherein Eskom has a controlling interest.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ANSI TIA-222-G Structural Standard for Antenna Supporting Structures and Antennas

[2] BS 4592. Industrial type flooring and stair treads. Published by the British Standards Institution

[3] Civil Aviation Authority (CAA) Regulations for structures that exceed surrounding building heights.

[4] DIN 7990 Steel Hexagon Head Bolts for Structural Steel Bolting – for supply with hexagon nuts.

[5] ISO 9001:2000 Quality Management Systems

[6] Occupational Health and Safety Act 85 of 1993, incorporation the 2003 Construction Regulations. Published by the South African Government Press, under auspices of the Department of Labour.

[7] SANS 10100 The Structural Use Of Concrete

[8] SANS 10400 The Application of the National Building Regulations.

[9] Published by the South African Bureau of Standards Southern African Steel Construction Handbook. Published by the Southern African Institute of Steel Construction.

[10] SANS 1200 A General

[11] SANS 1200 C Site Clearance

[12] SANS 1200 D Earthworks

[13] SANS 1200 F Piling

[14] SANS 1200 HA Structural Steelwork (Sundry Items)

[15] SANS 1200 HC Corrosion Protection Of Structural Steelwork

[16] SANS 121 / ISO 1461 Hot Dip Galvanizing Coatings on Fabricated Iron and Steel Articles – Specifications and Test Methods. Published by the South African Bureau of Standards

[17] SANS 1700. Fasteners. Published by the South African Bureau of Standards

[18] SANS 2001-CC1:2007 Concrete (Structural)

[19] SANS 2001-CS:2012 Structural Steelwork

[20] SANS 50025 / EN10025 Hot Rolled Products of Structural Steel. Published by the South African Bureau of Standards

[21] SANS 657-1 Steel Tubes For Non-Pressure Purposes Part 1: Steel Tubes For Scaffolding and For Structural and General Engineering Purposes

2.2.2 Informative

[22] ANSI TIA-1019A Structural Standards for installation, alteration and maintenance of antenna supporting structures and antennas

[23] ETSP0017 Eskom Microwave Station Earthing and Bonding

[24] SABS ISO-14713 Protection against Corrosion of Iron and Steel in Structures – Zinc and Aluminium coatings - Guidelines

2.3 Definitions

2.3.1 General

Definition	Description
Radio Tower	Any self-supporting lattice structure that is used to mount radio antennas for the purpose of transmission and reception of radio signals.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
I	Informative
M	Mandatory

2.5 Roles and Responsibilities

It will be the responsibility of the Regional Project Managers to identify the required item from the list and initiate the appropriate procurement process to acquire the item.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Not applicable.

3. General Requirements

3.1 Feeder Ladder and Attachment Points

A feeder ladder must be provided, accessible from the climbing ladder, allowing for feeder attachment points along the vertical section. Attachment points must be at most 500mm apart. The feeder ladder must be at least 300mm wide. Feeder ladder must allow for securing of standard Eskom approved cable clamps. The position of the feeder ladder will in no way obstruct the climbing of workers.

3.2 Feeder Gantry

Where required, a feeder gantry must be provided between the base of the tower and the adjacent equipment building, and must be fitted with a hail guard. Recommended approach would be for the horizontal feeder tray to allow for cables to be suspended underneath the tray. A support pole must be supplied and installed for every 5m of horizontal gantry. The feeder gantry must be at least 300mm wide.

3.3 CAA Regulations

Provision must be made for the installation of aircraft warning lights and daylight painting in accordance with the CAA regulations. All paint used to be of a water based type suitable for galvanised steel. The Supplier must specify painting standards applied and provide the specifications for the paint to be used.

3.4 Post Galvanization Drilling

There must be no drilling of the structure after galvanising.

3.5 Climbing Ttools

The climbing ladder must conform to OHSACT GSR 13A, must be vertical and must be fitted with a continuous safety cage on all towers, with the exception of the bottom two metres. Horizontal safety hoops must be spaced 1m apart with a diameter of 700mm. The ladder may be fitted to the inside or outside (outside preferred) of the tower and must be positioned in such a manner that it does not impede the mounting of antennas. Access from the ladder to the working platforms must be clear and unobstructed. Wherever a ladder or cage is deemed not to be required, it must be approved by an Eskom Telecommunications representative in writing.

3.6 Fall Arrest Systems

Any climbing facility without a safety cage must be provided with a fall arrest system. Climbing facilities without a cage will be an exception and must be approved by Eskom in writing.

3.7 Resting Platforms

Resting platforms shall be provided at the required height intervals. Each platform must have a waist and knee rail of sufficient strength to be suitable for the attachment of a safety belt. Working platform height intervals and positions will be provided in the Schedule of tower requirements

3.8 Rung Spacing

The spacing of all horizontal ladder rungs must be equal and there must be adequate clearance for hands and feet behind each rung (minimum 150 mm clearance). Rung diameter must be a minimum of 20mm solid steel. Rungs shall protrude through ladder stringers and welded inside and outside the stringers.

3.9 Earthing Plates

An earthing plate (as per ETSP0017) must be provided 1.5 m above the horizontal feed gantry at its tower end, to which the antenna feeders will be earthed. This bar must be connected directly to the earth ring of the tower by a copper strap.[M] Earthing plates (as per 240-568-72313) must be provided at all landings.

