MALAYSIAN COMMUNICATIONS AND MULTIMEDIA COMMISSION

INVITATION TO REGISTER INTEREST

AS

UNIVERSAL SERVICE PROVIDER

Appendix 2

Technical Specifications for Part 1

CONTENT

2.6.4. Pressure-Treated Timber Piles
2.6.4.1. Description
2.6.4.2. Materials
2.6.4.3. Manufacture
2.6.5. Bakau Piles
2.6.5.1. Materials
2.6.5.2. Pitching and Driving of Piles
2.6.5.3. Cutting and Preparing of Pile Heads
2.6.6. Pile Testing
2.6.6.1. Test Piles
2.6.6.2. Preliminary Pile Load Tests
2.6.6.3. Production Pile Load Tests
2.6.6.4. Preparation of Test Pile
2.6.6.5. Method of Loading
2.6.6.6. Measurement of Settlement
2.6.6.7. Method of Testing
2.6.6.8. Constant Rate of Penetration
2.6.6.9. Test Results
2.6.6.10. Interpretation of Test Results
2.6.6.11. Load Testing of Bakau Piles
2.7. Brickwork and Blockwork
2.7.1. Brick/Block Walling
2.8. Access Road
2.9. Land Drainage
2.9.1. Natural Drainage
2.9.2. Precast Or Cast In Situ Block Drain Sections
2.9.3. Setting Out
2.9.4. Laying of Block Drains
2.9.5. Backfilling
2.10. Anti Climb Fencing
2.10.1. Mesh
2.10.2. Fence Posts
2.10.3. Gates
2.11. External Works
2.11.1. Grading
2.11.2. Earth Inspection Pits

3. TOWER ANALYSIS AND DESIGN

3.1. Scope
3.2. Dead Load
3.3. Design and Analysis Assumptions
3.4. Analysis and Design Standards
3.5. Grade of Steel
3.6. Loading and Load Cases
3.7. Overall Stability of Structure
3.8. Foundation Design
3.9. Design of Members
3.10. Design of Joints
3.11. Vertical Cable Ladders
3.12. Design and Analysis Method
3.13. Report and Calculation Layout
3.14. Design
3.15. Aircraft Warning Lighting
3.16. Day Warning Paint
3.17. Fabrication

1 INTRODUCTION

1.1 Scope

This document outlines the specifications for the setting up of tower sites under the Invitation. It includes among others the requirements for the civil works, the design and parameters of the tower and the electrical installation, earthing and lighting protection at the site.

Licensees are to ensure that facilities installed at site must meet all the specifications specified in this document.

1.2 References

The specifications in this document are in conformance with the following technical standards and practice:

- British Standards and Code of Practice
- Malaysian Standards and Codes of Practice
- Malaysian Building legislation and regulations
- Malaysian Health and Safety Regulations
- JKR Guidelines for Slope Design; 2010
- The regulations for the Electrical Equipment of Building 17th Edition as issued by the Institution of Electrical Engineers, London
- The British Standard Electrical Codes of Practice
- The relevant British Standard Specification (BBS)

1.3 Glossary of Terms

Throughout this specification, all instructions are directed to the Licensee and the following terms are used:

ANSI	-	American National Standards Institute
ASTM	-	American Society for Testing and Materials
BEM	-	Board of Engineer Malaysia
BG	-	Birmingham Gauge
BOMBA	-	Jabatan Bomba Dan Penyelamat Malaysia
BS	-	British Standard issued by the British Standards Institution
CBR	-	California Bearing Ratio
CP(BS)	-	British Code of Practice issued by British Standards Institution
DCA	-	Department of Civil Aviation Malaysia
EN	-	European Standard
ICAO	-	International Civil Aviation Organization
IEE	-	Institution of Electrical Engineers
IP	-	Ingress Protection
ISO	-	International Standards Organisation
JKR	-	Jabatan Kerja Raya Malaysia
MS	-	Malaysian Standard issued by SIRIM
SESB	-	Sabah Electricity Sdn Bhd
SESCO	-	Syarikat SESCO Berhad
ST	-	Suruhanjaya Tenaga
SWG	-	Standard Wire Gauge
TNB	-	Tenaga Nasional Berhad

2 GENERAL SITE WORK

2.1 Scope

This section sets out the requirements for the design and construction of general site works under the Invitation. In relevant areas, consultation and endorsement from a professional engineer registered with the BEM shall be obtained by the Licensee prior to the commencement of the works.

2.2 Compound Layout

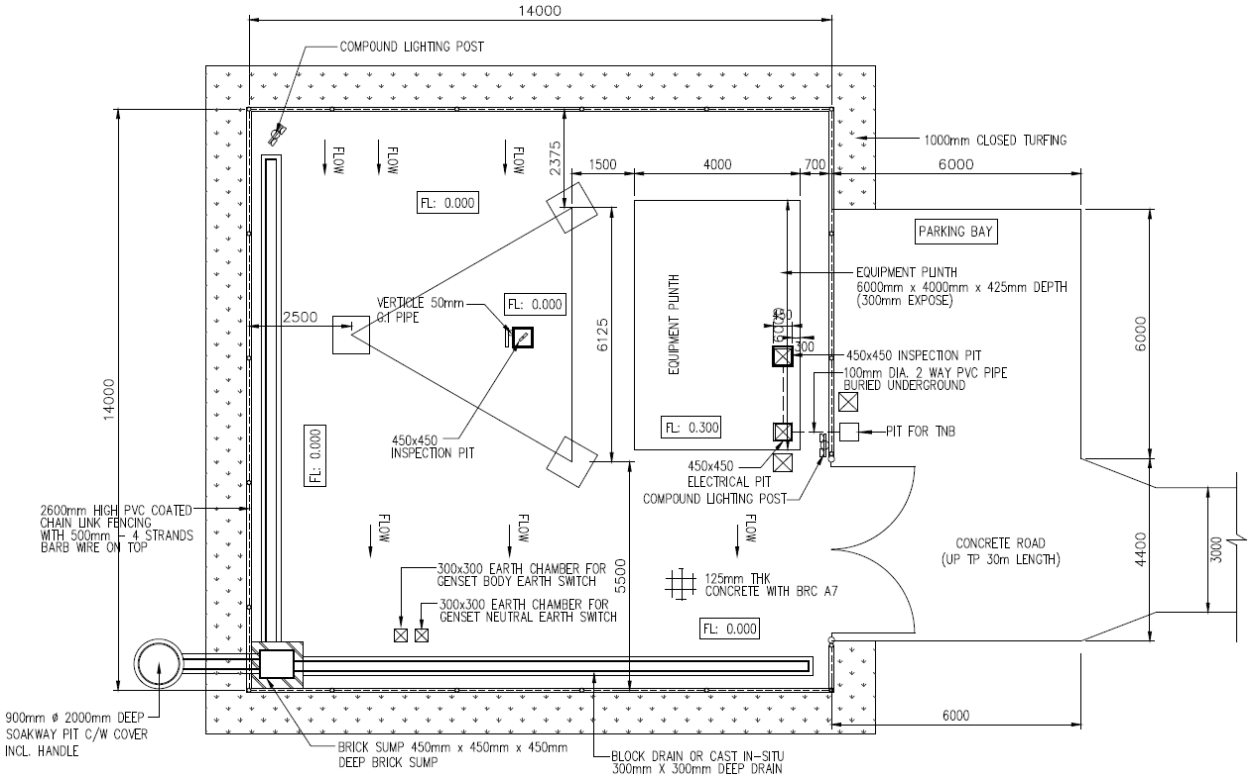
The site compound layout required under this Invitation can be referred to the drawings attached to this document.

