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Steel towers for communication services — Specification

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Steel towers for communication services — Specification

0 Foreword

Mobile communication networks and broadcasting services require supportive infrastructure to enable communication services be delivered. Network facilities including towers and masts are the lattice structures of either triangular or rectangular base sections that comprise leg and bracing members used in the telecommunication and broadcasting sector. Communication towers are available in two major types; self-supporting towers and guyed masts depending on the way towers are supported.

For the purpose of deciding whether a particular requirement of this standard comply with the final value, observed or calculated expressing the result of a measurement or test shall be rounded off in accordance with TZS 4, *Rounding off numerical values*.

1 Scope

This standard specifies the technical requirements for the designing, fabrication, installation, inspection and maintenance operations for steel towers, masts and their accessories used in communication industry. It covers monopoles, roof mount/ rooftop, self-supporting towers and guyed masts.

This standard ensures that the performance, reliability, public safety and safety of working personnel and equipment during installation, operation, inspection and maintenance. The requirements of the local operating environment are also taken into consideration by this standard alongside the need to achieve substantial conformity with applicable international best practices.

2 Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of this standard. All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standards indicated below:

FTZS 3457:2022, Code of practise for design and construction of foundations
FTZS 3491-1/ ISO 10721-1, Steel structures - Part 1: Materials and design
FTZS 3491-2/ ISO 10721-2, Steel structures - Part 2: Fabrication and erection
TZS 172/ISO 4014, Fasteners — Hexagon head bolts — Product grades A and B
TZS 173/ISO 4016, Fasteners — Hexagon head bolts — Product grade C
TZS 174/ISO 4032, Hexagon regular nuts (style 1) — Product grades A and B
TZS 175/ISO 4033, Hexagon high nuts (style 2) — Product grades A and B
TZS 176/ISO 4034, Hexagon regular nuts (style 1) — Product grade C
TZS 2893/ ISO 1461, Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods
TZS 2630-1/ ISO 9606-1, Qualification testing of welders - Fusion welding - Part 1: Steels
TZS 3082/ ISO 10684, Fasteners — Hot dip galvanized coatings
ISO 377, Steel and steel products — Location and preparation of samples and test pieces for mechanical testing
ISO 898-1, Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread

ISO 898-2, Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread
ISO 898-3, Mechanical properties of fasteners made of carbon steel and alloy steel — Part 3: Flat washers with specified property classes
ISO 2394, General principles on reliability for structures
ISO 14713-2, Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing
ISO 15350, Steel and iron — Determination of total carbon and sulfur content — Infrared absorption method after combustion in an induction furnace (routine method)
ISO 17054, Routine method for analysis of high alloy steel by X-ray fluorescence spectrometry (XRF) by using a near-by technique
ISO 19272, Low alloyed steel — Determination of C, Si, Mn, P, S, Cr, Ni, Al, Ti and Cu - Glow discharge optical emission spectrometry (routine method)
ISO 10333-4, Personal fall-arrest systems — Part 4: Vertical rails and vertical lifelines incorporating a sliding-type fall arrester
ASTM A 143, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ISO 17637, Non-destructive testing of welds — Visual testing of fusion-welded joints
ISO 17635, Non-destructive testing of welds — General rules for metallic materials
EN 1993-3-1, Design of steel structures – Part 3-1: Towers, masts and chimneys – Towers and Masts
EN 1993-1-11, Design of steel structures - Part 1-11: Design of structures with tension components
ANSI/TIA-222-H, Structural Standard for Antenna Supporting Structures and Antennas and small wind turbine support structures
BS EN 10025-2, Hot rolled products of structural steels. Part 2: Technical delivery conditions for non-alloy structural steels.

3 Terms and Definitions

For the purposes of this Tanzania Standard, the following definitions shall apply:

3.1 Lattice structure
a structure which is topologically ordered, three-dimensional open-celled structures composed of one or more repeating unit cells made up of leg and bracing members.

3.2 Tower
a lattice structure of either self-supporting or guyed (cable supported) that consists of an open network of metal braces and is usually triangular or square in plan, designed to support antennas for telecommunications and broadcasting services.

3.3 Self-supporting tower
a free-standing lattice structure which is tapered in shape and consists of an open network of metal braces and is usually triangular or square in plan, designed to support antennas for telecommunications and broadcasting services.

3.4 Monopole
a self-supporting pole/post which consists of a single vertical pole fixed into the ground and/or attached to a foundation, designed to support antennas for telecommunications and broadcasting services.

3.5 Mast
a lattice structure of either self-supporting or guyed (cable supported) which consists of an open network of metal braces designed to support antennas for telecommunications and broadcasting services.

3.6 Guyed mast
a lattice structure which is supported in whole or in part by cables anchored to the ground, consisting of an open network of metal braces, designed to support antennas for telecommunications and broadcasting services.

3.7 Roof mount/ Rooftop
a tower, mast or pole/post used in elevating signals above roof interference or any other obstruction designed to support antennas for telecommunications and broadcasting services.

3.8 Antenna
a device used to collect or radiate electromagnetic waves for transmission and reception of signals used in telecommunications and broadcasting services, including directional antennas, such as panels, wireless cable and satellite dishes, and omnidirectional antennas, such as whips, but not including satellite earth stations.

3.9 Leg member
a member forming the main load-bearing components of the structure.

3.10 Bracing member
a member other than legs carrying the horizontal forces due to the imposed loads on the structure.

3.11 Communications tower
a tower, mast or monopole (either a self-supporting or guyed), built to support one or more antenna(s) used in transmission and reception of signals for telecommunications and broadcasting services.

3.12 Candela
the base unit of light/ luminous intensity in the International System of Units, it is luminous power per unit solid angle emitted by a point light source in a particular direction.

3.13 Setback
the minimum distance required around any building or structure that must be set aside from a street or road or river or shore or flood plain any other place which is deemed to need protection.

3.14 Regulator
the relevant authority responsible for regulating the electronic and postal communication sector in Tanzania.

3.15 Reliability
a probability that the system will perform its function/tasks under the designed load conditions for a specified period, or a probability that a given item will indeed survive the given service environment and loading for a prescribed period of time.

3.16 Safety
the ability of a system not to cause harm to human (injuries or loss of life) or damage to another sytem.

3.17 RF Hazard Area
An area with exposure to very high radiofrequency intensities that can result in heating of biological tissue and an increase in body temperature.

3.18 Co-location
means the accommodation of two or more service provider’s switches, antennas or other electronic communications equipment in, or on a single steel tower within a single location.

4 Symbols and Abbreviations

4.1 For the purposes of this document, the symbols listed in Table 1 apply.

Table 1: Symbols

Symbol	Unit	Description	Reference
E_{inc}	V m-1	Incident E-field strength:	10.7
H_{inc}	A m^{-1}	Incident H-field strength	10.7
S_{inc}	W m^{-2}	Incident Power density	10.7
f_M	MHz	Frequency	10.7
f_G	GHz	Frequency	10.7
R_m	MPa[a]	Tensile strength	7.2.2
$R_{p0.2}$	MPa[a]	0.2 % proof strength, plastic extension	7.2.2
[a] 1 MPa = 1 N/mm^2.			

4.2 For the purposes of this document, the abbreviations listed in Table 2 apply.

Table 2: Abbreviations

Abbreviations	Description	Reference
TCRA	Tanzania Communications Regulatory Authority	10.7
TCAA	Tanzania Civil Aviation Authority	6.1, 6.9, 6.10, 10.6
ICAO	International Civil Aviation Organization	6.9, 6.10,
TANESCO	Tanzania Electric Supply Company Limited	10.5
ICNIRP	International Commission on Non-Ionizing Radiation Protection	10.7
TAEC	Tanzania Atomic Energy Commission	10.7
RF	Radio Frequency	10.7
OSHA	Operation Safety and Health Authority	11.1
NEMC	National Environment Management Council	10.6

5 Classifications of Communication Facilities

This standard recognizes the following types of telecommunication facilities, namely;

5.1 Monopole

a) Monopole consists of tapered steel tubes that fit over each other to form a stable pole.
b) A monopole may be guyed or self-supported and be fitted with climbing rungs where necessary. It should have the following features:
   i. Sections should be made from hollow, heavy duty, thick steel tubes, flanged steel tubes or low-alloy, high-strength steel.
   ii. Each shaft section should be a constant-tapered hollow steel section

iii. Slip joints should be designed with a minimum of 1 1/2 times the pole diameter at the splice.
iv. Pipe diameter should decrease from bottom to top
v. Monopole are to be made from galvanized hollow steel pipes or high strength steel and designed for a variety of multi-user configurations and finishes to meet local aesthetic requirements.
vi. The pipes shall be tapered to ensure that one pipe base fits into the top of another until the desired height is achieved. A joint in the arrangement should have an overlay between the two adjacent pipes.
vii. The depth of the overlay, the base width and the number of pipes in a particular monopole shall be determined by expected height of a tower, the thickness of the pipe walls, the base diameter and whether the tower shall be guyed or not.