3.10 Punched Data Plates

A punched data plate must be affixed to the tower between one and two metres above the ground such that it can be easily read. The following data must be recorded on this plate:

- Site Name
- Manufacturer
- Date of erection
- Tower height
- Tower type
- Drawing reference number for tower
- Drawing reference number for foundation
- Model number
- Maximum wind loading

Note: Maximum wind load area of antenna is the maximum flat plate area load which can be safely added to the tower over the top 15% height of tower. (i.e. 80m Tower – Top 12m)

3.11 Maintenance procedures

The tower manufacturer is to define their recommended maintenance procedures for their towers that must include at least:

- Frequency of inspections
- Checks for loose bolts
- Instructions on bolt tightening procedures for specific bolt and washer types with associated required torques.
- Checks for signs of movements at connections
- Checks for signs of rust on bolts and members
- Checks for signs of cracks on welds
- Checks on drainage hole blockages
- Checks for signs of cracks on concrete foundations
- Checks for signs of settlement on foundations

3.12 Construction of Towers within Substations

Where towers are to be constructed in Eskom electrical substations, the supplier shall ensure that the construction and erection crews fully comply with the relevant Eskom regulations. Details of the relevant regulations will be supplied and must be requested by the contractor. Documentation of relevant Eskom regulations must be requested by contractor and will be supplied by Eskom.

3.13 Copyright

Eskom shall retain the copyright of all towers designs and tower drawings in their network. In the case where tower design and drawings are provided by contractors, Eskom will attain a joint copyright of these towers.

3.14 Method Statements

The contractor shall provide detailed method statements (with diagrams or drawings), hazard and risk assessment and related safe work procedures. Contractor to also provide QITP's for review and acceptance by Eskom.

4. Design of Towers and Masts

4.1 General

Steel Towers shall be lattice steel self-supporting structures, of bolted construction and shall be designed to withstand all loading conditions specified. .Loading conditions shall be provided by the employer (Eskom)

4.2 Engineering Design Accreditation

All Towers and Masts designs and drawings must be compiled and submitted to Eskom under the responsibility of a registered Profession Structural Engineer or Engineering Technologist (registration with Engineering Council of South Africa or another Eskom approved equivalent body). A copy of the registration certificate must be submitted with tender documents and all towers supplied.

The registered Professional must sign off all drawings and designs and provide support during construction as per construction regulations.

4.3 Design Responsibilities:

a) Design and Detail by Contractor:

The design and detailing of the tower remains the full responsibility of the contractor. The acceptance of the designs by Eskom does not relieve the contractor's adequacy of the design, dimensions and details.

Design and drawings to be submitted to Eskom project manager for approval

b) Design and detail by Eskom:

The contractor issued with an Eskom copyright design, must satisfy themselves of the adequacy of the tower for erection and the site conditions proposed.

4.4 Tower Design Specifications

All tower loading and structural element design to be carried out in accordance with the latest version of TIA-222-G (Structural Standard for Antenna Supporting Structures and Antennas). Other recognised international tower specifications may be used at the discretion of the approval by Eskom. In the case of different design standards being used, information must be submitted for acceptance by Eskom, before design approvals of towers are submitted.

4.5 Wind Loading

The basic design wind speed for structures will be 40m/sec (3 second gust) with a mean return period of 50 years. For high wind load areas in South Africa the wind speed be adjusted in accordance with the regional wind speed map shown in figure 1.

Dynamic wind pressure may be adjusted for altitude based on the following table:

- 0m – 1
- 500m – 0.945

- 1000m – 0.89
- 1500m – 0.84
- 2000m – 0.79

All structures are to be designed with an importance factor based on a classification of Class II structure.

The wind load on the tower or mast must take into account the additional wind load of the antenna, the caged ladder, feeders, trays and platforms.

4.6 Exposure and Topographical Categories

Towers will be design for the relevant site exposure and topographical conditions relevant to the sites applicable. The categories will be clearly indicated on the design and drawings of the towers.

4.7 Antenna and Feeder Loading

The antenna loading requirement to be specified by Eskom Telecommunications.

The effects of wind loading on the antenna bracketry shall also be considered in the design.

4.8 Inclined Member loading

All tower members which have an inclination angle of 0 to 30 deg to the horizontal, shall be designed to withstand a load of 1,5kN acting vertically at the centre of the member.

4.9 Computer Models and Calculations

The Tower analysis and design calculations must be carried out in with the latest version of PLS Tower software (developed by Power Line systems of Madison, USA). All design calculations, computer models (PLS Tower backup files) and drawings for the towers must be provided to Eskom.

4.10 Approved Tower Types

The preferred tower type by Eskom is a self-supporting steel lattice towers. Parallel as well as tapered square towers (4 legs) will be considered. Alternate designs will be considered subject to Eskom acceptance. Triangular towers (3 legs) will be subject to Eskom approval.

Single pole or stayed masts will only be accepted in exceptional circumstance. Approval for the use of these structures must be given in writing by ESKOM

4.11 Tower Twist and Deflection Specifications

Tower deflection and twist shall be checked for a service load wind speed of 31m/sec (wind speed to be adjusted in accordance with exposure, topographical conditions on site). Load factors are to be used as per TIA-222-G, clause 2.8.3

The tower or mast shall be designed to allow a maximum twist at the antennae positions of less than 1 (one) degree. The allowable horizontal deflection at the top of the tower shall be restricted as far as possible to the height of the tower or mast divided by 250.

4.12 Tower Design Approval

Before any tower is used in the Eskom network, the designs and detail drawings must be submitted to Eskom for approval.

The design approval submission shall include (but not limited to):

- general arrangement drawing of drawing of the tower, which will included :
- all dimensions providing centreline geometry of tower

- all member sizes
- all details of redundant bracing members
- connection details (no. of bolts, bolt dia, etc)
- a schedule clearly indicating the load parameters of the tower (Site Exposure conditions, wind speed, topographical conditions,
- site altitude and antenna loading
- all design backup files for the design in the format of PLS Towers, will also be handed over to Eskom.