Compound layout shall be determined by tower heights.
Three (3) heights of structure shall be adopted in this tender:

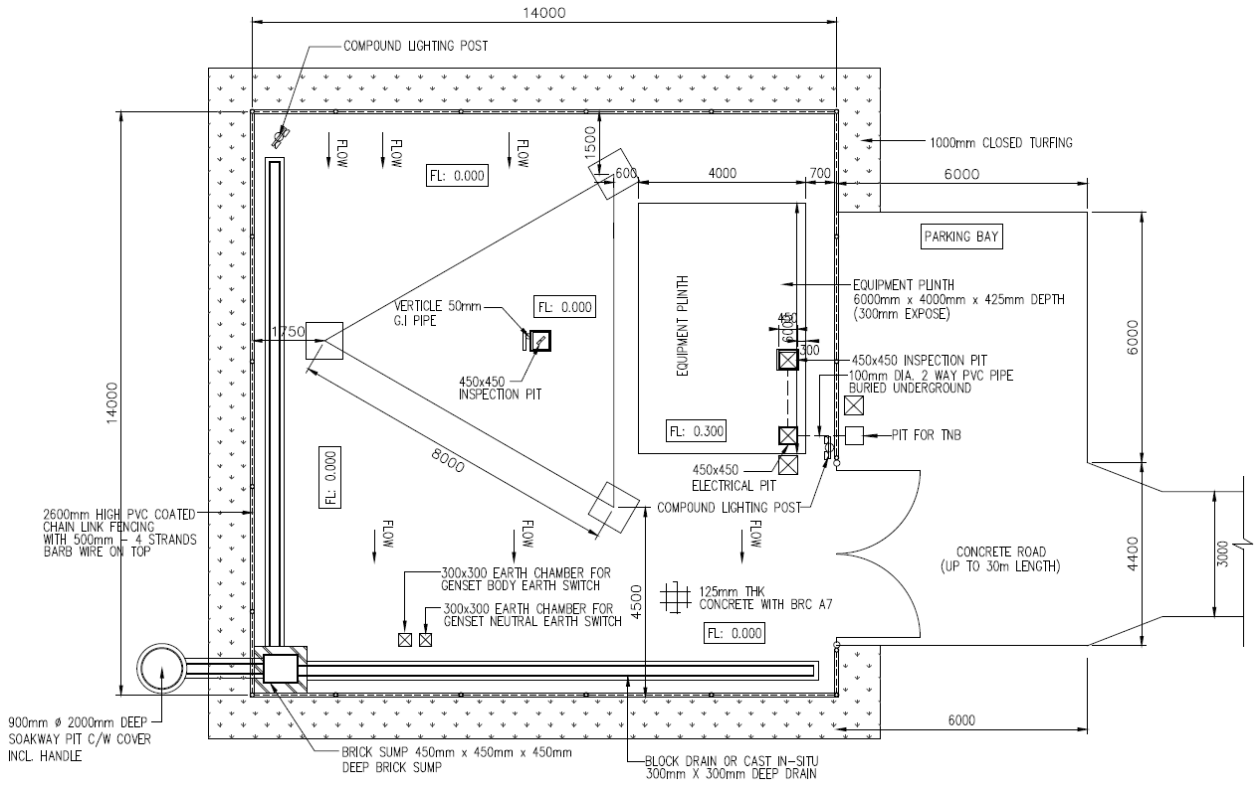
- 45m Tower having Compound Layout of 14m x 14m
  Approximate Leg-to-Leg dimension: 6.125m
- 60m Tower having Compound Layout of 14m x 14m
  Approximate Leg-to-Leg dimension: 8m
- 76m Tower having Compound Layout of 16m x 16m
  Approximate Leg-to-Leg dimension:10m

The general overall Compound Layout plan for each tower height shall be as per the diagram below.

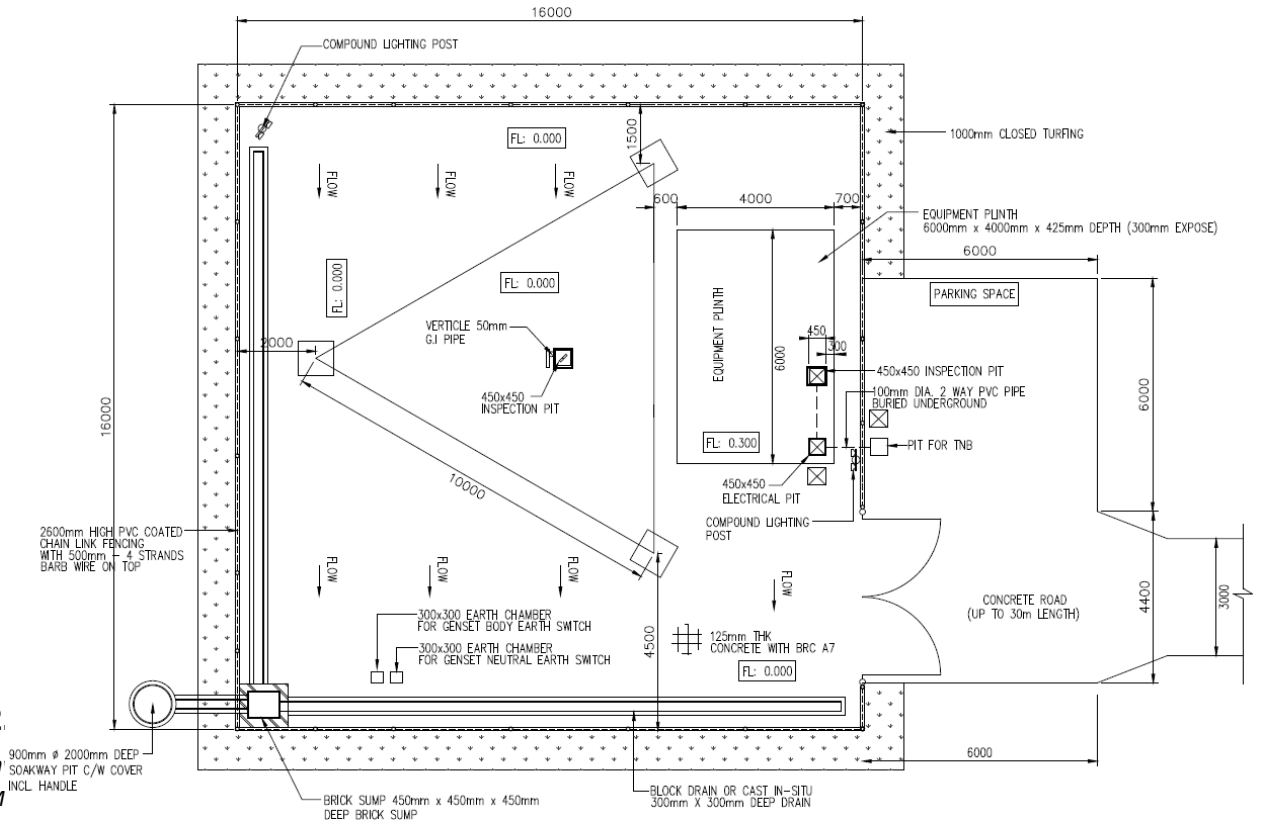
45m Tower: 14m x 14m Compound Layout [Tower Leg-to-Leg: 6.125m]



60m Tower: 14m x 14m Compound Layout [Tower Leg-to-Leg: 8m]



76m Tower: 16m x 16m Compound Layout [Tower Leg-to-Leg: 10m]



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2.3.1 Preliminary Site Works

Earthworks and general excavations shall be carried out by machine in a workmanlike manner complying to the requirements of BS 6031 – "Earthworks" and BS 8004 –"Foundations", subject to any qualifications given herein this specification.

Site work comprises all necessary work for excavation, placement or disposal of earth, rock or other material from or to the sites or adjacent.

2.3.2 Soil Investigation

A soil investigation shall be carried out at each site.

Wherever possible 1 No Bore Log and 5 Nos JKR Probe to be conducted for each site.

2.3.3 Setting Out

The sites shall be properly set out by the Licensee's Licensed Surveyor as shown on the drawings and inspected and approved by Licensee prior to commencing excavation.

2.3.4 Excavation

Excavation shall be taken out to such dimensions as required. Excavation shall, where so is necessary, be shored and strutted and kept free from water. The whole of the excavation shall be carried down to such depths as are necessary to obtain a secure foundation.

All excavation shall be completed before any fill is deposited. No concreting shall be commenced until the excavation has been carried out.

Excavation shall be carried out by the Licensee in such a way as to avoid disturbance to the surrounding ground. The Licensee is to ensure by means to be approved, that no excavations will cause damage to existing adjacent structures by permitting ground movement.

Upon clearing the site, all rubbish shall be deposited at an approved Dump Site.

2.3.5 Rock Excavation

Rock shall be defined as materials of a large coherent mass of such size and strength which would normally require to be removed by blasting, frilling and/or wedging, if carried out by hand. Removal of loose boulders of a volume not exceeding one cubic meter, encountered in all classes of excavation will not be treated as rock excavation and shall be paid for at normal excavation rates.

Should rock be met within the course of excavation, it shall be removed by wedges and levers.

However, should blasting need to be carried out, the Licensee shall ensure, by adherence to proper safety distances and by the use of heavy blasting mats, that no care shall be taken when blasting in wet ground to ensure that individual explosives are reduced to such a size as to preclude damage to any buildings or structures. The Licensee shall be held solely responsible for any damage or nuisance caused by blasting operations.

2.3.6 Other Hard Materials

Materials such as earth gravel, disintegrated or decomposed masses, geologically semi-formed "rock" such as very dense cemented sand and other such hard and complex materials that can be excavated and removed by the standard use of earth moving machines, shall be considered normal classes of materials excavated and shall be paid for at normal excavation rates.

A bulldozer equipped with a ripper shall be considered an ordinary earth moving machine.

2.3.7 Water Problem

The Licensee shall ensure that compound platform level is above stable ground water level. During construction, the licensee shall carry out all necessary arrangements for controlling the water inflow into the excavation pit during excavation, construction of formwork and concreting. These arrangements may include temporary cofferdams, well point system, pumps, trenches, flumes and other recognized means. The Licensee shall keep all surfaces upon or against which concrete is to be deposited free from running water and no concrete shall be placed until such surfaces are properly drained. Suitable precautions shall be taken to prevent running water from washing out concrete while it is curing or from damaging the Works in any other way.

2.3.8 Filling and Back Filling

All filling shall consist of suitable material and shall be compacted to not less than 95% of the maximum dry density of the soil optimum moisture (Proctor). Compacting shall be carried out in a series of continuous operations (not less than 3) over the full width of the layer. The thickness of layer shall not exceed 250mm. Compacting shall be executed with a vibrating plate compactor with a weight of not less than 100kg.

The Licensee shall ensure the following points during soil back filling:

- The excavations and areas to be filled shall be free from loose soil, rubbish and standing water.
- Different material shall be placed separately so that only one type of material occurs in each layer.
- The fill shall not include marshes or bogs, peat, logs, stumps and perishable material and any other unsuitable material as defined below.
- Material excavated from the trench shall be laid and compacted in layers with thickness not exceeding 300mm.
- Each layer shall be watered and thoroughly compacted with soil compactor, for example 4 times run over with a 100kg vibrating plate (wacker plate).
- Layers of clay and other cohesion materials shall not be watered.

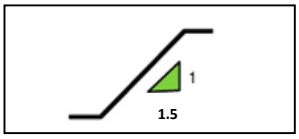
2.4 Slope Protection

2.4.1 Slope Stability

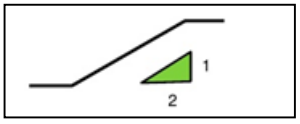
For site where earth slope is necessary in order to bridge difference between the proposed site level and its natural surroundings, and when such slope was found by detailed slip circle analysis and/or other suitable slope analysis method suitable and appropriate to the particular site condition and such that no retaining wall is necessary, then the proposed slope surface shall be closed turfing.

Design Criteria for slope:

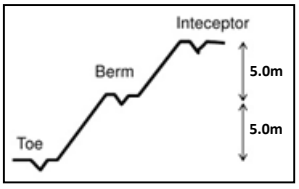
- Gradient for Cut Slope 1 : 1.5



- Gradient for Fill Slope 1 : 2



- For slopes above 5m high, 5m intervals with toe, berm & Intercepting drains



Overall (global) slope stability analysis may be required for case such as, though not limited to, slope more than 6m high with an average slope gradient steeper than 1V:2H coupled with adjacent (not more than 10m) away from essential public road or railway line, water reservoir and any other essential public utilities.

2.4.1.1. Rock slopes

All Rock slopes shall be analyzed and designed. Preliminary consideration can be used using 4V:1H for weathering grade I and 3V:1H for weathering grade II. If analysis indicates that it is unstable, it shall be designed to a better gradient and/or requiring extensive stabilization measures.

2.4.2 Turfing

Closed turfing shall be turfed with turf laid to a well bonded pattern with no gaps between the turfs and lightly compressed.

Where turf is to be laid a 100mm thick layer of approved topsoil shall be spread and compacted on the surfaces to be turfed.

All turfs shall be cut 300mm wide and at least 300mm long and 75mm thick, cultivated grass content shall be minimum 85%, free from minosa, lallang, creeping stoloniferous, perennial weeds and any other objectionable plants and should be preferably laid on the day it is cut. They shall consist of healthy dense grass firmly rooted into at least 50mm of topsoil.

Turf which cannot be laid within three days of cutting may, at the discretion of the Engineer, be used as topsoil. Turf laid on slopes shall be pegged down with split bamboo at least 230mm long.

All turfing shall be finished to give a smooth compact surface. Where strip and spot turfing is employed the turf shall not stand out above the level of the surrounding topsoil. Turfing shall keep pace with spreading of topsoil.

2.4.3 Retaining Wall

For site where due to unavoidable ground level differences such that retaining wall is necessary, then the type of retaining wall adopted shall be justified by design carried out using established soil mechanics method appropriate for its class of application. Wall construction, drainage during and after construction, treatment of surface drainage on top as well as in front of wall, drainage outlet position and its effect downstream are some of the factors that need to be explicitly described and duly considered for such application.

2.5 Concrete Work

All concrete works shall be executed in accordance with the requirements of BS 8110 – “The Structural Use of Reinforced Concrete in Buildings”.

The Licensee shall do all concrete work. The concrete work includes lean concrete, reinforcement and the pouring and curing of concrete. The temperature of the concrete at the time of placing shall be at least 5°C. The Licensee shall ensure that the temperature of the concrete does not fall below 5°C for the first 72 hours after casting.

Tower foundation calculations shall be based on loads from the tower legs and data from the soil investigation. The foundation shall be designed to be able to use the weight of the soil as part of the total counterweight towards pulling force from tower leg.

2.5.1 In Situ Concrete Mixes, Casting and Curing

2.5.1.1 Tolerances

Dimensional tolerances for concrete structure shall not exceed +/- 10mm. Tolerance for concrete cover according to 2.5.1.8.

2.5.1.2 Cement

The cement used shall be ordinary setting or rapid hardening Portland Cement of approved manufacture and shall comply with the requirements of MS 522 and BS 12:1978. Cement shall be obtained from a single identified source to ensure consistency of mix and colour.

2.5.1.3 Water

Water used in concrete must be clear and free from harmful matter and shall comply with the requirements of BS 3148. If the water is suspected to contain any harmful matter, salt etc., it shall be analyzed to clarify the content of such matters.

2.5.1.4 Aggregates

The aggregates shape, colour and grading must be consistent. The maximum size of aggregate shall be 20 mm. Aggregate shall comply with the requirements of BS 882 – “Specification for Aggregates from natural Sources for Concrete”. They shall not contain water soluble-sulphur trioxide (SO3) in excess of 0.1 percent.

The fine aggregates shall not contain silt or other fine material exceeding 6 percent by volume when tested according to the Standard Method given in BS 812 clause 15 and 28. The use of mining sand crushed stone will not be permitted as fine aggregates Sand for cement mortar shall conform to BS

1200.

2.5.1.5 Admixtures
The concrete admixture shall comply to BS5075.

2.5.1.6 Concrete Mixes
The consistency of the mix shall be such that both the specified surface finish and the required compaction can be achieved.

2.5.1.7 Chloride content
The total chloride content of the concrete mix arising from the aggregate, together with that from any other source, should not in any circumstances exceed 0.2 %.

2.5.1.8 Concrete Cover
The concrete cover shall comply to BS8110.

2.5.1.9 Concrete Surface Finish
The surface should be free from voids, honeycombing, or other large blemishes.

2.5.1.10 Curing
The methods of curing and their duration shall be such that the concrete will have satisfactory durability and strength, the member will suffer a minimum of distortion, be free of excessive efflorescence and will not cause, by its shrinkage, undue cracking in the structure.
The concrete shall be cured by covering it with a material such as polythene sheet or a curing compound or with an absorbent material which is kept damp for a minimum curing time of 48 hours. Under adverse conditions such as hot weather or drying winds, this time is to be doubled.

2.5.2 Formwork for In Situ Concrete
The formwork shall be sufficiently rigid and tight to prevent loss of grout or water from the concrete at all stages. It shall also be designed to withstand the forces caused by the method of placing and compacting concrete. The formwork (including supports) shall be sufficiently rigid to maintain the forms in their correct position, shape and profile so that the final concrete structure is within the limits of the dimensional tolerances specified. All debris and other deleterious materials shall be removed from the interior of the forms before the concrete is placed. The faces of the forms in contact with concrete shall be cleaned and treated.

2.5.3 Reinforcement for In Situ Concrete

2.5.3.1 General
All reinforcement shall be positioned as indicated on the drawings. They shall be secured against displacement. The actual concrete cover shall be equal or more than the required nominal cover minus 5 mm. All connections, laps and joints between bars shall be according to the British Codes of Practice. All reinforcement prior to concreting shall be free from mud, oil, paint, loose rust, loose mill scale, snow, ice, grease or any other substance which could affect the steel adversely or the concrete chemically or to reduce the bond.
Mild steel rod reinforcement shall be plain round hot rolled mild steel bars complying with the requirements of BS 4449.
High yield deformed steel rod reinforcement shall be high tensile steel bars complying with the requirements of BS 4449 Part I with a minimum yield stress of 410 N/mm2.

2.5.3.2 Durability
For durability of reinforcement, consideration shall be taken with respect to concrete cover according to 4.2.8, limitation of crack width and the occurrence of tensile stresses, limitation of chloride and composition of concrete. For durability of concrete, air content in concrete above the ground level and 1m down shall be minimum 5.5 %. For other parts a minimum air content of 4.5 % is applicable. The maximum stone diameter shall be 20mm and water- cement ratio shall be < 0.55.

2.5.3.3 Tower Template

The Licensee shall position and install the tower anchor bolts using a tower template. He shall ensure that the bolts are installed observing the specified tolerances. The template must not be removed within the first 72 hours of pouring the concrete. A damaged tower template shall not be used under any circumstances.

2.5.3.4 Worked Finishes To In Situ Concrete

All formwork shall be removed without shock or vibration that might damage the concrete. The Licensee shall decide the striking times for all formwork and shall ensure that these striking times do not lead to damage of the structure or its finish.

2.6 Piling Works

All piling shall conform to the requirements of CP 2004, subject to any qualifications here below unless otherwise specified in this specification.

This work shall consist of supply, installation and testing of piles. All materials and workmanship shall be the best of their respective kind.

2.6.1 General Requirements for Tolerances

Setting out shall be carried out from the main grid lines of the proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins, pegs or markers. For a pile cut off at or above ground level the maximum permitted deviation of the pile centre from the centre points shall not exceed 75mm in any direction. For a pile cut off below ground level an increase in this tolerance is permitted in accordance with the following clauses:

- The maximum permitted deviation of the finished pile from the vertical is 1 in 75.
- The piling rig shall be set and maintained to attain the required rake. The maximum permitted deviation of the finished pile from the specified rake is 1 in 25.
- Forcible corrections to concrete piles shall not to be permitted. Forcible corrections may be permitted to other types of piles are at the discretion of the Licensee. However, no forcible corrections shall be made to piles, which have deviated beyond the permissible limits specified above.
- The Licensee shall, if needed, extract and reinstall any pile which has deviated out of position or alignment by more than the specified limit.
- The Licensee shall keep records of the installation of each pile as required. Any unexpected driving or boring conditions shall be noted in the records.

2.6.2 Precast Reinforced Concrete Piles

2.6.2.1 Description

This work shall comprise the supply and installation of precast reinforced concrete piles, inclusive of pitching and driving, lengthening and cutting and preparation of pile heads, all in accordance with this Specification. Unless otherwise specified, ordinary Portland cement shall be used for the casting of piles.

2.6.2.2 Reinforcement

The main reinforcing bars in piles not exceeding 12m in length shall be in one continuous length. In piles exceeding 12m long, joints shall be permitted in main longitudinal bars at 12m nominal intervals. Joints in adjacent bars shall be staggered at least 1m apart along the length of the pile. Joints shall be butt welded as required.

2.6.2.3 Pile Shoes

The type of pile shoes to be used shall comply with the following as relevant:

- “Chilled-hardened” cast iron shoes as used for making grey iron casting to B.S. 1452, Grade 10; or
- Mild steel to B.S. 4360, Grade 50B; or
- Cast steel to B.S. 3100, Grade A.

2.6.2.4 Pitching of Piles

Piles shall be pitched in the accurate positions at all stages during driving and until the pile has set or been driven to the required length. All exposed piles shall be adequately supported and restrained

by means of leaders, trestles temporary supports or other guide arrangements to maintain position and alignment and to prevent buckling and damage to the piles.

2.6.2.5 Driving of Piles

Each pile shall be driven continuously until the specified set and/or depth has been reached. The driving equipment used shall be of such certified type and capacity.

A detailed record of the driving resistance over the full length of each pile shall be kept by the Licensee. The log shall record number of blows for every 0.5m of pile penetration.

Piles shall be driven in the required sequence to minimize the detrimental effects of heave and lateral displacement of the ground. When required, careful leveling from a datum unaffected by the pilling shall be made on the pile heads that have already been driven, before and after driving subsequent piles. Piles which have been displaced as a result of driving adjacent piles shall be re-driven to the required resistance.

2.6.2.6 Cutting and Preparation of Pile Heads

When a pile has been driven to the required set or depth, the head of the pile shall be cut off to the required level. If the length of reinforcing bars left projecting is insufficient, then they shall be extended by either of the following methods:

- Butt Welding - The extension bars shall butt on the projecting bars in true alignment and shall be butt welded in accordance with this specification.
- Splicing - The projecting bars shall be stripped of all surrounding concrete as necessary to allow splices of length 60 x diameters with extension bars. The extension bars shall be securely bound to the projecting bars with 1.63mm soft annealed iron wire. The concrete of the pile shall be made good either before or together with the casting of the pile cap.

Care shall be taken to avoid cracking or otherwise damaging the rest of the pile. Any cracked or defective section of the concrete pile shall be cut away and make good with new concrete properly bonded to the old.

2.6.3 Micropiles

2.6.3.1 Diameter of Piles

The diameter of piles shall be at the appropriate diameter at any level throughout its length.

2.6.3.2 Drilling

Drilling shall be carried down to the appropriate depths. Upon completion of drilling, each hole shall be inspected prior to the placing of reinforcement and grout.

2.6.3.3 Mixing and Placing Grout

Grout shall be mixed on Site and shall be free from segregation, slumping and bleeding. Grout shall be pumped into its final position in one continuous operation as soon as possible and in no case more than half an hour after mixing. Grout shall be tested in accordance with BS 4550 and BS 1881.

2.6.4 Pressure-Treated Timber Piles

2.6.4.1 Description

This work shall comprise the supply and installation of lengthening and preparation of pile heads, all in accordance with this Specification. The timber terms used in this Specification shall have the meanings assigned to them in MS 229.

2.6.4.2 Materials

Unless otherwise specified, Kempas (Koompassia Malaccensis) shall be used and this shall not be of a lesser quality than the grading specified in Appendix A of MS 822.

Pressure-treated timber piles shall conform to MS 822 and shall be approved by SIRIM.

2.6.4.3 Manufacture

The method of preservative treatment for timber piles shall be full-cell process as described in MS 360. The preservative used shall comply with MS 733. The depth of penetration of preservative shall be a minimum of 25mm and the net dry salt retention in the treated part of the timber shall be a

minimum of 16kg/cu.m.

Piles shall be within –2mm and +6mm of their specified cross-sectional dimensions. The centroid of any cross-section of a pile shall not deviate by more than 25mm from the straight line connecting the centroids of the end faces of the pile.

Before the treated timber pile is accepted for the work, the Licensee shall obtain from the manufacturer of the treated piles approved warranty which provides, that for a ten year period, the treated piles shall be free from fungus and insect attack.

2.6.5 Bakau Piles

2.6.5.1 Materials

All bakau piles shall be free from rot, fungal or past attack and any other defects. The piles shall be reasonably straight and circular in cross-section with all branch joints trimmed off to the general outline of the piles but leaving the bark intact on the piles.

2.6.5.2 Pitching and Driving of Piles

Piles shall be pitched in the accurate positions and spacing. Bakau piles shall be driven by means of a drop hammer of at least 250kg in mass, suspended from a shear-leg or approved pile-frame.

Piles shall be driven in a uniform sequence to minimize the detrimental effects of heave and lateral displacement of the ground. The pile head shall be flat and at right angles to the axis of the pile, its edges chamfered to minimize splitting during driving. The Licensee shall take precautions to avoid damage to the pile head during hard driving by providing a suitable metal helmet.

A hardwood dolly and, if necessary, a packing piece shall be used above the helmet. If during driving the head of the pile becomes excessively broomed or otherwise damaged, the damaged part shall be cut off, the head re-trimmed and the helmet re-fitted.

2.6.5.3 Cutting and Preparing of Pile Heads

When the piles have been driven to the required depth, the top of the piles shall be cut off to a uniform level. The cut-off level shall be below the lowest dry season ground water level.

2.6.6 Pile Testing

2.6.6.1 Test Piles

In order to determine the required length of pile at each location, the Licensee shall drive test piles accordingly. Test piles shall be driven with the same hammer that is used for driving foundation piles.

2.6.6.2 Preliminary Pile Load Tests

Preliminary pile load tests shall be carried out by the Licensee appropriately. The lengths of the piles for the preliminary load tests shall be determined by the Licensee.

2.6.6.3 Production Pile Load Tests

Load tests shall also be carried out during the installation of piles for the permanent Works. Such pile load tests shall be referred to as production pile load tests.

2.6.6.4 Preparation of Test Pile

The pile head shall be cut off or built up to the necessary elevation and shall be capped appropriately to produce a bearing surface perpendicular to the axis of the pile. The arrangement shall be such that none of the test load is carried by the ground under the cap.

2.6.6.5 Method of Loading

The test load shall be applied in one of the following ways:

- by means of a jack which obtains its reaction from kentledge heavier than the required load;
- by means of a jack which obtains its reaction from tension piles or other suitable anchors.

The load shall be measured using a calibrated load gauge and also a calibrated pressure gauge in the hydraulic system. The jack and load gauge shall be carefully aligned so that the load applied is co-axial with the pile.

When the first method is used, care shall be taken to ensure that the center of gravity of the kentledge is on the axis of the pile. The nearest edge of the crib supporting the kentledge stack shall not be closer than 1.3m to the surface of the test pile. Kentledge shall not be used for testing raked piles.

When the second method is used, all anchor piles shall be at a distance of at least three (3) pile shaft diameters from the test pile, center to center, and in no case shall they be less than 2m from the test pile.

If the anchor piles are to be permanent working piles, their levels shall be observed during application of the test load to ensure no residual uplift occurs.

2.6.6.6 Measurement of Settlement

Settlements shall be measured by use of a reference beam or wire supported independently of the load test pile, reaction pile or piles supporting reaction loads. Settlements shall be measured to the nearest 0.1mm for reference beams or 0.5mm for reference wires. The reference beams support shall be located at least 3m from the load test pile, reaction pile or piles supporting reaction loads. The reference beams or wires shall be protected from the effects of temperature changes.

2.6.6.7 Method of Testing

Maintained Load Test shall be conducted on test piles as selected by the Licensee.

2.6.6.8 Constant Rate of Penetration

For each pile load test, three cycles of pile loading test at a constant rate of penetration shall be carried out to a full test load equal to twice the design load.

2.6.6.9 Test Results

Full test date and results shall be signed and kept by the Licensee. The result shall consist of the following:

- for the Maintained Load Test, for each stage of loading, the period for which the load was held, the load and the maximum settlement. These are to be plotted as time-settlement graphs;
- for the CRP test, the maximum load reached and a graph of load against penetration.

2.6.6.10 Interpretation of Test Results

The Licensee's interpretation and conclusions on the test results shall be final. Unless otherwise specified, the pile so tested shall be deemed to have failed if:

- the residual settlement after removal of the test load exceed 6.50mm; or
- the total settlement under the Working Load exceeds 12.50mm; or
- the total under twice the Working Load exceeds 38.0mm, or 10% of pile diameter/width whichever is the lower value.

2.6.6.11 Load Testing of Bakau Piles

In general, all preceding requirements shall equally apply to the load testing of bakau piles, except that what is understood as single test piles shall mean a group of test piles for bakau piles.

2.7 Brickwork and Blockwork

2.7.1 Brick/Block Walling

All block work shall be set out and built to the respective dimensions, thickness and heights shown on the Drawings. All concrete blocks shall be cured before building into the wall. All block work shall be carried up in a uniform manner. No one portion being raised more than 0.90m above another at one time.

Blocks shall be properly bedded and jointed and all joints filled with mortar (10mm thick).
Concrete blocks shall be made of Ordinary Portland Cement or unless otherwise specified. Blocks shall be obtained from an approved manufacturer shall have a minimum compression strength test of 5N/mm2 after 28 days and shall comply with British Standard Codes of Practice. All blocks shall be properly cured and dry when delivered to the Sites.

Cement for mortar shall be ordinary Portland cement and shall comply with British Standard Codes of Practice.

Sand shall be clean, sharp sand, free from salt and shall comply with British Standard Codes of Practice. Water shall be clean and free from harmful matter and shall be tested in accordance with British Standard Codes of Practice.

2.8 Access Road

The access road shall be 4.4m wide for the first 6m outward from the site fencing gate, then tapered at 1:2 slope to narrow down to at least 3 meters wide beyond, and be able to carry the load of a light truck vehicle without damages at all times. 30m concrete/premix access road, measuring from the fencing gate outward, is standard with all sites.
A parking area measuring 6m x 6m concrete / premix beside the entrance gate is standard for all sites.
The variable is a crushed gravel road, which shall depend on individual site location, measured from the end of concrete / premix road section stated herein to the point of existing public access road.
The compaction and drainage requirement for access road shall be at least as described in section on earthwork stated herein.
An entrance culvert may be necessary, depending on natural site levels and drainage as well as the final platform level adopted.

2.9 Land Drainage

Drain construction consist of precast block drain embedded in 1:3:6 concrete mix including all bends, junctions, cascading step, etc, to match and brickwall sides, complete with all necessary weep holes, filter media, etc., including all necessary excavation formwork and part return, fill in and ram and remainder load and cart away from site to the Licensee's own dump.

2.9.1 Natural Drainage

The Licensee shall ensure that the natural water course is not obstructed during the various stages of contract works, and he shall when instructed provide silt traps at approved locations to prevent the loss of earth from exposed cuts or fills.

2.9.2 Precast or Cast In-Situ Block Drain Sections

All concrete block drains shall be the correct sizes and shapes in accordance with the general requirements as shown in the Drawings. The product shall be sound and have smooth inside surfaces for the flow of water.

2.9.3 Setting Out

The Interested Licensee shall set out clearly the lines and levels of cut, sight rails and boning rods for drain laying.

2.9.4 Laying Of Block Drains

Precast block drains shall be laid in trenches dug to the correct levels and alignment and jointed to produce a neat even alignment and gradient. Over-digging shall be made good by selected fill and well compacted.

2.9.5 Backfilling

Backfilling shall be carried out in layers of 150mm both sides and well compacted. Excess spoil after backfilling shall be removed and deposited in approved fill areas.

2.10 Anti Climb Fencing

Security fencing shall be Hot Dipped Galvanized High Tensile Wire Anti Climb Fence with specifications as below:

2.10.1 Mesh

Mesh netting shall be hot dipped galvanized high tensile wire with wire diameter 4mm.
Mesh spacing shall be 75mm Horizontal and 12.5mm Vertical
Panel Size shall be 2.4m high with approximately 2.4m width.
Bottom end of mesh to be embedded in 100mm x 150mm high concrete kerb above platform level.

2.10.2 Fence posts

Post specification shall be hot dipped galvanized Square Hollow Section 63.5mm x 63.5mm x 2.5mm thick complete with Flat bar 38 and M8 Carriage Bolt and Nut.
Bottom end of posts shall be embedded in 450mm x 450mm x 450mm mass concrete footing.

2.10.3 Gates

Gates shall be double-leaf gates 4m wide with the same height and specification as the adjoining fencing. The gates shall be fitted with adjustable hinges with anti- lifting devices complete with 1 No heavy duty padlock.

2.11 External Works

2.11.1 Grading

On completion of the works the ground surface within all sites and access roads shall be properly graded and planned.
Special care shall be given to preventing surface water from penetrating into the backfilling.

2.11.2 Earth Inspection Pits

When required earth pits will be concrete set into slab or in soil at ground level, they will have a secure cover and will allow access for the testing and inspection of the lightning protection / earthing network. They are to be free draining. Refer to drawing for further details.

3 TOWER ANALYSIS AND DESIGN

3.1 Scope

This section describes on the analysis and design requirements for the tower that shall be used for the project. It includes among others the fabrication of the tower, corrosion protection and the rotation and deflection limits of the tower. Where relevant, endorsement from a professional engineer registered with BEM shall be obtained by the Licensee prior to the engagement of the design.

3.2 Dead Weight

Total Dead Weight should be broken down to:

- Tower Self Weight

- Antenna / Equipment Weight
- Ancillaries Weight

3.3 Design and Analysis Assumptions

Member end conditions, its reference axis and any conditions that will affect the analysis due to the computer program in-built assumptions such as connected leg, allowance for loss in metal due to connection/splicing, orientation of principal axes etc must be clearly defined. Assumption to the conditions of support must be appropriate and also clearly be stated. Whether static or dynamic analysis / spectral analysis is to be used must be clearly defined and reference to the appropriate Code clauses. Second order effects may be required to be checked.

3.4 Analysis and Design Standards

All Standards and Codes of Practice shall be defined correctly and applied consistently between analysis and design. If Code of Practice for design of building is used for the detailed member design and stresses check, it must be shown clearly and explicitly that it is appropriate for such design. ALL load factors and material factors, its derivation and appropriateness in use must be clearly stated.

3.5 Grade of Steel

All grade of steel used shall be clearly specified. Steel grade, its relevant strength and the relevant BS and/or MS that is being used must be clearly specified. If different grade of steel is to be used in the same structure, method of identification of members after galvanizing and control at site must be clearly specified.

Tensile test shall be carried out to determine the actual strength of steel supplied. Mill certificate for the batch of members used must also be provided.

3.6 Loading and Load Cases

Load cases to be clearly shown whether primary loading cases or combinations of load cases. Loading derivation must be clearly defined for each ancillary item. The appropriate clauses of the adopted Loading Code must be clearly stated for each load derivation.

Load factor as required by the chosen Code of Practice must be clearly defined and shown explicitly in the various load combinations generated.

The position and direction of each antenna shall be put in such a manner that when combined with others produce the maximum forces in the structure. It must be noted that the disposition of each antenna shall not be limited to one on each face but in any manner possible and practical that will results in maximum stresses being generated in the tower and mast structure.

3.7 Overall Stability of Structure

The overall stability of the structure against overturning and sliding needs to be checked. The appropriate factor of safety adopted, the relevant forces (due to different loading combinations) must be clearly shown.

3.8 Foundation Design

The design of foundations shall be in accordance with BS 8004 and should accommodate all the forces (from different load combinations) imposed on them. The forces used for the foundation design shall be strictly in accordance with the recommendations of BS8100. No reduction in loading due to gustiness is allowed. When tensile force is present in the foundation, design must be shown to be appropriate to the response of soil in resisting gusty uplift forces. No dispersion of tensile stresses in soil is allowed for footing foundation.

3.9 Design of Members

Detailed Design Calculations of all members (primary, secondary and all other related members) shall be shown. Allowance for loss in cross-sectional area of member due to its end/intermediate

connection needs to be clearly shown.

3.10 Design of Joints

Detailed Design Calculations of all joints (welds, bolts, plates, stiffeners, etc) shall be shown. Derivation of the appropriate design strength of connecting elements shall be clearly stated. Prying force in tension connection using bolts shall be accounted for.

3.11 Vertical Cable Ladders

Design Calculations of vertical ladder shall be shown in detail including joints to the main structure.

3.12 Design and Analysis Method

The tower design shall be prepared using MS Tower Version 5. MS Tower must be verified, commercially available, comprehensive 3D structural engineering software with a direct emphasis on telecommunication tower design and analysis. Detailed printouts shall be attached to the report inclusive of input and output files. The wind load is applied to the tower in a full 360 degrees.

3.13 Report and Calculation Layout

All calculations must be compiled in the following order and must be endorsed by a professional engineer registered with the BEM.

Calculations submitted shall be sufficiently detailed for an independent appraisal to be carried out when required.

All calculations shall be submitted in hard and soft copy, in the original format. All relevant input and output MS Tower files shall be provided in soft copy.

3.14 Design

British Standard shall be used for the general design of the tower. All drawings produced shall be to a recognized scale in A3 landscape format. All dimensions shall be in millimeters and levels in meters unless noted otherwise on the drawing.

3.15 Aircraft Warning Lighting

Aircraft Warning lights shall comply with the requirements of DCA and the recommendations of ICAO. Licensee shall obtain approval for the installation from DCA.

The Aircraft Warning Lights shall be Solar LED type. The LED intensity shall be in compliance with DCA guidelines with 100,000 hours life expectancy. It shall be equipped with built-in back battery. Ingress Protection of the unit shall be IP68.

3.16 Day Warning Paint

Generally day warning paint is required and the rower shall be painted in white and orange in 7 equal bands in compliance with ICAO and DCA regulations.

3.17 Fabrication

The fabrication of the towers includes fabrication of all tower elements including all associated secondary steelworks, foundation bolts and templates.

The towers shall be self-supporting angle section lattice type. All other tower types are not permitted under this specification.

Only triangular section towers are permitted. The structural use of aluminium is not permitted. Site welding, cutting or drilling is also not permitted.

3.18 Safety

A general method statement will be required for all activities relating to the fabrication of the tower steelworks and ancillary items.

3.19 Corrosion Protection

Corrosion protection shall fulfil the requirements of British Standard. All steelworks except stainless steel and concrete reinforcement shall be hot dip galvanized after fabrication, but zinc layer shall be at least 100mm thick. Bolts, nuts and washers shall be hot dip spun galvanized.
Sherardized components are not permitted. Tubular members are to be galvanized internally.
Water shall drain freely from all parts of the structure. Adverse effects of electrolytic corrosion between dissimilar metals shall be prevented.

3.20 Design Life

The design life shall be 25 years.

3.21 Rotation and Deflection Limits

The tower shall be designed to limit the overall rotation of the antennas to the following limits at the 3-sec wind gust (measured at 10m high) operational wind speed of 33.33m/s:
Rotation limit: < 0.5°
Combined rotation and deflection limit: < 0.5°
Notes:

- Rotation limits quoted are the maximum allowable in any direction at the position of the antenna.
- These limits are governed by the requirement to maintain the antenna performance.
- Depending on the (layered) foundation soil conditions, additional rotation/tilt of the tower due to soil-structural interaction may be required to be assessed. Suitable method of analysis may be a finite element method employing plate elements for the tower foundation raft slab and an eight nodal solid element to simulate layers of soil with different elastic modulus characteristics.

3.22 Durability

For durability, designs using back to back members are not acceptable. Similarly, all hollow section members are to be free draining.

3.23 Robustness

The tower is to be generally of robust construction allowing free climbing access for riggers. In particular any members inclined at less than 300 to the horizontal shall be capable of carrying a vertical 100kg point load without permanent deflection. The climbing requirements of the latest British standard Codes of Practice shall be fulfilled.

3.24 Wind Loads

The wind load applied on tower structure and antennas shall be calculated separately for different wind zones according to British standard.
The applicable wind zones and the microwave/millimetric antennas and sector antennas as prescribed in the British Standard.
In addition, full account is to be taken of the wind loads associated with the waveguide/feeder cable.

3.25 Erection

Erection of structures shall comply with British standard Codes of Practice and other requirements by relevant authorities.
Bolts thread shall project at least 5 mm from the tightened nut. The maximum deviation of the vertical alignment shall be 1:500.

3.26 Earthing & Lightning Protection

Lightning protection and earthing shall comply with the relevant national standard.

3.27 Ladders and Platforms

All towers shall be provided with a single access ladder. The ladder provided shall comply with British standard.

Resting and working platforms shall be provided according to the following:

- The platforms shall be capable of supporting an imposed, uniformly distributed live load of 1.5 kN/m2;
- The balustrade to the platform shall be of steel, comply with latest British standard and capable of supporting the antenna loads and other loads according to Licensee's requirements;
- The rest platforms shall be located within the tower structure itself. Rest platforms shall be located with vertical c/c distance according to British standard;
- A working platform shall be located on the tower top. The floor of the platform shall be on the same level as the top of the tower structure or somewhat below;
- The tower shall be designed and prepared for installation of an additional working platform 3 m below the top working platform;
- All platforms shall be accessible from the ladder; and
- An access hatch shall be provided in the platform floor immediately above the access ladder.

3.28 Anti-Climb System

All towers are to be provided with an anti-climb system. The anti-climb system is provided for the climbing ladder and the tower legs.

3.29 Waveguide/Feeder Cable Support

Waveguide/Feeder cable supports shall be provided at a maximum spacing of 0.5m vertically. These support points are to be located adjacent to the access ladder for ease of installation and maintenance. If the support points are located directly behind the access ladder, a minimum 200mm space clearance between the ladder and feeder cables shall be maintained.

3.30 Fall Arrest System

A fall arrest system shall be installed and tested on all antenna support structures higher than 1.8m. This measure shall be taken from the working platform or area that the Licensee's maintenance personnel are expected to stand while accessing the antenna or other pole mounted equipment.

The system shall be designed to ensure that all equipment can be accessed easily and safely.

An 8mm stainless steel fall arrest system, including the Personal Protection Equipment (PPE) system shall comply with EN 361, EN 353-1/2, EN795, EN 354 and other relevant EN standards. This fall arrest system shall be on all Greenfield sites. The PPE system shall be universal to all 8mm fall arrest systems.

3.31 Tower Report

The report shall contain but not limited to, information in the following format:

- Introduction
- Assumptions
- Design Parameters
- The design standards and codes of practice as listed below
- Derivation of wind resistance and drag coefficient shall be clearly stated
- Loading (Dead Load, Antenna Load, Imposed Load and Wind Load)
- Summary of Tower Analysis
- Summary on Tower Stability
- Summary on Tower Design
- Summary on Tower Deflection

The above report shall also include an appendices section which shall contain an appropriate method of analysis, depending upon the structure type, which shall be explicitly stated for compliance of:

- Equivalent static method
- Non-linear analysis

The appendices deliverables shall contain the following items:

- Detailed Structural Analysis Calculations
- Detailed Wind Load Calculations
- Detailed Member Capacity Calculation
- Detailed Design of Joints
- Detailed Design of Base Plate and Holding Down Bolts For Towers

3.32 Foundations and Support Structures

For masts, foundation stiffness, such as beam support to mast, shall be included in the same analysis of the superstructure. Stress concentration and contact pressures from the superstructure onto the supporting structure, where applicable, shall be taken into account.

For towers, the following deliverable shall be provided for the different foundation designs:
For Piled Foundation:

- Determine the Geotechnical Capacity of Pile
- Depth of Pile (to be estimated from the Soil Investigation Reports)
- Design the Pile Cap

For Pad Foundation:

- Design the Pad Footing

3.33 Drawings

All Drawings must be in AutoCAD format. All drawings must be prepared and endorsed by a professional engineer registered with BEM.
Drawings must be submitted at various stages as follow:

- Stage 1 Design Drawings (Detailed Construction Drawings)
- Stage 2 Erection Drawings (Detailed Erection Drawings)
- Stage 3 As Built Drawings (Detailed As-Built Drawings)

4 TOWER STANDARDS

4.1 Scope

This section outlines the standards that shall be adopted by the Licensee for the design and erection of the tower.

4.2 Wind Loading Derivation

The following standards shall be used:

- BS8100: 1986 - Lattice towers and masts (Part 1 - Code of practice for loadings)
- BS8100: 1995 - Lattice towers and masts (Part 4 - Code of practice for loadings of guyed masts)

Specified design wind speed

- 3 sec gust wind speed 33.33m/s (120km/hr)
- Hourly mean wind speed 22m/s

Partial safety factors shall be determined in accordance with:

- BS8100: Part 1 for mast and towers
- BS8100: Part 4 for guyed masts

Classification of structure: Class A shall be adopted
The Licensee shall ensure that the design, fabrication, construction and material used for the tower and mast structures can meet the requirements of class A structure as defined in BS8100.

Terrain classification for tower and mast structure design shall follow the recommendations in BS8100 and appropriate to the site of application.
The design drawings and details of tower and mast as shown in other parts of this document are strictly for reference and guidance only, with the structure classified as A. Licensee is required to submit design of the tower and/or mast to Class A standard and in no way that the Licensee and their PE can relieve their responsibility in their own design submission.

4.3 Concrete Design

The following standard shall be used for concrete design:
BS8110: 1997 Part 1 - Code of practice for design and construction.
Gamma factor for steel stress shall be 1.15 for ultimate load design and 1.60 for service stress design.

4.4 Steel Design

The following standard shall be used for steel design:

- BS5950: 2000 Part 1 - Code of practice for design of rolled and welded sections. Gamma factor for material shall be 1.15.
- BS8100: Part 3 - (DD133: 1986) - Code of practice for strength assessment of members of lattice towers and masts.
- BS5950 cannot be used as a direct design reference without giving due considerations as outlined in BS8100: Part 3 - (DD133: 1986).

4.5 Materials - Tower Structure Design

The materials for the structure design of the tower shall be of the following:

Angles:

- Grade S275 or S355 to BS EN 10025: 1993
- Hot rolled products of non-alloy structural steel.
- Yield Stress fy = 275 or 355 MPa

Circular Hollow Sections:

- Grade S275 or S355 to BS EN 10210: 1994-1
- Hot finished structural hollow sections of non-alloy structural steel.
- Yield stress fy = 275 or 355 MPa

Bars:

- Steel bar to BS4449:1978
- Yield stress fy = 250 MPa (mild steel) or 460 MPa (hot rolled high yield)

Welding

- Class 35 as per BS5950-2
- Yield stress fy = 355 MPa other grades may be use where appropriate

Bolts:

- Grade 8.8 to BS3692
- Bolt shank shall be sufficient long to accommodate nut and washer, such that no connecting part shall bear on the bolt thread.

5 TOWER PARAMETER AND LOADING

5.1 Scope

This section outlines the parameters and loadings of the towers that shall be adopted by the Licensee under the Invitation.

5.2 Tower Design Parameter

The following design parameters are the minimum standard that shall be utilised for the tower design:

- Tower Classification A
- Partial Safety Factor for Wind (v) 1.20
- Partial Safety Factor for Material (m) 1.10
- Partial Safety Factor for Dead Load (DL) 1.05/0.90 (Comp/Tens)
- Terrain Category 3
- Wind Direction Factor (K_d) 1.0
- Terrain Roughness Factor (K_R) 1.0 (from Table 3.1 – BS 8100)

The following bolts parameters are the minimum standard required for the tower design:

- Standard DIN Grade 8.8
- Tensile Strength Fu = 830 MPa
- Yield Strength Fy = 640 MPa

The above information is used for direct tower comparison. However, site specific conditions may require more stringent design parameters.

5.3 Tower Physical Parameter & Loading

The following dimensions and load data shall be used for the design layout of the tower:

Element	3L-76m	3L-60m	3L-45m
Top Dimension	2m	2m	2m
Base Dimension	10m	8m	6.125m
Straight Section at Top	12m	12m	12m
Working Platform	5	5	4
Rest Platform	1	-	-
MW Antenna	2 x 2.4mØ - 72m [203kg/unit] 2 x 1.8mØ - 68m [125kg/unit] 2 x 1.2mØ - 64m [77kg/unit]	2 x 2.4mØ - 56m [203kg/unit] 2 x 1.8mØ - 52m [125kg/unit] 2 x 1.2mØ - 48m [77kg/unit]	2 x 2.4mØ - 41m [203kg/unit] 2 x 1.8mØ - 37m [125kg/unit] 2 x 1.2mØ - 33m [77kg/unit]
RF Antenna	3 Nos 2.6H x 0.26Wx 0.16D [28kg/unit]	3 Nos 2.6H x 0.26Wx 0.16D [28kg/unit]	3 Nos 2.6H x 0.26Wx 0.16D [28kg/unit]

6 Earthing and Lightning Protection

6.1 Electrical Earthing Installation

Earth continuity conductors and earth leads shall be of high-conductivity copper (aluminium earth conductors shall not be permitted for use on the Contract Works), continuous throughout their whole lengths and without joints, except by means of approved mechanical clamps.

In hazardous locations, additional earth continuity conductor networks with their own earth electrode systems shall be provided for bonding metalwork to earth. Such networks, when required, shall be indicated on relevant layout drawings.
The electrical earth resistance of any earth-continuity conductor or earthing lead measured from its connection with the main earth electrode system shall not exceed **five (5) Ohms.**

For earth electrode system, electrodes shall comprise 16 mm diameter, 1.6 m long, extensible-type, copper-steel-cored rods ("Copper weld" or approved equivalent make), driven into the ground at interval of at least twice the driven length of any two electrodes. Electrodes shall be driven into ground by means of a "KANGO" or similar type electric or pneumatic hammer.

The total earth resistance measured at the main earthing bar for electrical installation with the equipment and cable armoring earth connections disconnected shall not exceed 5 ohm. The minimum number of electrodes installed for each earthing point shall be two (2) and the minimum length of each electrode shall be 1.6m. The number of earthing points indicated in the drawings is indicative only and shall in no way imply that the earthing points are sufficient to obtain the value of 5 ohm.
The Licensee shall increase the driven length or number of earth electrodes and if necessary, non-soluble earth enhancing compound be considered to obtain the required earth resistance. In exceptionally bad areas, the Licensee shall propose the use of copper earth grids or earth plates to achieve the desired earth resistance value.
Interconnecting earth-continuity conductors between electrodes shall comprise Copper tape directly buried in the ground to a depth of not less than 300mm below finished ground level.

All materials shall be Cu in accordance with the British standard.

6.2 Lightning Protection of Greenfield Sites

6.2.1 Bonding to Towers

A lightning protection air termination finial or lightning rod shall be fitted to the top of each tower.
A copper earth bar shall be fitted to the tower as indicated in the drawing. The bar shall be fitted such that there is sufficient space between the bar and tower to allow bolts to be fitted from behind.

6.2.2 Ground Tape

A protection ring tape shall be installed around the base of the tower at a preferred depth of at least 300mm below ground level, unless other considerations, such as the need for bonding other objects to it or testing, make it desirable to leave it exposed, in these locations.

6.2.3 Bonding to Lightning Protection Ring

Connections to the ring shall be from the following items:

- Towers - each leg
- Lightning protection earth bars before entering BTS equipment
- Equipotential Bonding Conductor

All bonds are to be made using Cadweld. Bonds of different materials shall be designed to prevent electro-chemical corrosion.

6.2.4 Testing and Remedial Work

The complete system will be tested in accordance with the requirements of all the relevant specifications and regulations and should achieve a maximum value in accordance with British standard.
Where this value cannot be achieved, additional rod(s) shall be installed and connected to the ring tape.
Test certificates and drawings for the new installation, will be submitted on completion as part of the site document package.

7 AC Power Supply

7.1 Source of Supply

As specified in the Invitation, the provision of power supply at site shall be under the scope of work of Part 2 Licensee. The electrical supply shall be from the following:

- A dedicated supply from TNB, SESCO or SESB; or
- Any reliable standalone power system (i.e. Hybrid Power System, Permanent Genset etc).

Where possible, Licensees are required to obtain the electrical supply from TNB, SESCO or SESB.

7.2 Supply Requirement

For site with dedicated power supply from TNB, SESCO or SESB, the requirement shall be as follow:

- Supply Requirements: **60 Ampere**
- Voltage Required: **3 phase 415 V + N, 50Hz**

7.3 Power Distribution Unit

All distribution boards shall conform to Malaysian standards. Distribution boards supplied shall be metalclad, cubicle construction and suitable for outdoor usage. They shall be manufactured in accordance with BS 214: 1973, wherever applicable.

The AC Power Distribution Board (ACPDB) shall provide reliable power supply to the telecommunication equipment in accordance to the specification drawings, requirements of relevant authorities and standards. Only reliable and proven components shall be used to ensure maximum availability of power to the telecommunication equipment and to prevent system downtime due to nuisance tripping or damages caused by lightning surges. All the components shall be fully tropicalised and suitable for ambient temperature of up to 50 degree C under very humid tropical conditions. Connectors shall be provided on the ACPDB, for easy connection of cables to the changeover compartment, for sites with genset. The connectors used shall be of the highest quality pressure clamp type to ensure that strands of cable are securely contained. A removable, solid copper terminal jumper shall be installed on the connectors at the time of delivery.

Outdoor distribution board such as the Power Distribution Unit (PDU) shall be weatherproof (IP 54) and manufactured from 12 SWG gauge, electro-galvanised steel sheets, polyester powder coated, mounted on plinth and the door panel shall be lockable.

PDU shall be equipped with heavy-duty and reliable type lightning and surge protection system for essential and critical equipment.

7.4 Compound Lighting

250W high pressure sodium vapour floodlights shall be mounted on 6m high tapered octagonal lighting column as indicated in the drawings. The columns shall be manufactured from steel conforming to BS 7668, 1994 - Grade 43C or Grade 50C and fitted with climbing rungs for maintenance use.

8 As Built Documentation

8.1 As-Built Drawing

The contractor shall allow for the preparation of any as-built drawings required by the Contract Document (Civil & Structural works, Mechanical & Electrical Works). During the course of the

contract, prepare and keep up to date the as-built drawing to show each change from the contract drawing. The drawing shall be kept on site and used only for record purposes. The contractor shall provide four (4) sets of quality as-built binded drawing and two (2) softcopies burned in compact disc.

8.2 Progress Photograph of Before, During and After

The contractor shall take progress photographs (in digital format) of the works from time to time or upon request by MCMC. The average number of different photographs to be taken shall be sufficient enough to show the progress of the works but in any case the average number per month shall not be less than five set. The digital quality photographs in 4R size shall be all titled and dated and keep in album for safe keeping.