Figure 1: Monopole

5.2 Guyed Masts

a) These are towers that are stabilized by tethered wires
b) Guyed towers shall be designed and installed in the manner of the following specifications and recommended practices:
   i. Guyed masts may be in lattice, triangular or square, tapered or straight, as well as monopole structural forms.
   ii. Guyed masts shall be supported and held in position by guy wires or ropes.
   iii. Mast Guy Ropes shall be made from pre-stretched steel only. For every mast, the specified minimum strength of the guy wire shall be the maximum tension likely to occur in the worst loading condition.
   iv. Guy wires must not be over tightened in the installation of guy towers in order to avoid excessive tension which may cause alignment problems, cable rupture and permanent wrapping of tower structural parts.
   v. All sections must be straight square sections to eliminate potential problems associated with twisting or the need to shim the legs.
   vi. Typical tower sections are to have brace configuration with horizontals (z, x or k) and pivot base sections. These tower-structures should be wholly of steel, modular and hot-dip galvanized.
   vii. Sections can be of the same face width but in the event that the tapered type is considered, the design should be with junction flanges.
   viii. Guyed towers should have tube or solid legs with solid bracing which increases the tower rigidity to allow for the twist and sway.
   ix. Guy wires are to be engineered with precision and a minimum safety factor of 2.0 applied to the design.
   x. The design, based on the load calculations would determine working load and the break strength required of the guy wire and ultimately the choice of the size and grade of the wire.
   xi. The choice of each guy earth screw anchor would be dependent on its holding power in the soil, which is a function of its diameter and length to be used to compute the minimum number of guys required.
   xii. As a general rule, guys should be planted in three directions at 120◦ apart from each other. The distance from the base of the tower to the guy anchor base should be one quarter of the height of the tower.

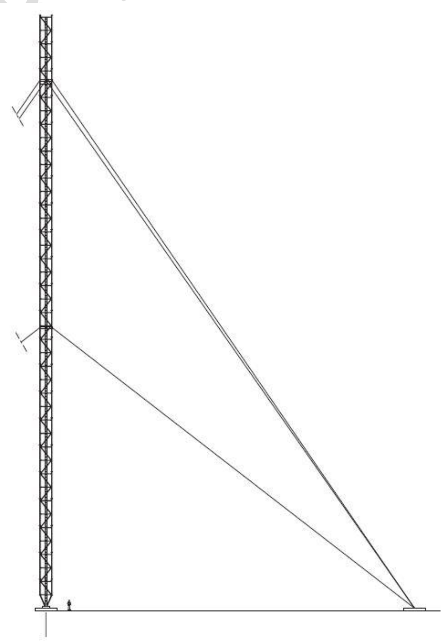


Figure 2: Guyed Mast

5.3 Self-Supporting Towers

a) Self-supporting towers are free-standing lattice structures
b) The use of self-supporting towers with tapered sections, and face width that vary according to height and load capacity is recommended when land availability is limited provided that it is technically feasible to install them.
c) Self-supporting towers shall be designed and constructed as Lattice structures in the manner described in this standard and shall have the following features:
   i. Triangular or square structure
   ii. Tube legs, angle legs, lattice legs or solid round legs
   iii. Sections in steel angle steel or steel tubes
   iv. Steel angle cross bracing.
   v. Tapered sections
   vi. Face widths vary according to height and load capacity.
   vii. Rest platforms provided every 45m of height
   viii. Work platforms provided at all height where antennas are to be installed
   ix. Fitted with climbing ladder

Standard support forms for lattice structures are specified as follows:
   i. Lattice Leg
   ii. Angle Leg
   iii. Tube Leg / Solid Round Leg

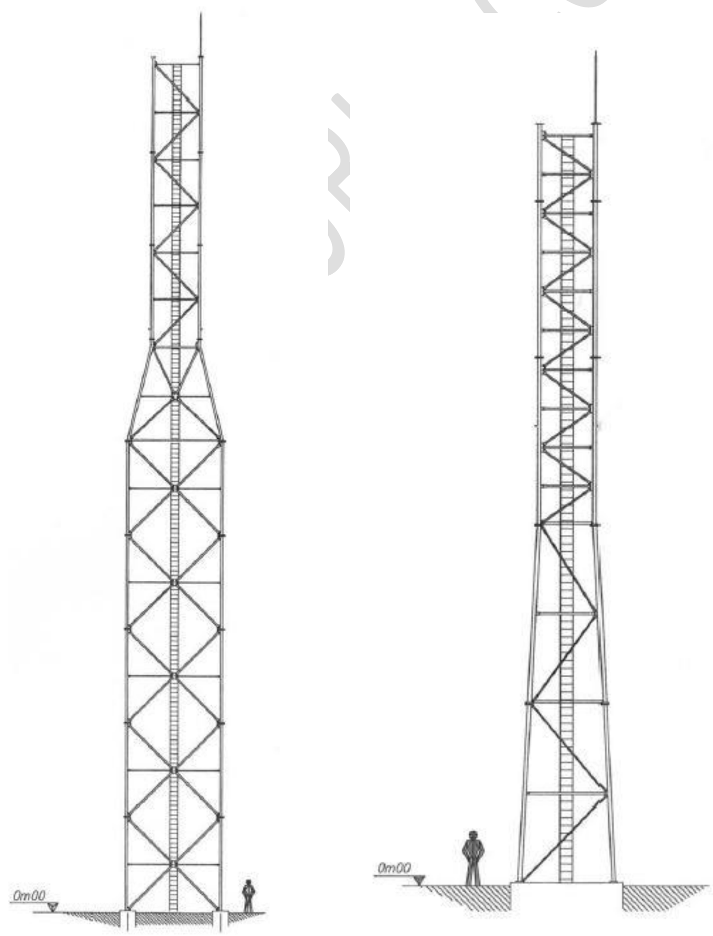


Figure 3: Self-supporting lattice tower

5.4 Roof Mount/ Rooftop

a) Roof mounts are an inexpensive way of elevating signals above roof interference or any other obstruction.
b) The design and installation of roof mounts shall take cognizance of the following specifications and recommended practices:
    i. Structural checks must be made to ascertain the capability of a chosen roof to withstand the additional load being imposed on it by the structure and the entire antenna array it will support.
    ii. All roof mounted masts or towers must be certified by the building's structural engineer before installation.
    iii. As a general rule, roof mounts should be limited to light weight structures of low heights and support minimal dead and dynamic loads.
    iv. Roof mounts can be installed in the penetrating or non-penetrating modes and can be self-support or guyed. However non- penetrating roof mounts are most suitable for flat surfaces.

5.5 General Features of Towers

a) In constructing tower legs, pipes or angle steel should be used.
b) Bracings should be of angle steel construction.
c) Mast sections, when made from steel pipes, should be joined to each other through joint plates welded to the base of each section. The width of the mast section joint plates should be double the width of the wall of the pipe they are supporting.
d) Gussets should be used in the strengthening of the weld joint between the base plate and the tower section.
e) Each plate should have four holes drilled to accommodate four bolts, nuts and washers.
f) When bolting sections together, bolts should be placed upside down with washers and nuts on topside of plates, the connecting face of plates should not be painted.
g) Lock nuts must be used but nuts on bolts may be clinched if lock nut is not utilized.
h) Lock washers and lock nuts should be used on antenna support steel work and dish panning arms in order to avoid loss of signals.
i) When a tower is made from angle steel, sections should be joined to each other through appropriately sized flanges, bolts, washers and lock nuts.
j) There should be adequate application of bracing to prevent towers been exposed to torque that may result in loss of signal during strong winds speeds.