Also refer to section 6.1

5. Tower Members and Connections

5.1 General

Tower members which have flat surfaces should be placed with flat surface uppermost where practicable. Pockets and depressions likely to hold water shall be avoided and, where unavoidable, shall be properly drained.

Bracing patterns using triangulated axial force systems are preferred to distribute the forces applied to the structure in a tension/compression fashion according to their geometry and member stiffness'. If "open panels" are used, bending stresses due to unbraced forces shall be considered.

The preferred included angle between the angle sections should exceed 18° but shall in no case be less than 15°.

All diagonal-bracing members shall be connected at their point of intersection by at least one bolt.

Cutting of flanges to interpose members should be avoided, and will only be allowed with Eskom's acceptance.

All members shall be capable of withstanding wind induced vibration when assembled and erected as part of a structure.

No commercial grade steels (<250MPa) will be used without prior consent from Eskom. Should approval be given by Eskom to use lower grade steel for bracing members, no mixed grades per section size may be used (i.e. - Equal angle 50x50 in two different steel grades will not be allowed).

5.2 Material Quality

The following material grades shall be utilized:

Steel Sections	S355JR
Plates (less than 19mm thick)	S355JR
Plates (greater than 19mm thick)	S355J0 (for better workability)
Bolts	Grade 8.8 to ISO 898
Nuts	Grade 8
Washers and Packers	S275JR

Impact properties in the longitudinal direction of all structural materials shall be determined for grade S355JR material greater than 19mm in thickness in accordance with the Charpy V-notch test. Charpy V-notch requirements at a minimum, shall meet the requirements of 27 J absorbed energy at room temperature (21° Celsius)

Silicon and Phosphorous content of steel is limited as follows:

"Aluminium Killed Steel": Silicon (Si) = 0.01 to 0.04%, Phosphorous (P) < 0.015% max

"Silicon Killed Steel" : Silicon (Si) = 0.15 to 0.25%, Phosphorous (P) < 0.02% max

5.3 Forms and Shapes of Hot Rolled Steel Products

The tower shall be constructed with hot rolled Steel angle sections, Circular Hollow Sections, Round Solid Bars and Plates. All member sizes and plates must be sizes which are readily available in the South African Steel manufacturing market (which are commonly manufactured). Members shall be in accordance with the Southern African Steel Construction Handbook, published by the Southern African Institute of Steel Construction. Flat bars, shall not be used as tower members.

5.4 Minimum Member Sizes and Thicknesses:

- Minimum section size to be used on the tower leg is:
  - Equal angle - leg length = 80mm - thickness - 6mm
  - Circular hollow section - diameter = 76mm - wall thickness - 4mm
- Minimum section size for bracing members:
  - Equal angle - leg length = 50mm - thickness - 3mm
  - Circular hollow section - diameter = 48mm - wall thickness - 3mm
- Minimum redundant bracing member size:
  - Equal angle - leg length = 45mm - thickness - 3mm
  - Circular hollow section - diameter = 48mm - wall thickness - 3mm
  - Minimum plate thickness - 6mm
- Sections using 12mm dia. bolt - 3mm thick
- Sections using 16mm dia. bolt - 3mm thick
- Sections using 20 & 24mm dia. bolt - 4mm thick

5.5 Allowable Slenderness Ratios

Member	Allowable Slenderness Ratios
Main Leg	120
All other load carrying members	200
Redundant members	250

The maximum unsupported horizontal length of members shall not exceed the following: For angle section 45 x 45 x 3 = 1 500mm.

All larger sections shall be governed by the slenderness ratios specified above.

To facilitate transport and galvanizing processes the maximum length of any tower member shall be 11m.

All long members shall be of sufficient section that, after punching or drilling, they will withstand ordinary rough handling during erection.

Where members of the same size but of different thickness are to be used in the same tower design the difference in thickness shall be more than 1mm.

5.6 Double-Angle Members

All double-members shall be connected at intervals between end connections by stitch bolts as follows:

1) Tension/compression members: spaced so that the L/r ratio of one angle between stitch bolts is equal to, or less than the L/r ratio of the member as a whole, with a maximum length between stitch bolts of 600mm. A minimum of two stitch bolts shall be used between panel points.

2) Angles with connected legs greater than 100mm shall be stitched at each point with two bolts and a plate.

3) Angles with connected legs 100mm or less shall be stitched at each point with one bolt and ring spacer.

5.7 Fasteners

Bolt dimensions shall conform to DIN 7990, but with thread length equal to 1.5 x diameter and washers having thickness of 3mm. Nominal washer dimensions are indicated below:

Bolt Diameter (mm)	Nominal Washer Diameters (mm)		Washer Thickness (mm)
	Outside	Inside	
Ø 12	24	14	3
Ø 16	30	18	3
Ø 20	37	22	3
Ø 24	44	26	3

Equivalent square washers may be utilized

Maximum of two washers per bolt

Packers shall have thicknesses of 5, 8 or 12mm.

5.8 Antenna Brackets

Antenna support brackets shall be designed such that the connection of the brackets to the tower coincide with node points on the tower to eliminate bending forces in the tower members. All brackets and booms will be design and approved by the engineer. The bracket attached to the tower (and antenna placed on bracket or boom), will be appropriate for the leg member size it is attached to.

5.9 Holding Down Bolts and Base Plate

Holding down bolts and base plate shall be designed and detailed in accordance with design recommendations as per Southern African Steel Construction Handbook.

6. Tower Drawings

6.1 General

Drawings shall be prepared utilizing the latest version of AutoCAD mechanical 2010. Drawings shall be produced at an acceptable scale to be plotted on an A1 paper size. A suitable scale shall be used depending on the content. Each drawing shall have a suitable border and title block indicating the following:

- Name of Client
- Project Name
- Drawing Title

- Drawing Number
- Sheet Number
- Revision Number
- Date
- Scale
- Names and Signatures of Persons who detailed, checked and approved the drawing
- Revision table

Note: A template drawing will be provided to the appointed contractor by the employer.

The following drawings shall be prepared for each tower type:

- Design Drawings
- Workshop Drawings (Manufacturing Drawings)
- Erection Drawings

The above mentioned drawings are described below.

6.2 Design Drawings

The design drawings shall show the following data and information for each tower type, including all tower extensions.

6.2.1 General Arrangement Information

1) A large single line diagram drawn accurately to scale and showing:
   a) geometry dimensions of tower
   b) member sizes
   c) bolt sizes
   d) number of fasteners per connection
   e) member identification labels adopted in the design
2) Ladder positions
3) Summary of foundation reactions
4) Table showing designed site conditions
5) Antenna loading including:
   a) antenna sizes
   b) antenna types
   c) antenna height above ground

6.2.2 Design Information

Separate Member Schedule: a tabulation of the design calculations showing the design of each member, i.e. the magnitude of governing compression/tension forces, governing load case, section size, gross and nett cross sectional areas, unbraced lengths, slenderness rations, yield stress or reduced yield stress, TIA-222-G design curve number, compression/tension capacities of member, connection capacity of member in respect to bolt shear and bolt bearing, indication of number of holes deducted from gross cross sectional area of tension members, bolt size, and number of bolts required.

6.3 Workshop Drawings

Workshop drawings shall have all their details necessary to fabricate tower members. Drawings shall show tower members and plates in their assembled positions with design reference dimensions indicated. The orientation of members shall be clearly indicated.

- Dimensional tolerances of hot rolled sections and plates as well as fabrication tolerances shall be considered when workshop drawings are prepared.
- All bent angles and plates shall be detailed to finished dimensions. Hot and cold bending shall be clearly indicated.
- Suitable bolt grip tables shall be prepared based on the available bolt lengths and one washer thickness.
- Member identification
- Bill of materials – each workshop drawing shall include the complete bill of materials for the tower article indicated on the drawing. The bill of material shall include the following information:

Tower Members	Mark, Quantity, Section, Length, Unit Mass and Total Mass
Bolts	Diameter, Length and Quantity
Nuts	Diameter, Quantity
Washers	Diameter, Thickness, Quantity
Packers	Diameter, Thickness, Quantity
Total Mass	Members, Fasteners, Galvanizing, Grand Total

6.3.1 General Information

The following information shall be included on each drawing:

- Quality and specification of all materials
- Legend for matching bolts and bolt holes
- Legend describing cutting and clipping codes
- Range of members described on the drawing
- Small tower outline with applicable tower article highlighted.

6.3.2 Mass of Tower Articles:

The calculations of mass for angles and other rolled shapes shall be in accordance with the mass per metre listed in the latest edition of the South African Steel Construction Handbook, published by the South African Institute of Steel Construction. All plate material shall be based on a mass density of 7 850kg/m³. Lengths used to determine mass of members shall be based on the detailed lengths shown on the finals, accepted shop drawings and not on the “ordered overall lengths”. Material lost from clips, back cuts, blocks, holes etc, shall not be deducted from the mass of a member or plate.

Of the above calculated mass, 3.5% of the uncoated material shall be used for the mass of the zinc coating (galvanising).

6.4 Tower Erection Drawings

The erection drawing shall show the identification mark and orientation of each member, the number and type of bolts, nuts, washers and packers required at connections. Lifting points and component masses and installation of torque fasteners shall also be indicated.

Note: Fabrication drawings and erection drawings may be combined

7. Tower Fabrication

7.1 General

The supplier and his manufacturing facility shall employ a production process that has an integrated Quality Management System. The Quality Management System employed shall be based on the framework of SABS /ISO 9001 standards for Quality Management Systems or be an equivalent recognised system approved by Eskom Quality Assurance Division. Details of the QMS shall be provided.

7.2 Galvanising

Galvanising shall be in accordance with SANS 121 / ISO 1461. All tower members shall be suitably straightened after galvanizing without causing damage to the galvanizing surface or to the member itself. No curved, bent or twisted members will be accepted.

7.3 Steel Specification

As a minimum, SANS 50025 grade S355JR steel or better must be used for the design and manufacturing of the tower and external crows nests. Commercial grade steel may be used for the manufacturing of the cat ladder and internal platforms. Fasteners shall be of grade 8.8 quality.

7.4 Steel Grading

Certification of the grade of steel being supplied by the steel merchants must be made available to Eskom for inspection if required.

7.5 Welder Specification

Coded welders must be used on all welds. Welder's certification papers must be made available to Eskom for inspection if required.

7.6 Quality Plan

The supplier shall provide a Quality Plan for each stage of the sourcing, manufacture, supply, delivery and installation of the towers. The supply must provide a complete set of quality documents for each of the towers at each stage of the process.