6 General Requirements

6.1 Firefighting equipment

Each facility of communication towers shall be equipped with the appropriate fire extinguisher to be used in case of fire emergency.

6.2 Tower height

The maximum height of steel towers for communication services shall be subjected to the approval of the relevant authority, Tanzania Civil Aviation Authority (TCAA). The maximum height for steel towers (lattice and monopoles) mounted on top of buildings (rooftops/roof mounts) shall not exceed 12m.

6.3 Parking area

Adequate parking spaces shall be provided for use by maintenance personnel on each site so that right-of-way for parking on a public road will not be necessary. A minimum of one parking space shall be provided per user located on the facility site.

6.4 Signage

No signage, lettering, symbols, images, or trademarks in excess of $1200cm^2$ shall be placed on or affixed to any part of a tower, mast, antenna or antenna array fencing other than as required by the regulator for the purposes of identifying the operator. No adverts shall be allowed on any of the communication structures.

6.5 Antenna Mounting Frames

Frames for mounting antennas on towers or masts shall be designed upon consideration of the type of tower structure and the type, weight and size of the antenna. The frames shall be made from galvanized steel, stainless steel or aluminium and care must be taken to ensure that there are no welded parts, and that bolts and nuts are used for implementing joints.

6.6 Metallic Coatings

All steel materials to be used in the finishing of the superstructure shall be hot-dip galvanized before painting.

6.7 Painting

All tower structures must be painted in accordance to Tanzania Civil Aviation Authority (TCAA) guidelines on safety regulation for aerodromes and ground aids and/or International Civil Aviation Organization (ICAO) guidelines on paint instructions for obstructions as specified below:

a) For structures up to 212 m, the structure shall be given seven equal bands of red and white paint or orange and white paint.
b) For structures above 212 m, nine bands of paint in alternating red and white or red and orange.
c) In all cases the top and bottom of mast or tower must be painted red or orange.
d) Paint shall be non-gloss finish (matt).

6.8 Obstruction Lighting/ Aviation Warning Lights

All lattice structures (mast and tower) must conform strictly to TCAA and ICAO guidelines with respect to obstruction lighting of tall structures as specified below:

a) For every 50 m of height above ground level, a tower shall have installed on it, one lamp on top and two lamps at the sides.
b) Obstruction lamps shall be maintained in a working condition at all times on all structures within 15 km of an airport or helipad.

Light intensity and colour specifications should be as provided hereunder in Table 3.

Table 3: Light intensity and colour specifications

Tower Height (m)	**Light Intensity** (in **candelas)**	**Light Colour**
Below 45	10 – 1,600	Red and fixed
Between 45 and 150	1,601 – 4,000	Red and flashing
Greater than 150	4,001 – 20,000	White Flashing

6.9 Security fencing

Security fencing, where installed, shall be a wrought iron, barbed wire, or steel chain link fence with evergreen hedge or a masonry wall not less than 2.5 m in height. The security fence has to be provided even when the steel tower is located in the compound of institution or company with the fence.

6.10 Decommissioning of steel towers

The steel tower when removed from service (decommissioned) should be removed from site within six months by the owner and/or the service provider and the erection of a new one capable of accommodating other antennas should be considered. The steel tower shall be decommissioned when it poses a safety concern or its condition is incapable of supporting switches, antennas or other equipment.

6.11 Tower site cleanliness

The owner steel tower and/or the service provider should ensure that all obsolete or abandoned equipment installed on the steel towers are completely removed from the site and the general cleanliness of the site including proper dressing of electrical and signal cables.

6.12 Tower Co-location

An individual or entity intends to construct a tower must demonstrate that all reasonable steps have been taken to investigate tower sharing (Co-location) before applying to the permitting agencies to construct a new tower within a specified radius of 400m of the proposed site.

Where tower heights are shorter, a smaller search radius can be used as follows:

(a) Two towers above 46m, a radius of 400m shall apply; and

(b) Two towers below 46m towers, a radius of 300m shall apply.

However, the following factors may inhibit co-location:

(a) Lack of structural capacity to support weights, orientation, heights and wind loads from additional equipment.

(b) Lack of ground space to accommodate shelter for base stations and other equipment.

A written documentation in a form of a co-location statement, which indicates the reason why co-location was not possible, shall be submitted when co-location is not technically feasible. The applicant shall submit the co-location statement to the permitting agencies on application for a new site.

7 Design requirements

7.1 Design requirements

The steel towers shall be designed according to any recognized standard/code including FTZS 3491-1/ ISO 10721-1, FTZS 3491-2/ ISO 10721-2, EN 1993-3-1, EN 1993-1-11 or ANSI/TIA-222-H. The foundations shall be designed according to FTZS 3457. The general principles on reliability for structures are provided in ISO 2394.

7.1.1 Loading

The predominant load on tower structures shall be wind load. Towers shall be analyzed under three (3) specific types of loading for structural integrity:

a. Wind
b. Environmental
c. Seismic

The steel tower co-location should be considered during designing.

The possible antenna load, possible wind speed and allowable tilt and sway angle should be as shown in Table 4 and Table 5.

Table 4: Loading requirements for self-supporting steel towers

Parameters	**Categories**			
	Very Light	**Light**	**Medium**	**Heavy Duty**
Possible antenna load (in m²)	from 4 to 6	from 6 to 10	from 10 to 20	from 20 to 25
Possible wind speed (in km/h)	from 120 to 200	from 120 to 200	from 120 to 200	from 120 to 200
Tilt and sway (in degree)	± 1°	± 1°	± 1°	± 1°
Application	Very light antenna load	Light antenna load	Medium antenna load	Heavy duty antenna load

Table 5: Loading requirements for guyed masts

Parameters	**Categories**			
	Very Light	**Light**	**Medium**	**Heavy Duty**
Possible antenna load (in m²)	from 1 to 3	from 3 to 8	from 8 to 20	from 20 to 50
Possible wind speed (in km/h)	from 120 to 200	from 120 to 200	from 120 to 200	from 120 to 200
Tilt and sway (in degree)	± 1°	± 1°	± 1°	± 1°
Application	Very light antenna load	Light antenna load	Medium antenna load	Heavy duty antenna load

7.2 Materials requirements

7.2.1 General requirements

Communication facilities (towers, masts, and monopoles) shall be made of structural steel materials which will be suitable for hot dip galvanizing.

7.2.2 Structural member requirements

All members shall be made of structural steel material complying with BS EN 10025-2:2019. Therefore, leg and bracing members shall be of structural steel grades of S235JR, S235JO or S355JO complying with Table 6 and 7.

Each structural member shall be made of hot dip galvanized structure steel sections before being painted. All structural members shall be hot dipped galvanized according to TZS 2893/ISO 1461.

Table 6: Chemical composition for product analysis

Designation		**Method of deoxidation**	**C in % max. For product nominal thickness in mm**			**Si % Max**	**Mn % Max**	**P % Max**	**S % Max**	**N % Max**	**Cu % Max**	**Other % Max**
Steel name	**Steel number**		**≤ 16**	**> 16 ≤ 40**	**> 40[c]**							
S235JR	1.0038	FN	0.19	0.19	0.23	-	1.5	0.045	0.045	0.014	0.60	-
S235JO	1.0114	FN	0.19	0.19	0.19	-	1.5	0.040	0.040	0.014	0.60	-
S355JO	1.0553	FN	0.23	0.23[l]	0.24	0.6	1.7	0.040	0.040	0.014	0.60	-
FN – Rimming steel not permitted;												

Table 7: Mechanical properties – Tensile test properties at room temperature

Designation		**Minimum yield strength, R_{eH} MPa Nominal thickness, mm**						**Tensile strength, R_m MPa Nominal thickness, mm**			**Other % Max.**
Steel name	**Steel number**	**≤ 16**	**> 16 ≤ 40**	**> 40 ≤ 63**	**> 63 ≤ 80**	**> 80 ≤ 100**	**> 100 ≤ 150**	**< 3**	**≥ 3 ≤ 100**	**> 100 ≤ 150**	
S235JR	1.0038	235	225	215	215	215	195	360 - 510	360 - 510	350 - 500	-
S235JO	1.0114	235	225	215	215	215	195	360 - 510	360 - 510	350 - 500	-
S355JO	1.0553	355	345	335	325	315	295	510 - 680	470 - 630	450 - 600	-

7.2.3 Test methods

Location and preparation of samples and test pieces for mechanical testing shall be done in accordance to ISO 377. Tensile tests shall be carried out in accordance with ISO 6892-1. The manufacturer may choose between method A or B specified in ISO 6892-1.