7.7 General

a) All parts of structures shall be fabricated in accordance with the dimensions, arrangements, sizes weights, thicknesses and material quantities indicated on the workshop detail drawings and generally carried out in accordance with TIA-222-G and SABS 1200H unless indicated otherwise herein. Workmanship and finish shall be equal to the best modern practice for tower work. Pieces having the same mark shall be interchangeable. Members shall be straight, true to detail drawings and free from lamination, flaws and other defects. All clipping, back-cuts, grinding, bends, holes etc, must be true to detail drawings and free of burrs.

b) All parts of the structure shall be neatly finished and free from kinks or twists. All holes, blocks and clips shall be made with sharp tools and shall be clean cut without torn or ragged edges.

c) Shearing and cutting shall be nearly and accurately done. Cuts shall be clean without drawn or ragged edges. Particular care shall be taken in the edge finish of plates subjected to large bending moments or large bends in fabrication.

d) Redundant material on gusset plates shall be removed

e) All holes in structural steel less than 18mm thick may be punched to full size unless otherwise noted on the accepted drawings. Holes shown on the drawings as drilled holes, and all holes in structural steel 18mm or more in thickness, shall be drilled or subpunched and reamed. All shall be clean cut and without torn or ragged edges. All burrs resulting from reaming or drilling shall be removed. All holes shall be cylindrical and perpendicular to the member. Where necessary, to avoid distortion of the holes, holes close to the points of bends shall be made after bending. The use of a torch for cutting holes shall not be permitted.

f) For punching holes to full size, the diameter of the punch shall not be more than 2mm larger than the nominal diameter of the bolt, and the diameter of the die shall not be more than 2mm larger than the diameter of the punch.

g) For sub punching, the diameter of the punch shall be 6mm smaller than the nominal diameter of the bolt, and the diameter of the die shall not be more than 3mm larger than the diameter of the punch. Subpunching for reamed work shall be such that after reaming, no punched surface shall appear in the periphery of hole

h) Where holes are reamed or drilled, the diameter of the finished hole shall not be greater than the nominal diameter of the bolt plus 2mm.

i) All holes shall be spaced accurately in accordance with the drawings and shall be located on the gauge lines. The maximum allowable variation in hole spacing, from that indicated on the drawings for all bolt holes, shall be 1mm. Misdrilled, or mispunched holes may not be refilled by welding.

j) Traceability between fabricated components and mill test certificates for mechanical characteristics and chemical composition shall be maintained at all times.

7.8 Bending

a) All forming or bending during fabrication, shall be only done according to the methods accepted by the project manager, such that will prevent embrittlment or loss of strength in the material being worked. The technical requirements for hot and cold forming are as follows:

1) Only the direct resistance heating method shall be used

2) The length of the section to be heated shall be clearly marked on the section and heating equipment set accordingly.

3) The required bending tool shall be ready on the bending press with checking jogs available at all times

4) A dry run shall be made first to check that all systems are operational and that the proper tools are used.

5) Material shall be uniformly heated over the required length, to a temperature of between 750° C to 900°C. Oxidation of the material shall be minimised.

6) Heated material shall be inserted into the bending press and formed while the temperature is still within the specified range.

7) Formed material shall be checked immediately to ensure that they have been formed correctly.

8) Formed material shall be left to cool naturally

9) Re-checks shall be made with the appropriate jigs when material is cold.

b) If more than one bend is required on a section, the operation shall be repeated for each bend. Repeated heating of a bend position shall not be allowed

c) New bends shall not deform the bend previously made.

d) For bending limitations on the flaring of flanges on angle sections, refer to the project manager. Any other bending of angle sections must be done hot.

e) Cold bending limitations on plates are as follows:

Plate Thickness	Maximum Deviation Angle
Up to 12mm	14°
14 to 22mm	7°

A minimum bend radius of 8mm shall apply for the above table. Cold bending is not allowed for the plates in excess of 22m thickness.

Alternative bending procedures according to an approved National Standard may be followed if adequate proof of in-service can be provided.

7.9 Testing and Inspection

a) The work may be inspected, and any tests witnessed at any stage during manufacture.

b) Witnessed tests to SABS1431 may require samples of steel from the stockpile

c) Tests may be done according to the SA Bureau of Standards, to ensure satisfactory quality of the galvanising.

d) Certificates shall be obtained proving compliance with all aspects of material quality, manufacture and galvanising.

7.10 Fabrication Tolerances

Fabrication tolerances shall be according to SABS 1200

a)	On overall length of any member	+- 1mm
b)	On member straightness	
	1) Members up to 100 x 100	0.4% of length
	2) Members above 100 x 100	0.2% of length
c)	On specified un-galvanized hole diameter (on the punch side when punched)	+ 0.3mm / -0mm
d)	Maximum taper in punched opening out to die side; increase in specified hole	Larger of 0.8mm
	Diameter where t= thickness of metal	or t/10
e)	On centres of holes in a group	+- 1mm
f)	On centres of groups of holes	+- 1.5mm
g)	On back marks	+- 1mm
h)	On distance from end of bar to centre of nearest hole	+- 1mm
i)	On corner cuts, notches, flanges cuts, etc	
	1) Angles up to 100 x 100	+- 1mm
	2) Angles above 100 x 100	+3mm / -2mm

Fabrication tolerances are not to be considered cumulative.

7.11 Marking of Tower Members

a) All separate structure members and parts shall be hard stamped before galvanizing with the following marking: Manufacturers identification, structure code and member identification number as indicated on the workshop and erection drawings.

b) Marking shall be done by stamping the marks into the metal with numerals or letters of 10mm minimum height. The marking shall be consistently in the same relative location near the ends on all pieces. No other marking shall be used.

c) The manufacturer's identification marking shall consist of a minimum of three letters and shall be of the same height as the tower code and member identification number. Acceptance of the marking shall be obtained prior to usage.

d) Where high strength steel is used, an additional letter H shall be stamped immediately after the member identification number.

7.12 Prototype Assembly

All structures shall be test assembled in the shop to the extent necessary to ensure accurate fit in the field. Prototype assembly shall include all structure components and accessories. Assembly procedure shall demonstrate that each section fits the adjacent section.

A Prototype Assembly Report shall summarize the findings of the prototype assembly and ll necessary modifications to the members.

The prototype structure shall be assembled with the correct fasteners and bolts tightened to the correct torque.

8. Foundations

8.1 General

The following foundations types will be acceptable for use by Eskom:

Self-Supporting Towers:

- Raft Foundations (single concrete slab/ raft connected to base of tower) - on the surface or below natural ground level.
- Individual pad foundations – individual concrete foundations per tower leg consisting of the column extended above ground, extending into pad and plinth below ground level.
- Piled foundations- individual foundation per tower leg consisting of a pile cap connecting multiple piles.

8.2 Foundation Design Loads

The foundation calculations and installation must take into account local ground conditions and allowable bearing pressures. Foundation design loads shall be indicated on the foundation drawings.

The foundation shall be designed for all combinations of load reactions from the tower it is supporting. The foundation stability will be checked against allowable soil capacity, using the serviceability foundations. Serviceability load for foundation design will be reaction without load factors and assuming a wind direction probability factor of 1.0 (Kd = 1.0 - table 2.2 - TIA-222-G).

Ultimate design loads are based on loading with all load factors included.

Estimated ultimate foundation loads of telecom towers (kN) (based on member capacity)

Tower HT (m)	GA dwg Ref	Estimated foundation reactions (kN)			
		C	U	HC-T	HU-T
15	0	0	0	0	0
20	0.53/1980	379	365	55	54
30	0.53/1951	609	562	61	58
35	0.53/2284	427	387	75	72
45	0	0	0	0	0
50	0.53/2285	734	660	132	126

Tower HT (m)	GA dwg Ref	Estimated foundation reactions (kN)			
		C	U	HC-T	HU-T
50	0.53/1961	711	614	78	71
60	0.53/1969	1296	1163	123	113
65	0.53/2286	612	502	67	59
0	0	0	0	0	0
80	0.53/2287	887	716	137	124
80	0.53/1978	1175	996	109	96

Main leg compression capacity based on ASCE10-97 Curve 1

K-bracing member compression capacity based on ASCE10-97 Curve 4

C = Estimated factored compression load acting on foundation

U = Estimated factored uplift load acting on foundation

HC-T = Estimated factored horizontal transverse load acting on foundation under compression condition.

8.3 Design Strength of Foundations and Soil

The following soil design parameters must be used for the design of the foundation based on normal soil conditions.

- normal soil – equal or better consistency than one encountered in stiff cohesive soil or dense cohesionless soils above the water table
- minimum allowable soil bearing pressure - 150kPa
- soil uplift frustrum angle – 30 deg

The foundation will be designed with a resistance factor of not less than 1.5 for uplift, sliding and overturning moments. These checks will be based on the serviceability loads indicated above.

The foundations will be designed for the maximum combinations of vertical compression, uplift, and horizontal shear loads acting at ground level.

Maximum allowable displacement under ultimate load conditions shall be less than 20mm.

The foundation concrete design strength shall be in accordance with SANS 10100, based on ultimate foundation loads.

8.4 Profiling and Geotechnical Investigation

The soil profiling and geotechnical investigation shall be carried out by an experienced registered professional to determine the design parameters for the foundation design.

Sufficient trial pits will be excavated on site to allow an accurate investigation of the soil profile which will be included for the support of the foundation. All soil investigations carried out on site must be recorded and submitted to Eskom for approval, including a proposal of the foundation type and drawing to be used for these conditions.

At the discretion of the Eskom project manager/ engineer, laboratory or insitu testing of soils may be requested for poor soil conditions.

8.5 Inspection of Excavation and Concrete Reinforcing Bars

An Eskom representative must inspect and approve the excavation and installed reinforcing for the tower foundation prior to concrete casting. An appointment must be set up with the Eskom project manager for the inspection at least five working days in advance. The tower foundation will not be accepted without Eskom's approval of the excavation/reinforcing check prior to concreting

8.6 Concrete Plinth Design

All foundations designed to be below ground level must protrude at least 250mm above the natural ground level. The top if the concrete shall be cast so as the level falls away from the centre, to allow the run off of water and no ponding occurs.

The natural ground shall be shaped to ensure runoff of water away from the site

8.7 Cube and Slump Testing

The minimum characteristic concrete strength for foundations shall be 25MPA at 28days. The concrete slump shall range between 75-100mm at the time of placement.

8.8 Concrete Mixing

Both site batching and readymix concrete may be used on site. In both cases the concrete mix shall be made up with material (cement, aggregates and admixtures), which are in accordance with the relevant South Africa National Standard. The concrete mixes intended for site shall be submitted for approval to Eskom at least two weeks before the casting of concrete on site.

For readymix concrete the waybill shall be obtained, and kept in site records. A copy must also to be forwarded to Eskom project manager. Cube testing must also be carried out on concrete delivered to site.

When site batching is carried out on site, material shall be measured out by accurate volume batching method. Concrete Cubes shall be taken on site and tested at 3, 7 and 28days.

All concrete cube strengths will be recorded. Records to be kept with site build records, also a copy of the cube results shall be forwarded to Eskom project manager directly after each test.

8.9 Concrete Placement and Compaction

Suitable provision shall be made on site to ensure backup of equipment and working personnel should any delays or breakdowns occur on site while concrete is in progress. This includes backup power, and other equipment prone to general maintenance failure.

8.10 Concrete Compaction and Finishing

The concrete must be thoroughly compacted with an approved high-frequency, low amplitude vibrator.