Test methods for chemical analysis shall be in accordance with ISO 17054, ISO 15350 or ISO 19272 depending on the elements to be analyzed and their content. The choice of a suitable chemical analytical method for analysis shall be as per agreement between purchaser and manufacturer.

Guidelines and recommendations for the protection against corrosion of iron and steel in structures should be as per ISO 14713-2.

7.2.4 Fasteners Requirements
The fasteners shall be made of carbon steel material.

7.2.4.1 Fastener Dimensions and Tolerances
The standard dimensions and tolerances of fasteners shall be used in accordance to the design requirements and shall comply with either TZS 172/ISO 4014, TZS 173/ISO 4016, TZS 174/ISO 4032, TZS 175/ISO 4033 or TZS 176/ISO 4034.

7.2.4.2 Mechanical properties of fasteners
The mechanical properties of bolts made of carbon steel and alloy steel shall be in accordance to ISO 898-1. The mechanical properties of nuts made of carbon steel and alloy steel shall be in accordance to ISO 898-2. The mechanical properties of washers made of carbon steel and alloy steel shall be in accordance to ISO 898-3.

7.2.4.3 Coating properties of fasteners
All fasteners shall have a hot dip galvanized coatings with local coating thickness of a minimum of 40 µm and the batch average coating thickness of a minimum of 50 µm according to TZS 3082/ISO 10684.

Foundation anchors bolts shall be of hot dip galvanized coating complying with a local coating thickness of a minimum of 40 µm and the batch average coating thickness of a minimum of 50 µm according to TZS 3082/ISO 10684.

8. Fabrication and erection
The fabrication of parts/members and installation of the steel tower shall be done in accordance to FTZS 3491-2/ISO 10721-2. The base of tower leg member shall be provided with draining hole or slope angle to prevent water collection and rusting. The standard parts of the steel structure during installation and maintenance shall not be modified prior to approval by the designer/engineer.

8.1 Fabrication
Production will be controlled with suitable machines, appropriate work areas; manpower to carry out the work will be suitable and competent to perform various works. During the manufacturing process safety precautions should be taken according standard practice for safeguarding against embrittlement of hot – dip galvanized structural steel products and procedure for detecting embrittlement ASTM A 143.

8.1.1 Cutting, Drilling, Deformation and Punching of Members
All members shall be carefully cut and holes accurately located, so that when members are assembled, the holes will be truly opposite each other before being bolted. Holes in material having a thickness exceeding 15 mm or exceeding the diameter of the holes shall be drilled, other holes may be punched.

The diameter of the hole shall not exceed that of the bolt by more than 1.5 mm, measured before galvanizing for bolts 16 mm and less and 2.0 mm for bolts greater than 16 mm measured before galvanizing. In addition, the diameter of the die used in the punching machine shall exceed the diameter of the punch by the minimum practical amount so as to avoid excessive hole taper and consequent heavy bearing stress on the bolt shank. In no case shall the die exceed the punch diameter by more than 12.5 percent.

Deforming of members by swaging, opening or closing angle legs shall only be permitted where this detail has no detrimental effect on the performance of the structural element. All punched or drilled flanges of rolled steel sections shall have a width equal to or greater than 45 mm for nominal bracing and 50 mm for load carrying members. All plates up to 12 mm in thickness may be bent cold. Plates greater than 12 mm may be bent cold provided the angle of set does not exceed 15^{o}.

All fabricated units shall be supplied in pieces to be bolt assembled and shall be based on the principles contained in steel structures. All components shall be fabricated using jigs and machines such that close tolerances are maintained and burred and sharp edges, weld spatter, weld slag and galvanizing slag are avoided. The steel shall be in all cases free from blisters, scale, laminations or any other defects. All members shall be carefully cut and holes accurately located, so that when members are assembled, the holes will be truly opposite each other before being bolted.

8.1.2 Welding

All welding shall be carried out by qualified welders experienced in the type of work covered by this specification according to TZS 2630-1/ISO 9606-1. The welder shall check the welding visually to make sure it meets the requirements specified in the ISO 17637.The non-destructive testing of welds shall be carried out using any standard test methods recommended by ISO 17635.

8.1.3 Finishing

The surface of all welds shall be smooth and free from sharp contour changes.
The all burrs and sharp edges shall be removed from all steelwork before galvanizing.
Welded end plates and contacting surfaces of parts to be bolted shall be free from distortion which would prevent the connecting faces from being in full contact when bolted.

8.2 Erection

Before galvanizing, all members shall be stamped with an alphanumeric mark number to identify the member. This marking shall be carried out in such a manner as to enable it to be clearly read after galvanizing.

For roof mount/rooftop masts and towers the base of the tower is mounted on concrete or steel frame (consists of I-beams or inverted I-beams) with the frame fixed on the rooftop existing concrete columns/pedestals. For rooftop pole the base of the pole is fixed with steel dowels drilled into the roof.

8.3 Tolerances on fabrication and installation

8.3.1 Overall Height

The overall height of an assembled structure shall be within +1% and -1/2% of the specified height, not to exceed +1.5 m or -0.6 m.

8.3.2 Guy Tensions

The maximum deviation from the design initial tension shall be

(i) ± 10% for guys up to and including 25 mm diameter and
(ii) ± 5% for guys greater than 25 mm diameter, of the specified design initial tension at an anchorage, corrected for the ambient temperature.

8.3.3 Plumb

The horizontal distance between the vertical centerlines at any two elevations shall not exceed 0.25 percent of the vertical distance between the two elevations.

8.3.4 Twist

The twist between any two elevations shall not exceed 0.5 degrees in 3m. The maximum twist over the structure height shall not exceed 5 degrees.

8.3.5 Slip Splice

The slip splice length tolerance shall not exceed 10% of the design slip splice length. Splices shall be pulled together to ensure firm contact.

8.3.6 Straightness
The straightness of the individual members shall be within a tolerance of 1 in 500 but not more stringent than 1.6 mm of the length between points which are laterally supported.

8.3.7 Measurements
Measurements shall be taken at a time when the wind velocity is less than 4.5 m/s at ground level and with no ice on the structure or the guys.

8.3.8 Take-Up Devices
For initial installations, the minimum take-up adjustment available after the structure is plumb and the guy tensions are set, shall be:
a) 152 mm for guys with nominal diameter of 13 mm or less;
b) 254 mm for guys with nominal diameter greater than 13 mm.

9 Earthing and lightning protection requirements

9.1 General
a) All masts shall be grounded and the earth resistance measured at the earth terminal block shall be less than 5 ohms.
b) A lightning air terminal (Faraday Rod) shall be mounted on mast top and a vertical copper earth wire or tape run down the side of one mast leg to ground and connected to the earth at the terminal box.
c) Due recognition should be taken of the fact that the most important factor in getting a good earthing is the use of good quality materials for installation. Care should be taken to ensure that the earthing and lightning protection design and methods are followed.

9.2 Earthing
a) Earthing and Lightning protection shall be provided in all completed towers sites to protect equipment from damage and personnel from harm which may result from excessive voltages during a lightning strike.
b) The arrangement shall be such that lightning discharge current must be prevented from entering equipment rooms.
c) Equipotential conditions shall be maintained throughout the site by bonding.
d) Due recognition must be taken of the following:
   i. The resistance achievable in an earth installation is directly proportional to the resistivity of the soil at the depth to which the earth rod has been driven.
   ii. When the soil resistivity of a site is not known it can be measured without excavation by using a direct reading meter and earth spikes.
   iii. It can also be read out from tables if soil type is accurately known.
   iv. Resistivity at any depth is related to the diameter of the earth rod, the target resistance and the depth to which the earth electrode is driven into the soil by:

   $$R = (\rho / 275L) \times \log_{10} (400L / d)$$

   Where R is the target resistance
   ρ is the resistivity of the soil
   L is the length of electrode in meters
   d is the diameter of electrode in cm
   v. An accurate assessment of the soil resistivity should be made around the tower base using a direct reading resistance meters to determine among other things the appropriate depth to drive in the copper earth rods, the number of rods and the need for an earth mat, among other thing.

9.3 Lightning Protection

a) Separate down conductors shall be installed from each air terminal (lightning spike) and in addition, the structure shall also be a return path to the earth.
b) These two systems shall be bonded together and Lightning spikes shall be long enough to give 45° cone of protection over all aerials.
c) Air terminations shall be made of copper rod, hard or medium – hard drawn, 12mm in diameter and down conductors shall be made from 25mm by 3mm soft annealed copper strip.
d) The earth termination shall be independent of the foundation reinforcement.
e) Where rods are used as earth electrodes they shall be driven into the ground to a depth of at least 2.4m in normal soil or the depth predetermined for the site from measurements.
f) Longer lengths shall, when necessary, be built up of 1.2m lengths screwed onto each other with internal screw and socket joints.
g) Where one earth electrode cannot obtain the specified resistance, additional electrodes should be connected in parallel and such additional electrodes may be those provided for other down conductors.
h) The distance between any two driven electrodes shall be equal to their driven length.
i) All connections between earth conductors and steelwork shall be via sacrificial legs or brackets where copper would be in contact with concrete and painted with bitumen or separated from the concrete with itemized paper.
j) Earth conductor runs shall be straight as far as is practicable and where bends are unavoidable shall be smooth and of maximum radius.
k) The resistance to ground of the earth system shall be below 2 ohms.

9.4 Protective Grounding

a) Structures shall be directly grounded to a primary ground.
b) A minimum ground shall consist of two, 1.2m long; 16 mm diameter galvanized steel ground rods driven not less than 2.4m into the ground, 180° apart and adjacent to the structure base.
c) The ground rods shall be bonded with a lead of not smaller than 5 mm tinned bare copper connected to the metal base of the structure of each leg of a tower.
d) A similar ground rod shall be installed at each guy anchor and connected to each guy at the anchor in case of guyed towers.
e) Self-supporting towers exceeding 1.5m in base width shall have one ground rod per tower leg.
f) All the earth rods shall be tied together to maintain an equipotential condition all over the structure while top and bottom ground straps are to be bonded at both ends.
g) All equipment on a structure such as antennas, antenna supports and warning safety lights shall be connected by a secondary ground.
h) The earth of the tower shall be bonded to the general earth of any adjoining equipment room and all shall form a single earth.
i) The maximum permissible resistance to earth shall be 2 ohms.

10 Safety requirements

10.1 Fall arrest systems

Fall arrest systems shall be installed on every tower above the height of 45m. A complete fall arrest system shall consist of the rail and the trolley according to ISO 10333-4.

a) The trolley is a locking brake pawl attached to the harness of a climber.
b) The trolley moves freely along the Safety Rail with climber in normal climbing position
c) In case of a slip trolley brakes remain locked until the force is removed. Falls are instantly arrested when a sudden downward motion is applied to the Trolley. Trolley remains stationary once disconnected from the harness.

10.2 Anti-Climb Shields

Anti-Climb shields shall be installed on every tower above the height of 45m. Anti-Climb shields consist of metal sheets bolted to tower legs. These are constructed to prevent unauthorized persons from climbing a tower. It is ideal for tower sites around schools and public areas where public safety is a concern.

10.3 Climbing Facilities

a) Access Ladders

i. Access ladders shall be made from hot dip galvanized steel or aluminium sections mountable on all tower types and monopoles amenable to inside or outside mounting.
ii. Climbing Ladders shall be of steel or aluminium depending on tower material and shall be provided with Safety cages, Landing places (rest and work platforms) and Protective finishes.
iii. Ladders shall be attached to the tower structure.
iv. The lowest point on the ladder shall be at a height of 3m to 4.5m above ground level and it shall run all through to the top of the structure.
v. The ladder shall be so located that a clearance of at least 150mm at the rear of the ladders exists between the ladder and the structure.
vi. Anti-climbing devices shall be provided on the structure to prevent access except from the climbing ladder.
vii. The vertical separation between rest platforms shall be 20m.
viii. Work and test platforms shall be located at those points where antennas are to be installed.
ix. The cable tray not to be positioned in front of the access ladder and instead to be either on the left side or right side of the ladder for the safety purposes.

b) Platforms – Work / Rest / Test

i. All platforms shall be readily accessible from the climbing ladder.
ii. The access to all platforms and walkways from the vertical climbing ladder shall be from one direction only.
iii. Platforms and walkways shall be designed to carry a point load of 150kg at any point without a deflection exceeding 6.0mm.

c) Guard-rails

i. Guard-rails shall be of height range between 0.9m and 1.1m and shall be provided on all platforms, stairways and horizontal members used as walkways.
ii. They shall have an intermediate rail at half this height and a toe board not less than 150mm high.
iii. The distance between any toe-board and the lowest guard – rail above it shall not exceed 750mm.
iv. Widths of walk-ways and platforms shall not be less than 650mm.
v. Walk-ways and surface used as working platforms or traversed to gain access to platforms or traversed to gain access to working positions shall be provided with anti-slip surface.
vi. Guard rails and toe boards shall be attached at each stanchion and secured to prevent rotation.

10.4 Safety Enhancement

Safety in the installation and use of masts and towers are enhanced by the following practices which shall be mandatory for all tower owners and installers.

i. Tower assembly parts shall be standardized e.g. fasteners for the main structure shall be of only one size, length and material.
ii. Manual handing over of parts or tools between installers during tower construction is forbidden.
iii. All parts shall be labeled in detail especially where the method of assembling is not obvious.
iv. Towers shall be structurally designed for simple assembly by the promotion of ease in fittings and elimination of small loose parts.
v. On-site welding and riveting is prohibited. Owners and installers of mast and towers who engage in these practices shall be liable to pay a penalty to the regulator.

vi. All site connections shall be by bolt and nut with a means provided for locking the nut against loosening by vibration.
vii. All nuts, bolts and washers shall be galvanized for easy assemblage.
viii. Taper washers shall be used whenever the steel section shape requires their use.
ix. Bolt lengths shall be such that with the locking device in place, a minimum of one complete thread shall protrude beyond the nut.
x. Bolt threads shall protrude inside the structure only.

10.5 Proximity to Power Lines
The communication towers shall not be constructed in close proximity to high voltage (11kV and above) electrical power transmission and distribution lines. The nearest distance of a tower to a high voltage electrical power transmission line shall be according to TANESCO specifications shown in Table 8.

Table 8: Minimum safe distance from high voltage electrical power transmission and distribution lines

Electrical power transmission lines (High Voltage in kV)	**Minimum safe distance on each side from the center line** (in m)	**Minimum total safe distance** (in m)
11	2.5	5
33	5	10
66	10	20
132	20	40
200	30	60
330	40	80
400	40	80

10.6 Proximity to Aviation Sites and Other Environment
No steel towers (irrespective of the height) may be installed without prior approval and permits from relevant authorities, including NEMC, TCRA and TCAA.

10.7 Public Exposure to the Electromagnetic Radiation (EMR)
For the purpose of annual inspection, all the operators shall provide to regulator, details of all their base stations countrywide. This shall include the name of operating company; their emissions; the height of the antenna above ground level; the date that transmission started; the frequency range and signal transmission characteristics. Both the regulator and operator shall keep this information.

The antenna should not be less than 15m from the ground. For roof mounted antennas, the transmitting antennas should be kept away from the areas where people are most likely to be. Antenna sites should be designed in such a way that the public cannot access such areas, the nearest the public can be from an antenna should not be less than 3m.

For each RF hazard area, an operator shall ensure warning signs are in place in a location and in a manner that is appropriate so that they are clearly visible.

The signal of the strongest intensity should not land on the ground at a horizontal distance less than 100m from the foot of the antenna. The beam of greatest radio frequency intensity from a base station sited within or near public areas (markets, parks, education facilities, health facilities etc) shall not be permitted to fall on any part of the grounds or buildings of the institution.

The operator shall avoid siting towers in or near wetlands, near known bird concentration areas or in habitat of listed as threatened or endangered species or in migratory bird's routes.

The operator shall comply with the guidelines established by TAEC and ICNIRP for public exposure to radiation. Regular independent random audits shall be carried out by regulator, TCRA to ensure conformity to TAEC and ICNIRP guidelines according to Tables 9, 10 and 11.

Table 9: Basic restrictions for electromagnetic field exposure from 100 kHz to 300 GHz, for averaging intervals ≥ 6 min.

Exposure scenario	Frequency range	Whole body average SAR (Wkg^{-1})	Local Head/ Torso SAR (Wkg^{-1})	Local Limb SAR (Wkg^{-1})	Local Sab (Wm^{-2})
Occupational	100 kHz to 6 GHz	0.4	10	20	NA
	>6 GHz to 300 GHz	0.4	NA	NA	100
General public	100 kHz to 6 GHz	0.08	2	4	NA
	>6 GHz to 300 GHz	0.08	NA	NA	20

Note:
1. “NA” signifies “not applicable” and does not need to be taken into account when determining compliance.
2. Whole-body average SAR is to be averaged over 30 min.
3. Local SAR and S_{ab} exposures are to be averaged over 6 min.
4. Local SAR is to be averaged over a 10-g cubic mass.
5. Local S_{ab} is to be averaged over a square 4-cm^2 surface area of the body. Above 30GHz, an additional constraint is imposed, such that exposure averaged over a square 1-cm^2 surface area of the body is restricted to two times that of 4-cm^2 restriction.

Table 10: Reference levels for exposure, averaged over 30 min and the whole body, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed RMS values).

Exposure scenario	Frequency range	Incident E-field strength: E_{inc} ($V\ m^{-1}$)	Incident H-field strength: H_{inc} ($A\ m^{-1}$)	Incident Power density; S_{inc} ($W\ m^{-2}$)
Occupational	0.1 – 30 MHz	$660/f_M0.7$	$4.9/f_M$	NA
	>30 – 400 MHz	61	0.16	10
	>400 – 2000 MHz	$3f_M0.5$	$0.008f_M0.5$	$f_M/40$
	>2 – 300 GHz	NA	NA	50
General public	0.1 – 30 MHz	$300/f_M0.7$	$2.2/f_M$	NA
	>30 – 400 MHz	27.7	0.073	2
	>400 – 2000 MHz	$1.375f_M0.5$	$0.0037f_M0.5$	$f_M/200$
	>2 – 300 GHz	NA	NA	10

Note:
1. “NA” signifies “not applicable” and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz.
3. S_{inc}, E_{inc} and H_{inc} are to be averaged over 30 min, over the whole body space. Temporal and spatial averaging of each of Einc and Hinc must be conducted by averaging over the relevant square values.
4. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither E_{inc} nor H_{inc} exceeds the above reference values.
5. For frequencies of >30 MHz to 2 GHz (a) within the far-field zone: compliance is demonstrated if either S_{inc}, E_{inc} or H_{inc} does not exceed the above reference values (only one is required) : S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if either

Sinc or both E_{inc} and H_{inc}, does not exceed the above reference level values; and (c) within the reactive near-field zone: compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference values; Sinc cannot be used to demonstrate compliance, and so basic restrictions must be assessed.

6. For frequencies of >2 GHz to 300 GHz: (a) within the far –field zone: compliance is demonstrated if S_{inc} does not exceed the above reference level values; S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if S_{inc} does not exceed the above reference level values; and (c) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

Table 11: Reference levels for local exposure, averaged over 6 min, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed RMS values).

Exposure scenario	Frequency range	Incident E-field strength: E_{inc} (V m^{-1})	Incident H-field strength: H_{inc} (A m^{-1})	Incident Power density; S_{inc} (W m^{-2})
Occupational	0.1 – 30 MHz	1504/f_M0.7	10.8/f_M	NA
	>30 – 400 MHz	139	0.36	50
	>400 – 2000 MHz	10.58f_M0.43	0.0274f_M0.43	0.29f_M0.86
	>2 – 6 GHz	NA	NA	200
	>6 – <300 GHz	NA	NA	275/f_G0.177
	300 GHz	NA	NA	100
General public	0.1 – 30 MHz	671/f_M0.7	4.9/f_M	NA
	>30 – 400 MHz	62	0.163	10
	>400 – 2000 MHz	4.72f_M0.43	0.0123f_M0.43	0.058f_M0.86
	>2 – 6 GHz	NA	NA	40
	>6 – 300 GHz	NA	NA	55/f_G0.177
	300 GHz	NA	NA	20

Note:

1. “NA” signifies “not applicable” and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz; f_G is frequency in GHz.
3. Sinc, E_{inc} and H_{inc} are to be averaged over 6 min, and where spatial averaging is specified in Notes 6–7, over the relevant projected body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see eqn 8 in Appendix A for details).
4. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither peak spatial E_{inc} or peak spatial H_{inc}, over the projected whole-body space, exceeds the above reference level values.
5. For frequencies of >30 MHz to 6 GHz: (a) within the far-field zone, compliance is demonstrated if one of peak spatial S_{inc}, E_{inc} or H_{inc}, over the projected whole-body space, does not exceed the above reference level values (only one is required); S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if either peak spatial S_{inc}, or both peak spatial E_{inc} and H_{inc}, over the psrojected whole-body space, does not exceed the above reference level values; and (c) within the reactive near-field zone: compliance is demonstrated if both E_{inc}

and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance; for frequencies >2 GHz, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

6. For frequencies of >6 GHz to 300 GHz: (a) within the far-field zone, compliance is demonstrated if S_{inc}, averaged over a square 4-cm^2 projected body surface space, does not exceed the above reference level values; S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if S_{inc}, averaged over a square 4-cm^2 projected body surface space, does not exceed the above reference level values; and (c) within the reactive near-field zone reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.
7. For frequencies of >30 GHz to 300 GHz, exposure averaged over a square 1-cm^2 projected body surface space must not exceed twice that of.

11 Inspection and maintenance requirements

The scope of inspection and maintenance should cover all aspects that are relevant to the maintenance of structural integrity, and to the serviceability of the structure and its communications functions.

Maintenance and inspection of steel towers and antenna supporting structures should be performed by the owner/operator of the facility on a routine basis. The regulator shall be responsible for performing initial inspections of towers and masts before issuing the license and be responsible for verification of periodic inspections of towers and masts done by the owner/operator. The owner/operator of the network facilities (towers and masts) shall be responsible for performing the required maintenance and repair tasks as directed by the regulator.

The inspection and maintenance records for every tower site shall be kept by the owner or operator and shall be readily accessible to the inspectors or any duly authorized person from regulator upon request.

11.1 Qualifications of inspection and maintenance personnel

Both ground and aerial inspection and maintenance should be performed by authorized personnel, qualified on working in heights and its safety precautions according to OSHA requirements.

11.2 Inspection frequency

Preventive maintenance inspection checks shall be done by the operator/ owner at least once in every 3 years for guyed towers and at least once in every 5 years for self-supporting towers. Shorter inspection intervals of 2 years for guyed towers and 3 years for self-supporting towers may be obligatory for structures in coastal regions, in salty/corrosive environments and in areas that are frequently affected by severe winds (storms or cyclones), earthquakes or vandalism.

Routine inspection checks shall be conducted to all towers at least once in every year, to assess the structural condition of the tower and support equipment by the operator/ owner and serviced as frequently as may be necessary, to maintain the tower in a safe and best operating conditions. The regulator shall also conduct routine inspection checks on facilities least once in every year to ensure compliance.

Steel towers in the specific location shall be subjected to either routine or preventive inspection after occurrence of the following environmental conditions:

a) Severe winds, storms and tropical cyclones
b) Other extreme conditions (like Floods)
c) Severe seismic events (Occurrences of an earthquake)

11.3 Inspection tasks

Inspections tasks should be undertaken by experienced crews with the appropriate equipment as per Annex A.

The inspections should cover, as far as possible, the following:

a) Loose or missing bolts.
b) Fatigue cracking.
c) Damage from structural overload.
d) Vandalism (including rifle damage).
e) Corrosion of galvanized steelwork.
f) Degradation of paint systems.
g) Vibration.
h) Lightning damage.
i) Foundation deterioration and cracking.
j) Loose or damaged guy wires and fittings.
k) Ground surface erosion.
l) Evidence of soil creep or landslides.
m) Settlement.
n) Earthing integrity.
o) Auxiliary antennas, mountings and feed systems.
p) Maintenance of safety facilities.
q) Site security.
r) Tower or mast verticality and twist.
s) Navigation lighting.
t) Condition of insulators.

The inspection intervals need to be tuned to the operational environment and structural/service functional needs. Structures that have known vibrational problems, or are in a very corrosive environment, or are in a very windy or ice environment may need more frequent inspections.

The interval between maintenance inspections in particular will depend on factors such as:

(a) Corrosion potential of the environment and the degree of protection required for maintenance of design reliability;
(b) Importance of the structure to its service;
(c) Severity of local conditions (i.e. wind, storms, cyclones and earthquakes);
(d) Sensitivity to structural response; and
(e) Influence of ground conditions.

It is recommended that the interval between inspections should be according to the relative importance of the above factors.

11.4 Maintenance tasks

Maintenance and repair tasks should be undertaken by experienced crews with the appropriate equipment according to Annex B. The replacement of any structural members should be approached with caution and an engineering valuation may be necessary before work commences.

On guyed masts, variation in guy tensions may be critical to the performance of the facility. Where inelastic construction stretch is not removed from guys prior to installation, it may be necessary that re-tensioning be undertaken at the end of 12 to 18 months after construction. Guy tensions should be maintained to within ± 5% of the design values.

Maintenance crews should be aware of any electrical hazards, particularly radiation, while undertaking work on communication structures. Advice on these aspects should be sought from the site owner.

12 Marking, Labeling and Packaging

12.1 Member marking

All structural members or welded structural assemblies, except for hardware, shall have a part number. The part numbers shall correspond with the assembly drawings. The part number is to be permanently attached (stamped, welded lettering, stamped on a plate that is welded to the member, etc.) to the member before all protective coatings are applied. The part number shall have a minimum character height of 13 mm.

12.2 Tower marking

Each completed communication tower must have a name plate attached to one of its legs on which the following particulars are detailed:

a) Name, address and telephone numbers of the owner, fabricator and installer
b) Tower Height
c) Base Section area (in m^2)
d) Tower loading requirements for Antenna (in m^2), Cabling (in m^2) and Weight (in kN)
e) Maximum wind speed considered (in m/s or km/h)
f) Payback Period (in years)

12.3 Antenna marking

The antenna of each tower shall contain the following particulars:

a) Date of erection
b) Height
c) Number of antenna
d) Operating Frequencies
e) Location address
f) Geographical coordinates
g) Name of operator and licensee
h) Effective Isotropic Radiated Power
i) Records showing inspection dates and types of inspections performed and detailed particulars of the inspector.

12.4 Packaging and labeling of parts

All items of tower shall be dismantled except the cross-arms for towers, according the drawings. All items of each part of tower shall be placed in separate bundles according to fabrication drawings (Material packing table). Bundles of steel angles shall be properly tied together: long items will be placed underneath; small angles will be above. All bundles will be placed on a wood skeleton platform (consisting of deck boards and runners) and secured with double 6 mm thick galvanized steel strips at least in 3 places. Deck board shall have a minimum thickness of 25 mm.

Cross-arms will be assembled with bolts, nuts, screw washers according to the drawings. The hangers and the vertical diagonals will be tied to a cross-arm leg with double 6 mm thick galvanized steel strips at least in 3 places.

Each packing shall contain a packing list with part drawing and circle around each item that is in the package. Packing list will be in a waterproof envelope. All the plates shall be packed separately in boxes. The plates shall be threaded on galvanized wire 4 mm thick. An identification label and box marking will be threaded on the same wire.

There will be a separate label for each part of the tower. The boxes shall be closed. Each label will include the following information:

i. Name of manufacturer
ii. Country of manufacture
iii. Type of tower
iv. Name of part of the tower
v. List of items marked on drawing
vi. Bundle Weight (kg).

12.5 Site Identification, safety and warning signs

Each completed communication tower site must be protected by a security fence that must have the following information on its entrance:

i. Site identification

A standard way of identification for all towers that communicates essential information to all parties including owner, operator and regulator.
Example; DAR-UBU-HAL-00111-06793918
Whereby:-
DAR - First three letters of region, Dar es Salaam
UBU - First three letters of district, Ubungo
HAL - First three letters of Owner/Operator of the tower, Halotel
00111 - Serial number of the tower
06793918 - Coordinates expressed as the combination of latitude 06.79º and longitude 39.18º

ii. Safety and warning signs

Radiation hazards
Fall from height hazard
Electric shock hazard
Safety gears required to enter and work in the facility

Annex A

(Normative)

Routine Inspection Checks

The following routine checks should be carried out during the service life of the Structure:

a) Main structure
   i. Check that there are no structure components missing
   ii. Check that bars are neither warped, holed nor spitted and replaces all defective parts.
   iii. Check structure components for corrosion
   iv. Check that draining holes on pipe leg members, pipe lattice parts are not blocked.
   v. Check the climbing facilities, platforms, catwalks for integrity

b) Tower Base Foundation
   i. Check for settlements or movements
   ii. Check for erosion
   iii. Check general site condition (standing water, drainage, trees etc.)
   iv. Check bolts, nuts and lock nuts for tightness
   v. Grout condition

c) Guy wires
   i. Check that each cable that is part of the guy wire is neither broken nor warped
   ii. Measure the tension of each guy wire using a strand dynamometer and compare result with the installer's stated values.
   iii. Check guy wires condition (corrosion, breaks, nicks, kinks, etc)
   iv. Check that the guy wire tightening system is properly greased.
   v. Check for loose or missing fasteners
   vi. Check base for settlement, movement or earth cracks
   vii. Check backfill heaped over concrete for water shedding
   viii. Check anchor rod condition below earth
   ix. Check for signs of corrosion and take remedial timely steps
   x. Ensure anchor head is clear of earth

d) Bolting parts
   i. Check that no bolts or nuts or any bolting part like washers, pins, etc is missing. Replace these immediately.
   ii. Check bolts tightening.
   iii. Check bolts, nuts and bolting parts for corrosion.
   iv. Check anchorage rod in the concrete.

e) Verticality
   i. Check with the appropriate devices such as theodolite that the structure stands in a vertical position.
   ii. There shall be no tilts. Take two measurements in two different planes with a 90' angle difference.

f) Antennas and Accessories
   i. Check antennas and antenna supports
   ii. Check coaxial cables
   iii. Check fixing clamps.

g) Safety components
   i. Check that access ladder is in good condition

ii. Check rest and work platforms for defects, wear and tear
iii. Check that all safety components are existing and complete
iv. Check the correct functioning of the fall arrestor system
v. For a fall arrestor system with cable, check that the cable has not been over tightened.
vi. Check that the anti-climbing door is functioning.

h) Lightning and Earthing system
i. Check that all lightning and Earthing components are existing and complete including lightning arrestor, copper strip, connection plate,
ii. Check the Earthing connection of coaxial cables,
iii. Measure the resistivity of the Earth and confirm conformity to expected values.

i) Aviation Safety Lights
i. Check that all components are in place,
ii. Check condition and well-functioning of components (Light bulb, energy cables, fixing parts, photoelectric cell, connections)
iii. Check earthing of the light wiring.

j) Anti-corrosion protection
i. Check all galvanized members for integrity.
ii. Check paint condition.
iii. Check for signs of corrosion on the structure, of the bolts, bolting accessories, harnesses, antenna supports, etc.
iv. For guyed masts, check for corrosion on the entire guy assembly.

k) Salty environment

i. Wash the structure and accessories with clean water once every six (6) months to eliminate residue salt particles which may not be washed away by rain.

l) Concrete blocks

i. Check the good condition of above ground concrete block parts.
ii. There must not be any water collection, cracking or splitting, chipped or broken concrete.
iii. Check the condition of anchor setting in the concrete block.
iv. Check anchor-bolt corrosion.

m) Tower loading

i. Check types, numbers and installed heights of all antennas currently on the structure and confirm that the loading does not exceed structure design load

Annex B

(Normative)

Preventive Maintenance Inspection Checks

The following Preventive Maintenance Checks shall be carried out during the service life of the Structure.

a) Structure
   i. Tension of Guy wires using a dynamometer.
   ii. Geometry of the structure.
   iii. Re-tighten main structure and accessories bolted parts (10%)
   iv. Geometry of the Bars.
   v. Rigidity of Antennas and Accessories.

b) Safety
   i. Ensure that anti climb door can open and close. Clean and grease all hinges.
   ii. Ensure the work platform's trap can open and close. Clean and grease all door hinges.
   iii. Check the fall arrestor system
   iv. Check tower ladder for any signs of weakness, re-tighten all bolts
   v. Check the riggers' safety gear, take inventory and record it
   vi. Check the positioning and installation of safety components.
   vii. Test the fall arrestor system with individual equipment.

c) Earthing
   i. Check the physical condition of the lightning rod and lightning arrestor
   ii. Check the physical condition and installation of the copper strip
   iii. Check the connection of the concrete block copper belting onto the copper strip the connection of coaxial cables earthing onto the copper strip
   iv. Check the connection between the bottom coaxial cable earthing and the collection Copper bar fixed on the concrete block
   v. Check the tightening of the brass bolts of the lightning protection electrodes
   vi. Check the resistivity of the lightning protection electrodes
   vii. Earth resistance

d) Aviation Safety Lights
   The following checks should be carried out:
   i. Functionality of controllers, flashers, alarms and photo control
   ii. Condition of electrical wires, connectors and earthing
   iii. Condition and fixing of energy cables
   iv. Conduit, junction boxes, and fasteners weather tight and secure
   v. Bulb condition - change all bulbs at the same time immediately before the rated service hours is achieved.
   vi. Condition and fidelity of the power supply systems

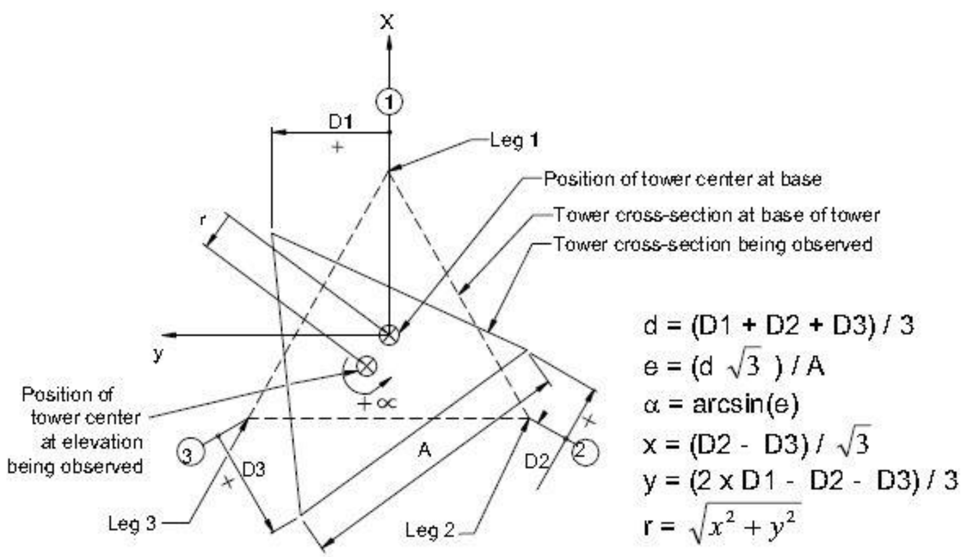
e) Coating
   i. To prevent discrepancies in galvanization
   ii. Paint coating. Repaint every three years
   iii. Rust and/or corrosion conditions
   iv. ICAO / TCAA Colour marking conditions
   v. Water collection in members - unplug drain holes, etc.

f) Records
   i. A record keeping method shall be maintained in which all maintenance checks made will be documented.
   ii. The contents of the records shall include: date of checks, what was checked, observations of the check, and name and signature of the personnel that conducted the check.
   iii. The records shall be made available to the regulator or its due representative on demand.

g) Tower Alignment

Tower Plumb and Twist (See Figures 1 and 2)

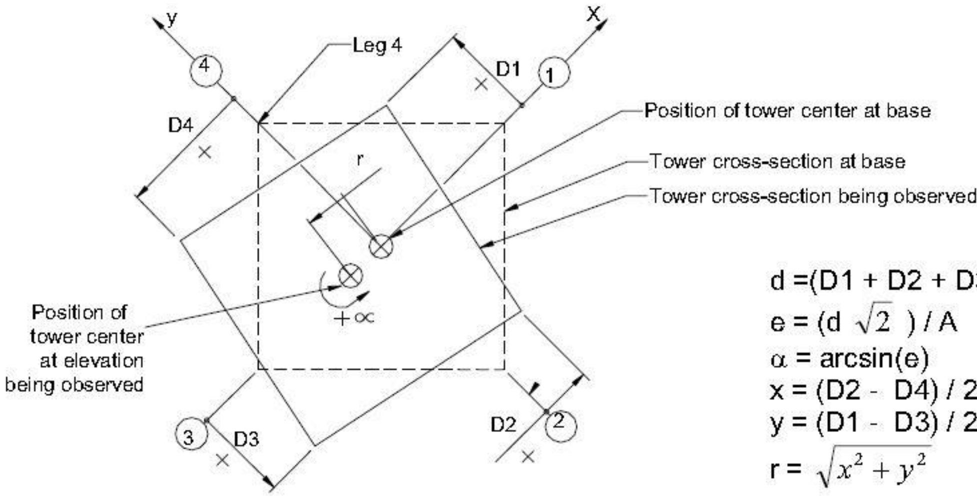
The transit is to be set up on each leg azimuth at the base of the tower. The corresponding tower leg at the base of the tower is used to set the vertical baseline. The deflection at each point of interest on the tower is measured from this vertical baseline, as shown below.



OBSERVED LEG DISPLACEMENTS					CALCULATED TWIST			CALCULATED OUT-OF-PLUMB		
SIGHTED ELEV ft [m]	A in [mm]	D1 in [mm]	D2 in [mm]	D3 in [mm]	d in [mm]	e	α deg.	x in [mm]	y in [mm]	r in [mm]

Figure 1: Twist and Out-of Plumb Determination for Triangular Towers

The transit is to be set up on each leg azimuth at the base of the tower. The corresponding tower leg at the base of the tower is used to set the vertical baseline. The deflection at each point of interest on the tower is measured from this vertical baseline, as shown below.



$$d = (D1 + D2 + D3 + D4) / 4$$
$$e = (d \sqrt{2}) / A$$
$$\alpha = \arcsin(e)$$
$$x = (D2 - D4) / 2$$
$$y = (D1 - D3) / 2$$
$$r = \sqrt{x^2 + y^2}$$

OBSERVED LEG DISPLACEMENTS						CALCULATED TWIST			CALCULATED OUT-OF-PLUMB		
SIGHTED ELEV ft [m]	A in [mm]	D1 in [mm]	D2 in [mm]	D3 in [mm]	D4 in [mm]	d in [mm]	e	α deg.	x in [mm]	y in [mm]	r in [mm]

Figure 2: Twist and Out-of-Plumb Determination for Square Towers

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