Concrete shall be suitably finished off as per South African National Standards.

8.11 Grouting

Flowable 30MPa non-shrink grout must be placed under the base plate

8.12 Chamfering

All top edges of concrete above ground level must have a 20 mm chamfer at 45°.

8.13 Anchor Bolts

The tower leg shall be connected to the foundation by means of a base plate connected to anchor bolts cast into a concrete foundations. All anchor bolts shall be of minimum grade 4.6 quality steel. Anchor bolts shall be suitably fixed in position before the casting of the concrete base. All holding down bolts are to be galvanized. The holding down bolts must protrude sufficiently to allow double nut fixing per bolt, with at least three threads above the last nut.

8.14 Rooftop Towers

If a mast is positioned near to a building or other structure, or if a mast is connected onto a building or structure, the specific requirements of the owner of the building shall be met.

In the case where an existing structure must support a tower, the existing structure must be certified by a professional engineer to ensure that structure can withstand and resist reaction loads from the tower under maximum load combinations.

9. Erection

9.1 Specifications

The foundations and structure must be erected in accordance with the drawings, manufacturer's requirements and the SANS specifications listed below:

SANS 1200 A	General
SANS 1200 C	Site clearance
SANS 1200 D	Earthworks
SANS 1200 F	Piling
SANS 1200 G	Concrete (structural)
SANS 1200 H	Structural steelwork
SANS 1200 HA	Structural steelwork (Sundry items)
SANS 1200 HC	Corrosion protection of structural steelwork

9.2 Qualification of Riggers

Qualified riggers must supervise the structural erection and they must provide proof of their qualifications.

9.3 Certification of Erection

The contractors must provide a certificate, signed by a Professional Engineer (Civil) indicating that that the tower and foundation has been installed in accordance with all the requirements indicated in this document and all other supporting specifications referenced in this document.

The engineer shall further provide reference to all the site conditions for Eskom records, these will include the following:

- Site Co-ordinates
- Site Exposure Category
- Site Altitude
- Site Topographical Category
- Tower model

- Tower Drawing No.
- Foundation Drawing No.

9.4 Handling of Material

The storage of tower steel shall be on blocks lifting material off the ground. Sufficient blocks will be provided to prevent bending and warping of the members. Tower may only be handled with the use of nylon or fabric slings, no unprotected wire slings will be permitted. Material will be carefully offloaded and stacked and shall not be dropped or dumped off the truck

9.5 Plumb of Tower after Erection

All towers shall be vertical within 2mm in1metre in both the transverse and longitudinal directions when erection of the tower is complete, unless a difference tolerance is specified.

9.6 Connections

- The contact surfaces between connections shall be clean and free of any foreign matter.
- Wherever possible the bolts will be positioned with the thread and nut on the outside, while the bolt head will be on the inside of the column or truss. In such positions where the members are horizontal the bolts shall be positioned with the threaded portion upwards and the bolt head downward.
- All bolts must be tightened to the bolt manufactures specification. The required torque recommendation must be on the erection drawing. Turn of the nut method may be used by trained personal but it must be spot checked with a calibrated torque wrench. Should the turn of the nut method be used then Molybdenum grease must not be used but the bolts must be degreased prior to the installation as mentioned above.
- No slotted holes will be allowed in any connections.
- If blind or partially blind holes, missed clips, or other minor mis-fabrication steel members are discovered in the field, the contractor shall notify the supervisor and receive his acceptance prior to effecting field repairs.
- Where drilling, punching or clipping is done in the field, all exposed steel surfaces shall be coated with a heavy layer of zinc-rich paint or an accepted equivalent.
- All connections shall be bolted. Welded connections shall not be permitted.
- Connections shall be detailed in a manner to avoid eccentricity as much as possible. Assembly bolts shall be located as near as the centre of gravity of angles as is practicable.
- Splices in main legs of towers shall be located immediately above bracing members.
- Bolts of different diameters can be used on the same tower, provided that the bolts sizes are not mixed in any one connection.
- No threaded portion of any bolt shall occur within the thickness of the parts bolted together. To ensure this is a single washer of suitable thickness, it shall be placed under the nut.
- The threaded portion of all bolts shall project through the corresponding nuts by an amount not exceeding 15mm and no less than 3mm.
- Spacers shall be provided, as necessary, for all gaps to prevent distortion of structural members.
- Spacers between tower members, where more than one bolt is involved, shall be one plate of the required thickness. Where a single bolt is involved, the spacer may be made up of up to 3 pieces. The thickness of individual spacers shall be limited to the following standard sizes: 5mm, 8mm and 12mm.

- Bolts and nuts that bear on sloping faces shall be provided with bevelled washers.
- Assembly bolts shall not connect more than 3 thicknesses of material.

9.7 Painting of Nuts and Bolts

All bolts and nuts must be painted with Polygalv or similar product to be approved by Eskom.

9.8 Fall Protection Plan

The erecting contractor must provide a Fall Protection Plan, Emergency plan and Risk Assessment as well as Environmental Management Plan prior to commencing erection. Must comply to the requirements of the SHE specification

9.9 Erection of Guyed Towers

Provision shall be made for the erection of guyed towers on terrain with various ground slopes

Adjustable Guy Grips are to be installed at the end of each guy strand. Sufficient adjustment must be allowed for erection and any tightening required after creep on the guy rope.

The guy grips will be installed in accordance with the manufacturer's recommendation.

At the time of erection, all guys shall be tensioned to 10% (+/- 2%) of the minimum breaking strength of the guy strand. This shall be the tension in the guy after all fittings have been attached and all rigging used to tension the guy has been removed. The contractor shall be responsible for the establishing a suitable method of determining installed tensions in the guy strands

The guys shall be tensioned to hold the tower plumb as soon as the tower is erected. The tower shall not be more than 2mm in 1m from the vertical in both the transversal and longitudinal direction

10. Earthing Requirements

10.1 Tower resistance

The Supplier shall provide the tower resistance from the base to apex for each tower design**.**

10.2 Brazing of bolts

All joints are to be hard-brazed, with Sibra Alloy rods, or CAD welded, except to the base where a bolt and lug connector of 75 mm^2 contact area is to be used.

10.3 Earth ring

A tower earth ring must be provided using interconnected earth electrodes placed at each tower leg in accordance with Eskom specification 240-56872313. The tower earth ring must be interconnected with the station and/or building earth in accordance with Eskom specification 240-56872313.

11. Authorisation

This procedure has been seen and accepted by:

Name and surname	Designation
J Manyisa	Eskom Telecommunications Manager
B Nala	Group Manager – National Planning
C Naidoo	Technology & Services Manager
K Cornwall	National Key Account, Sales and Marketing

Name and surname	Designation
M Ganesan	SHEQ Manager
K Cornwall	National Key Account, Sales and Marketing
Riaz Vajeth	Senior Manager Line Engineering

12. Revisions

Date	Rev	Compiler	Remarks
Aug 2018	1	N Muthadi	First issue

13. Development team

The following persons were involved in the compilation of this document

S Natesan	Chief Engineer – Lines
R Page	Senior Consultant
JW Chetty	Engineer – Lines
C Juggernath	Engineer - Lines
N Muthadi	Engineer - Lines

14. Acknowledgements

Not applicable.

Annex A – Schedule A – Statement of Technical Conformance

(One sheet must be completed per tower/mast offered)

Tower / Mast

DESCRIPTION	PARTICULARS OF ESKOMS REQUIREMENTS	GUARANTEED TECHNICAL PARTICULARS OFFERED	REMARKS
1. Mast / Tower Design Height (m)	Specify		
2. Mast / Tower Design	SANS 10100 SANS 10160 SANS10162 BS8100 Pt 1 & 2 ANSI TIA-222-G		
3. Total Mass of Structural Steel (kg)	Specify		
4. Total Mass	Specify		
5. Maximum Head Load	Specify		
6. Wind Return Period	1 in 50 years		
7. Max Twist and Sway	≤ 1° & <height/250 & ≤ 0.3m		
8. Leg Diameter	≥ 45mm O/D		
9. Cross Tube Diameter	≥ 30mm O/D		
10. Mast / Tower Configurations: Tapered / Parallel	Specify		
11. Grade of Bolts and Nuts Used: Tower Steel Work Foundation Anchor Bolts	Grade 8.8 Min Grade 4.6		
12. Cable Tray and Feeder Ladder Width	≥ 250mm		
13. Feeder Cable Attachment Points	≥ 500mm		
14. Safety Cage	Hoops 700mm in dia. and 1m apart		
15. Tower Steel Work Quality Tower Members Ladders Platforms	S355JR Specify Specify		

Foundation

DESCRIPTION	PARTICULARS OF ESKOMS REQUIREMENTS	GUARANTEED TECHNICAL PARTICULARS OFFERED	REMARKS
1. Angle of Internal Friction	Specify		
2. Cohesion	Specify		
3. Grade of Concrete	25 MPa		
4. Volume (m^3)	Specify		
5. Allowable Bearing Pressure (kPa)	Specify		
6. Maximum Bearing Pressure (kPa)	Specify		
7. Safety Factor Against Overturning	Specify		
8. Safety Factor Against Sliding	Specify		
9. Fixing Requirements to Building	Bolted / Not Bolted		
10. Specification: Design of Reinforced Concrete	SANS 10100		
11. Foundation Type	Pad & Chimney Piled or Other (Specify)		

RESPONSE TO SPECIFICATION

Clause	Compliance/Non-Compliance/Information
3	**General Requirements**
3.1.1	
3.1.2	
3.1.3	
3.1.4	
3.1.5	
3.1.6	
3.1.7	
3.1.8	
3.1.9	
3.1.10	
3.1.11	
3.1.11	
3.1.12	

4	**Design of Towers and Masts**
4.1.1	
4.1.2	
4.1.3	
4.1.4	
4.1.5	
4.1.6	
4.1.7	
4.1.8	
4.1.9	
4.1.10	
4.1.11	
5	**Foundations**
5.1.1	
5.1.2	
5.1.3	
5.1.4	
5.1.5	
5.1.6	
5.1.7	
5.1.8	
5.1.9	
5.1.10	
5.1.11	
6	**Erection**
6.1.1	
6.1.2	
6.1.3	
6.1.4	
6.1.5	
6.1.6	

Clause	Compliance/Non-Compliance/Information
7	**Earthing**
7.1.1	
7.1.2	
7.1.3	
7.1.4	
8	**Tower Fabrication**
8.1.1	
8.1.2	
8.1.3	
8.1.4	
8.1.5	

Annex B – Tower Requirements

Compiled by: Date:

Project Information

Site Name		**Proximity**	
Project Name		**Project No**	

Tower Height

Working platform heights		**GeoTech Investigation needed (y/n)**	
Height of section required		**Top / Bottom Section**	
Design Height		**Landing 1 height**	
Aircraft Warning Lights		**Landing 2 Height**	
Painting Required		**Site Accessibility**	
Horizontal Cable Tray		**Cable Gantry Length estimate**	

Tower Loading

Antennae	Height	QTY	Feeder
Future:			

Additional Requirements: