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AS

UNIVERSAL SERVICE PROVIDER

Appendix 9

Tower and Site Technical Specifications

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Table of Contents

1 INTRODUCTION 7

1.1 SCOPE 7
1.2 REFERENCES 7
1.3 GLOSSARY OF TERMS 7

2 GENERAL SITE WORK 8

2.1 SCOPE 8
2.2 COMPOUND LAYOUT 8
2.3 EXCAVATING AND EARTHWORK 8
2.3.1 Preliminary Site Works 8
2.3.2 Setting Out 8
2.3.3 Excavation 8
2.3.4 Rock Excavation 9
2.3.5 Other Hard Materials 9
2.3.6 Water Problem 9
2.4 FILLING 9
2.4.1 Back filling 10
2.4.2 Turfing 10
2.4.3 Retaining Wall 11
2.5 CONCRETE WORK 11
2.5.1 In Situ Concrete Mixes, Casting and Curing 11
2.5.2 Formwork for In Situ Concrete 12
2.5.3 Reinforcement for In Situ Concrete 13
2.6 PILING WORKS 13
2.6.1 Codes of Practice 13
2.6.2 General Requirements for Tolerances 14
2.6.3 Precast Reinforced Concrete Piles 14
2.6.4 Micropiles 15
2.6.5 Pressure-Treated Timber Piles 16
2.6.6 Bakau Piles 16
2.6.7 Pile Testing 17
2.7 BRICKWORK AND BLOCKWORK 18
2.7.1 Brick/Block Walling 18
2.8 ACCESS ROAD 19
2.9 LAND DRAINAGE 19
2.9.1 Natural Drainage 19
2.9.2 Precast Or Cast In-Situ Block Drain Sections 19
2.9.3 Setting Out 19
2.9.4 Laying Of Block Drains 20
2.9.5 Backfilling 20
2.10 FENCING 20
2.10.1 Netting 20
2.10.2 Fence posts 20
2.10.3 Wiring 20
2.10.4 Erection 21
2.10.5 Gates 21
2.11 EXTERNAL WORKS 21
2.11.1 Grading 21
2.11.2 Earth Inspection Pits 21

3 TOWER ANALYSIS AND DESIGN 22

3.1 SCOPE 22
3.2 DEAD WEIGHT 22
3.3 DESIGN AND ANALYSIS ASSUMPTIONS 22
3.4 ANALYSIS AND DESIGN STANDARDS 22

3.5 GRADE OF STEEL 22
3.6 LOADING AND LOAD CASES 22
3.7 OVERALL STABILITY OF STRUCTURE 23
3.8 FOUNDATION DESIGN 23
3.9 DESIGN OF MEMBERS 23
3.10 DESIGN OF JOINTS 23
3.11 VERTICAL CABLE LADDERS 23
3.12 DESIGN AND ANALYSIS METHOD 23
3.13 REPORT AND CALCULATION LAYOUT 24
3.14 DESIGN 24
3.15 AIRCRAFT WARNING LIGHTING 24
3.16 DAY WARNING PAINT 24
3.17 FABRICATION 24
3.18 SAFETY 24
3.19 CORROSION PROTECTION 24
3.20 DESIGN LIFE 25
3.21 ROTATION AND DEFLECTION LIMITS 25
3.22 DURABILITY 25
3.23 ROBUSTNESS 25
3.24 WIND LOADS 25
3.25 ERECTION 26
3.25.1 Earthing & Lightning Protection 26
3.25.2 Ladders and Platforms 26
3.25.3 Anti- Climb System 26
3.25.4 Waveguide/Feeder Cable Support 26
3.25.5 Warning Signs 26
3.25.6 Fall Arrest System 27
3.25.7 Tower Report 27
3.25.8 Foundations and Support Structures 28
3.26 DRAWINGS 28

4 TOWER STANDARDS 29

4.1 SCOPE 29
4.2 WIND LOADING DERIVATION 29
4.3 CONCRETE DESIGN 29
4.4 STEEL DESIGN 30
4.5 MATERIALS - TOWER STRUCTURE DESIGN 30

5 TOWER PARAMETER AND LOADING 31

5.1 SCOPE 31
5.2 TOWER DESIGN PARAMETER 31
5.3 TOWER PHYSICAL PARAMETER 31
5.4 TOWER LOADING 32
5.4.1 Weight and Dimension of Antenna 32
5.4.2 Equipment Orientation 32
5.4.3 Tower Load Chart 33

6 ANTENNA SUPPORT STRUCTURE 33

6.1 SCOPE 33
6.2 REQUIREMENT 33
6.3 ANTENNA MOUNTING STEELWORK 33
6.3.1 Microwave Transmission Dish 33
6.3.2 Sector Antenna 34

7 CABIN 35

7.1 SCOPE 35
7.2 CABIN SIZE 35
7.3 SERVICE CONDITION 35
7.3.1 Loading 35
7.3.2 Wind Speed 35

7.3.3 Thermal Insulation 35
7.3.4 Design Life 36
7.4 DESIGN 36
7.5 MATERIAL 36
7.5.1 Floor Frame Construction 36
7.5.2 Floor 36
7.5.3 Wall 36
7.5.4 Roof 37
7.5.5 Door and Door Frame 37
7.6 FABRICATION 37
7.6.1 Steelwork to Floor Frame 37
7.6.2 Steelwork to Cabin Wall 37
7.6.3 Other Materials 37
7.7 CORROSION PROTECTION 37
7.7.1 General Requirement 37
7.7.2 External Finish 37
7.8 WEATHER PROOFING 38
7.9 SECURITY 38
7.9.1 General 38
7.9.2 Conventional Locking System 38
7.10 SAFETY 38
7.10.1 General 38
7.11 FIRE ENGINEERING 38
7.11.1 Flame Spread 38
7.11.2 Fire Resistance 38
7.12 CABLE MANAGEMENT AND CABLE ENTRIES 39
7.12.1 Ladder Racking 39
7.12.2 Cable Entries 39
7.13 MECHANICAL SERVICES 39
7.13.1 Air Conditioning System 39
7.13.2 High Temperature Sensor 39
7.14 ELECTRICAL SERVICES 39
7.14.1 Mains Power Distribution System 39
7.14.2 System of Wiring 39
7.14.3 Lighting 40
7.14.4 Small Power Installation 40
7.14.5 Earthing Facility and Cross Bonding 40
7.14.6 Total Flooding Fire Suppression System 40
7.14.7 Security Facility 40
7.14.8 Alarm 40
7.14.9 M & E Control Signal Cabling 41

8 ELECTRICAL INSTALLATION, EARTHING AND LIGHTNING PROTECTION 41

8.1 SCOPE 41
8.2 AC POWER SUPPLY 41
8.2.1 Source of Supply 41
8.2.2 Supply Requirement 41
8.2.3 Genset 41
8.2.4 Hybrid Power System 42
8.2.5 Emergency Power Socket 42
8.2.6 Arrangement with Electrical Authorities 42
8.2.7 Take-Over Test 43
8.2.8 Supply Fusing 43
8.2.9 Metering Arrangement 43
8.2.10 Isolation of Supply 43
8.3 ELECTRICAL INSTALLATION 43
8.3.1 Cables 43
8.3.2 Conduit 43
8.3.3 Steel Trunking 44
8.3.4 Cable Tray 44

8.3.5 Distribution Board 44
8.3.6 Transfer Switch (Isolator Switch or Automatic Changeover Contactor) 44
8.3.7 Isolators 44
8.3.8 Miniature Circuit Breakers 45
8.3.9 Moulded Case Circuit Breaker 45
8.3.10 HRC Fuse-Links 45
8.3.11 Earth-Fault Relays 45
8.3.12 Current Transformers (CTs) 45
8.3.13 Voltmeters 45
8.3.14 Ammeters 46
8.3.15 Indicator Lamps 46
8.3.16 AC Contactors for LV Circuits 46
8.3.17 Time Switches 46
8.3.18 Lighting Switches 46
8.3.19 Switch-Socket Outlet 46
8.3.20 Earth Leakage Circuit Breaker (ELCB) 47
8.3.21 Terminal Blocks 47
8.3.22 Self-Contained Emergency and "KELUAR" Lighting Luminaries 47
8.3.23 Compound/Perimeter Lighting 47
8.3.24 Fluorescent Fittings 47
8.4 LIGHTNING SURGE PROTECTION SYSTEM 48
8.4.1 General 48
8.4.2 Primary Surge Voltage Arrestor (PSVA) 48
8.4.3 Secondary Surge Voltage Arrestor (SSVA) 49
8.4.4 Series Surge Suppressor – Pluggable (SSS-P) 49
8.4.5 Automatic Restoration System (ARS) 50
8.5 EARTHING AND LIGHTNING PROTECTION 51
8.5.1 Electrical Earthing Installation 51
8.5.2 Materials 52
8.5.3 Lightning Protection of Greenfield sites 52

9 MECHANICAL INSTALLATION 53

9.1 SCOPE 53
9.2 AIR CONDITIONING FOR CABIN 53
9.2.1 Environmental Conditions 53
9.2.2 Air Conditioning System 53

10 CME REQUIREMENT FOR NATURAL DISASTERS 54

10.1 CME WORKS FOR CABIN/ OUTDOOR BASE AND GENSET/ FUEL TANKS BASE 54

11 AS BUILT DOCUMENTATION 54

11.1 AS-BUILT DRAWING 54
11.2 PROGRESS PHOTOGRAPH OF BEFORE, DURING AND AFTER 54

LIST OF GENERAL TECHNICAL DRAWINGS

Drawing 1 - Compound Layout Plan for Light Duty Tower (76m)
Drawing 2 - General Earthing Layout Plan
Drawing 3 - Plan and Sections Details of Earthing System
Drawing 4 - Plan and Sections Details of Earthing System
Drawing 5 - Inspection Pit A, B and C Plan, Sections and Details
Drawing 6 - PDU Electrical Single Line Diagram (60Amps)
Drawing 7 - PDU Weather Proof (Outdoor Type) Power Distribution Unit to Manufacturer's Details
Drawing 8 - Compound Lighting
Drawing 9 - Compound Lighting Column
Drawing 10 - Cable Gantry Layout Plan
Drawing 11 - Cable Gantry Details
Drawing 12 - Genset Plinth Plan, Sections and Details
Drawing 13 - Details of BTS Plinth for Site with 76m Tower Plan, Sections and Details
Drawing 14 - Fencing Details
Drawing 15 - Greenfield Site 76m LD Tower

LIST OF TECHNICAL DRAWING FOR NATURAL DISASTERS

Drawing 1 - Compound Layout Plan for Natural Disaster Design Model
Drawing 2 - General Arrangement of Standby Genset Model
Drawing 3 - Greenfield Sites Plinth Section and Foundation Details Model
Drawing 4 - Isometric Genset Plinth Design (3m x 7m) Model
Drawing 5 - Isometric Plinth Equipment Design (5.35m x 9.15m)
Drawing 6 - Outdoor Equipment

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;
- 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; and
- 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
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.

2.3 Excavating and Earthwork

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 B.S. 6031 – "Earthworks" and B.S.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.

A soil investigation shall be carried out at each site. The report from the investigation shall cover, but not limited to, the following items:

- Soil material classification (identification of hazardous materials);
- Allowable bearing capacity, for a probable elastic settlement of 25mm under the design serviceability limit state loads, giving due considerations to the possibility of high variability of subsoil layers;
- Suitability interpreted modulus of elasticity, for soil layers up to at least 1.5 times the longest plan dimension of the tower foundation;
- Coefficient of active and passive soil pressure;
- Internal friction angle;
- Unconfirmed compression strength;
- Ground water table level;
- Soil density;
- Allowable end bearing and skin friction, suitable for the design of pile foundation;
- Recommended piling system;
- Earth Resistivity; and
- Ground water pH.

2.3.2 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.

2.3.3 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.

2.3.4 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 metre, 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.

2.3.5 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.

2.3.6 Water Problem

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 recognised 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.

2.4 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.

Suitable material shall have the following requirements:

- The plasticity index (PI) shall not exceed 30%;
- The percentage passing a 75microns sieve shall not exceed 40%;
- The C.B.R. swell shall not exceed 1% after 40 hours soaking;
- The maximum laboratory dry density shall not be less than 1800kg/m3; and
- The material shall not contain rock or stones exceeding 100 mm measured in any direction.

2.4.1 Back filling

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 300 mm;
- Each layer shall be watered and thoroughly compacted with soil compactor, for example 4 times run over with a 100 kg vibrating plate (wacker plate); and
- Layers of clay and other cohesion materials shall not be watered.

2.4.2 Turfing

In general, the entire ground surface of the site bounded by perimeter PC drains and the premix site entrance shall be covered with concrete foundations, plinths as well as surface sealant using lean concrete.

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.

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

Notwithstanding Clause 2.4.2, 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.

Overall (global) slope stability analysis may be required for case such as, though not limited to, slope more than 10m 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.

2.5 Concrete Work

All concrete works shall be executed in accordance with the requirements of B. S. 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 M. S. 522 and B.S. 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 B. S. 3148. If the water is suspected to contain any harmful matter, salt etc., it shall be analysed 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 B.S. 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 B. S. 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 B.S. 1200.

2.5.1.5 Admixtures

No admixtures are permitted except air.

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 be 50mm +/- 3mm.

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 B.S. 4449.

High yield deformed steel rod reinforcement shall be high tensile steel bars complying with the requirements of B.S. 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. If a damaged template has been delivered to the Licensee, the Licensee shall be informed immediately. The templates shall be reused and the Licensee is responsible for the cleaning and storing of the used template.

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

2.6.1 Codes of Practice

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.

2.6.2 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; and
- 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.

2.6.3 Precast Reinforced Concrete Piles

2.6.3.1 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.

2.6.3.2 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.

2.6.3.3 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.

2.6.3.4 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.

2.6.3.5 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 levelling 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.

2.6.3.6 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.

2.6.4 Micropiles

2.6.4.1 Diameter of Piles

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

2.6.4.2 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.

2.6.4.3 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.

2.6.5 Pressure-Treated Timber Piles

2.6.5.1 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.

2.6.5.2 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.

2.6.5.3 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.

2.6.6 Bakau Piles

2.6.6.1 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.

2.6.6.2 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 minimise the detrimental effects of heave and lateral displacement of the ground. The pile head shall be flat and at right angels to the axis of the pile, its edges chamfered to minimise 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.

2.6.6.3 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.

2.6.7 Pile Testing

2.6.7.1 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.

2.6.7.2 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.

2.6.7.3 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.

2.6.7.4 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.

2.6.7.5 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; and
- 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 centre 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, centre to centre, 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.

2.6.7.6 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.

2.6.7.7 Method of Testing

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

2.6.7.8 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.

2.6.7.9 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; and

- for the CRP test, the maximum load reached and a graph of load against penetration.

2.6.7.10 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.

2.6.7.11 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 4.8m wide for the first 6m outward from the site fencing gate, then tapered at 1:2 slope to narrow down to at least 3 metres 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. The variable is a crushed gravel road, which shall depend on individual site location, measured from the end of 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. Refer to drawing for the general guiding requirement of type and size.

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 wall 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 Fencing

Security fencing shall be PVC coated chain link fence complying with British standard Codes of Practice.

On sites adjacent to existing sites, security fencing shall be equivalent to the existing fencing.

2.10.1 Netting

Netting shall be PVC coated chain link. The wire diameter shall be 3.3/2.8 mm. The netting shall be 2.6 metres high with mesh size 50 x 50mm.

The netting shall be intertwined with a 3.2 mm thick hot-dipped galvanised MS Flat bolted with M10 hot-dipped galvanised to the vertical post at each position of the horizontal strand wire.

2.10.2 Fence posts

Fence posts shall be 75mm x 75mm x 5mm thick mild steel angles and spaced at a maximum of 3.0m on centres. The bracing posts shall be placed at every corner posts and at the middle of every 20m fence. All fences shall be secured to the posts with steel plates. The diagonal braces shall be 50 x 50 x 5mm thick hot-dip galvanised mild steel angles.

All posts, including corner posts shall be cranked outward 45º to receive 4 strands of barbed wire.

Posts shall be 3.6 metres high overall including the 500 mm length built or cast into the base wall or foundation and including the cranked top. Posts shall be infilled with concrete and shall be strong enough to support all fencing items as well as the force of intruders.

2.10.3 Wiring

Barbed wire shall be hot-dip galvanised steel. 4 strands of barded wire with suitable spacers shall be provided.

Three 3.3/2.8 mm diameter stay-wires shall be provided (one at top, one at fence mid-height and one at bottom) secured to the post at each intersection, for the purpose of tying on the netting to the stay-wires.

2.10.4 Erection

Security fencing shall be erected in steps to accommodate changes in ground-level. At no point shall the total overall height of the fencing be less than 3.1 metres.

2.10.5 Gates

Gates shall be double-leaf gates 4 metres wide with the same height as the adjoining fencing. The gates shall be fitted with adjustable hinges with anti- lifting devices, 4 No strands of barbed wire 14 mm diameter hardened locking eyes, 2 No drop-bolts with PVC pocket sleeves and 1 No padlock.

Gate frames shall be in accordance with clause 2.10.2 Fence posts, gate posts shall be set firmly in concrete to a depth of 500 mm. Vertical members in gate frames shall be cranked in accordance with clause 2.10.2 Fence posts and barbed wire with clause 2.10.3 Wiring.

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;
- Equipment Weight; and
- 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 galvanising 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 recognised scale in A3 landscape format. All dimensions shall be in millimetres and levels in metres 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 LEDs shall be ultra-high intensity 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 galvanised after fabrication, but zinc layer shall be at least 100 μm thick. Bolts, nuts and washers shall be hot dip spun galvanised.

Sheradized components are not permitted. Tubular members are to be galvanised 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; and
- 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 a 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 100 kg 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.

3.25.1 Earthing & Lightning Protection

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

3.25.2 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.

3.25.3 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.

3.25.4 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.

3.25.5 Warning Signs

The warning signs shall be made from weatherproof material, be of a uniform format and in Malaysia and English languages.

The following warning signs shall be installed at all sites:

- High Voltage hazard;

- Radiation hazard; and
- No Smoking

Adhesive type shall be used for indoor installation and metal type for outdoor installation. The signs shall be installed as indicated below:

For Greenfield sites:

- Both the High Voltage and the Radiation signs shall be posted on the fence at eye level; and
- The No Smoking sign shall be posted inside the cabin at eye level.

3.25.6 Fall Arrest System

A fall arrest system shall be installed and tested on all antenna support structures higher than 1.8 metre. 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.

3.25.7 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; and
- 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; and
- 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; and
- Detailed Design of Base Plate and Holding Down Bolts For Towers.

3.25.8 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); and
- Design the Pile Cap.

For Pad Foundation
- Design the Pad Footing.

3.26 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); and
- 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 Interested 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 (γ_v) 1.20
- Partial Safety Factor for Material (γ_m) 1.10
- Partial Safety Factor for Dead Load (γ_{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

The following dimensions shall be used for the tower design layout to accommodate the requirement of collector site and infra sharing among the service providers, the type of tower that shall be used under the project is **76m.**

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

Element	76m Tower
Top Dimension	2
Base Dimension	10
Straight Section at top	12
Working Platform 1	74
Working Platform 2	68
Working Platform 3	59.5
Working Platform 4	43

Element	76m Tower
Working Platform 5	28
Rest Platform 1	12

The towers shall be self-supporting triangular section lattice type. All tower designs and drawing must be endorsed by a professional engineer registered with BEM.

5.4 Tower Loading

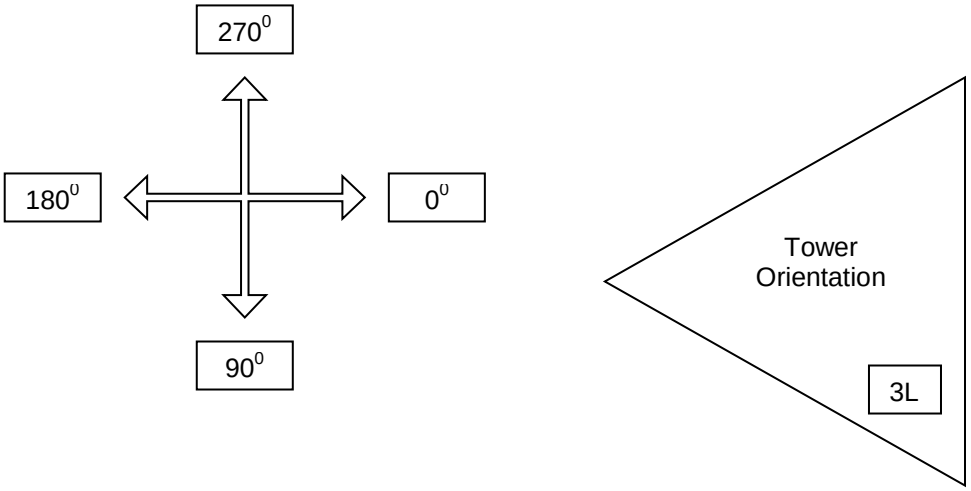
5.4.1 Weight and Dimension of Antenna

The tower shall be designed to carry antennas using the weights and dimensions outlined below:

Antenna Type	Dimension (m)	Weight (kg)	Area (m^2)
TX	3.6	386	10.18
TX	3.0	245	7.07
TX	2.4	203	4.52
TX	1.8	125	2.54
TX	1.2	77	1.13
TX	0.6	23	0.28
GSM	2.6H x 0.26W x 0.16D	28	0.68

5.4.2 Equipment Orientation

The equipment azimuth is outlined in the tower load charts contained in the following sections. The diagram below should be used for antenna orientation for 76m tower.



5.4.3 Tower Load Chart

5.4.3.1 76*m Tower Load Chart*

For the purpose of designing 76m Light Duty tower, the following load configurations shall be used:

Mounting from Tower Base (m)	Antenna Type and Position	Azimuth in Degrees
75	3 x GSM	60, 180, 330
72	2 x 2.4m Dia	60, 330
71	3 x GSM	60, 180, 330
68	2 x 1.8m Dia	60, 330
67	3 x GSM	60, 180, 330
64	2 x 1.2m Dia	60, 330

Loading Configuration Summary

- 9 units of GSM Antenna
- 2 nos of 2.4m diameter MW
- 2 nos of 1.8m diameter MW
- 2 nos of 1.2m diameter MW

6 ANTENNA SUPPORT STRUCTURE

(Applicable Only to Part 2)

6.1 Scope

This section will explain on the requirement of the antenna support structures that shall be installed on the tower by Part 2 Interested Licensee.

6.2 Requirement

Offset brackets on towers (Headframes) shall be design to facilitate the mounting of antennas. Such frames shall allow easy retracting of antenna for servicing and adjustment. The details shown in the drawing shall serve as a general guide for further development.

6.3 Antenna Mounting Steelwork

If antenna space diversity is prescribed all necessary steelworks for the arrangement of antenna shall be included.

6.3.1 Microwave Transmission Dish

Circular hollow section steel tubes are to be provided for the mounting of these dishes including all necessary clamp fittings for fixing the antenna stay brackets to the tower members. Consideration is to be given to allowing the widest possible variation in the panning of these dishes. It is therefore recommended to have a 500mm horizontal space clearance between the tower and these dishes.

Some of the transmission dishes might have integral rear mounted Radio Frequency (RF) units. Consideration is to be given as to how these dishes are to be accessed for routine adjustments and maintenance of the RF units and wherever possible access is to be possible from the tower ladder.

6.3.2 Sector Antenna

Circular hollow section tubes are to be provided for the mounting of these antennas.

7 CABIN

(Applicable Only to Part 2 if necessary)

7.1 Scope

Outdoor cabin size **of 4.8m x 3m x 3m** shall be used in the project complete with all necessary accessories.

This section will explain on the requirement of the cabin that shall be installed at site by Part 2 Licensee.

As specified under the Invitation, the cabin shall only be installed at collector sites and the number of collector sites for each cluster shall not exceed 20% of total number of sites in the cluster.

7.2 Cabin Size

The cabin size to be used in the project shall be at the size **of 4.8m x 3m x 3m.**

7.3 Service Condition

7.3.1 Loading

The floor shall be designed to support the loads of the cabinets and a distributed load of 2.0kN/m2 for spaces not occupied by cabinets. The roof shall be designed to support a minimum load of 1.5kN/m2 as well as a point load of 1.0kN.

The cabin shall be designed and built in such a way that, when fully equipped, no damage will be caused as a result of long transports by truck. It shall also withstand loading and unloading by forklifts, cranes and other normal handling.

Consideration shall also be given to the thermal load that may affect cabin details whenever great temperature differences exist between the inside and the outside of the cabin.

The overall strength requirements are that, on a surface subject to load forces, the deflection must not exceed 1mm per m and that permanent deformation or cracks must not occur.

The cabin and cabin mounted accessories shall be able to withstand shock-loads equivalent to 0.3 g in random directions without damage.

7.3.2 Wind Speed

The wind speed that shall be used in terms of the design of the cabin shall be 33.33 m/s.

7.3.3 Thermal Insulation

The cabin's thermal insulation shall be designed so that the total thermal coefficient (K value) shall be equal or less than 0.5 W/m2 x ^{o}C.

7.3.4 Design Life

The cabins shall be designed to have a life span of a minimum of 20 years. For the purpose of design the assumed maintenance procedure will be as follows:

First maintenance inspection:	Five years from installation
Subsequent:	Every three years

The external finish, locks, hinges, and door seals are to be inspected and any necessary maintenance works carried out.

7.4 Design

The supplier shall specify the materials to be used and the layer thickness valid for different parts of the cabin. No hazardous materials will be allowed in the construction of the cabin. Wooden material will only be allowed in the floor decking.

The design shall allow for foundation supports only in the four corners of the cabin. The fixing devices shall be designed in such a way that the risk of local damages and thermal bridges is minimised. All openings in the cabin walls shall be supplied with rain diverting devices.

The cabin shall be prepared in advance for the installation of radio and power equipment. The documentation required for the correct positioning of hole patterns, brackets etc. will be supplied by Licensee.

7.5 Material

7.5.1 Floor Frame Construction

The floor frame shall be constructed of steel to form a rigid frame for rooftop cabins only.

All Steelwork materials for the floor construction are to comply with BS 5950 (as stated in section 3 of this document) unless specified otherwise. All Steelwork shall be in grade 43A in accordance with BS 4360: 1990.

7.5.2 Floor

The floor shall consist of 3mm thick antistatic vinyl tiles, 24mm thick cemboard. In addition, for rooftop cabin with base skid, 0.5mm thick GI sheet shall be provided.

In the case of Greenfield cabin, the cemboard shall rest directly on the finished concrete surface coated with one layer of bituminous water proofing membrane. No brush on waterproofing system is allowed. General requirements for floor treatment to cabins are shown in the drawings.

7.5.3 Wall

The construction of the walls shall comprise of an external skin and an internal skin, which shall each be a minimum of 0.5mm thick steel with a 8mm thick central plywood. The space between the skin and central plywood shall be filled with PU material to a overall thickness of 75mm.

The walls must come in modular panels. The jointing system of the panels shall assure accurate alignment, air tight joints, easily dismantled and reconnected.

7.5.4 Roof

The roof shall be sloped at least 2% to prevent the ponding of rainwater on the roof. Single pitch roof is not allowed. In addition to this, the cabin shall be covered with a metal decked pitched roof as shown in the drawings.

7.5.5 Door and Door Frame

The cabin shall be equipped with a door, size 900 x 2100mm, in the middle of the gable. The door shall have a tight fit. The door shall open outwards and be right hinged.

To prevent damages, the door shall be equipped with a stop mechanism. The outside door handles shall be possible to operate with a glove-covered hand. The doors and frames are to be sufficiently robust to withstand a high degree of vandalism.

The door frames are to be integral with the structure of the cabin. The hinges shall be of steel and a minimum of 3mm thick. They shall have hinge bolts fitted or shall be constructed to prevent the hinge pins being removed. They shall be welded or screwed into position. The edge of the door and the frame shall be reinforced in such a way as to prevent the door being forced open.

7.6 Fabrication

7.6.1 Steelwork to Floor Frame

Fabrication of the steelwork shall be in compliance with the relevant British Standards and Codes of Practice.

7.6.2 Steelwork to Cabin Wall

Fabrication of the steelwork shall be in compliance with the relevant British Standards and Codes of Practice.

7.6.3 Other Materials

All other materials are to be fabricated/manufactured strictly in accordance with the manufacturers' instructions or the relevant British Standards Codes of Practice.

7.7 Corrosion Protection

7.7.1 General Requirement

The finish is to achieve a minimum of 20 year life under "Exterior exposed polluted inland" environment as specified in the relevant British Standards and Codes of Practice.

7.7.2 External Finish

The surface preparation of steelwork is to be such that the adhesion of the finish is not compromised. Preparation is to be done immediately prior to applying the first coat.

7.8 Weather Proofing

The cabin door seals shall be constructed to the rating IP 54.

7.9 Security

7.9.1 General

The cabins shall be sufficiently robust to offer a reasonable amount of protection against vandalism, criminal damage and arson.

7.9.2 Conventional Locking System

A separate mortise latch is to be fitted operated from both sides by aluminium lever furniture.

The door shall have a single point locking system. The locking system is by mortise deadlock operated by a cylinder (with internal turn knob). Lock system shall have the following hierarchy:

- Master Key – Malaysia – Not Required;
- Level 1 – State – 6 Keys per State;
- Level 2 – Area – Not Required; and
- Level 3 – Individual Site – 6 Keys per Site.

7.10 Safety

7.10.1 General

The cabins shall be designed and fabricated so that they comply with the relevant authority prescriptions. The cabins are to be manufactured such that they have no protrusions, which may catch passers-by or snag clothing.

Sharp corners or edges are to be avoided. This requirement applies to the cabin interior as well. In the event of catastrophic damage caused by vehicular impact, the cabinet shall not collapse in such a way as to cause injury to bystanders.

7.11 Fire Engineering

7.11.1 Flame Spread

Both the external and internal faces of the cabins are to have surface spread of flames as defined by the British Building Regulations.

7.11.2 Fire Resistance

The cabin is to be constructed generally from non-combustible material.

7.12 Cable Management and Cable Entries

7.12.1 Ladder Racking

A 450mm wide horizontal ladder rack is to be provided and fitted as shown on the layout drawings.

7.12.2 Cable Entries

A cable entry gland is to be provided and fitted complete with all details. The power entry is to be through the floor by means of a cable entry gland.

7.13 Mechanical Services

7.13.1 Air Conditioning System

The proposed air-conditioning system shall be able to keep the inside temperature and relative humidity as stated in section 9 of this document.

7.13.2 High Temperature Sensor

A high level thermostat shall be located 400 mm below the ceiling to register when the cabin temperature has exceeded the pre-set limit of 38 °C.

7.14 Electrical Services

7.14.1 Mains Power Distribution System

The mains power distribution system shall consist of an intake point located in the floor of the cabin and a power distribution board. The distribution board shall be a Three Phase metal clad type and shall be fitted with the necessary MCB's.

A circuit schedule shall be affixed to the inside of the front cover of the distribution board, and shall be presented in a neat and tidy manner, enclosed within a clear plastic envelope. The distribution board circuit schedule shall be provided in a neat and tidy manner to be approved. A duplicate copy of the schedule shall be provided by the Licensee.

Labelling shall be provided to comply with the relevant IEE Wiring Regulations.

7.14.2 System of Wiring

The system of wiring shall comprise of copper/PVC single insulated cables to BS 6004:1990. The cables shall generally be installed within a conduit or trunking in a neat and tidy manner. Routes of cables shall be fully co-ordinated with all the various systems within the enclosure.

The manufacturer shall size all electrical cables to take account of voltage drop, grouping, and environmental conditions all in accordance with the relevant IEE Wiring Regulations.

7.14.3 Lighting

The cabin shall be provided with ceiling mounted high efficiency fluorescent lighting giving at least 300lux at floor level. It shall also be provided with a 3 hour emergency lighting and “Keluar” sign. The emergency lighting and “Keluar” sign shall consist of solid state switching, static invertor, nickel cadmium cells and an automatic trickle charge facility. The lighting fitting shall be controlled from a switch near the entrance.

7.14.4 Small Power Installation

A surface mounted twin socket outlet shall be provided. The socket outlet shall be connected into a radial circuit using 4.0 mm2 cables and protected by a 30 A MCB, located within the distribution board. Supplies to fixed equipment shall be provided as required, fed from radial circuits protected by MCB's.

The circuits to the DC power supply unit shall be provided. The circuits shall be run directly from the MCB provided in the distribution board for that purpose. All items shall be provided with an engraved label stating its circuit reference.

7.14.5 Earthing Facility and Cross Bonding

The earthing of the installation shall in every respect comply with the requirements of IEE Wiring Regulations. An earth point shall be installed at high level adjacent to the telecom cabling entry gland. Earth connections to the telecom earth bar shall be provided in accordance with the earth bar schematic.

The cabin structure shall be connected to the lightning protection system at all corners, externally at low level. 50mm2 green/yellow earth cable shall be cad weld to the cabin corners and run to the common earth bar or common perimeter earth tape. On rooftops where the cabin is not protected by the building or antenna support lightning protection system, lighting spikes shall be installed at each end of the roof.

7.14.6 Total Flooding Fire Suppression System

To provide design, equipment, installation, testing and maintenance of fire suppression system and shall be in accordance with the following requirement:

- Aerosol Fire Extinguishing system;
- Approved by Jabatan Bomba dan Penyelamat Malaysia;
- Comply with NFPA 2010, AS/NZS 4487:1997, UL 2775, NFPA 72.

7.14.7 Security Facility

The cabin door system shall be provided with a reed switch door contactor to monitor the site access.

7.14.8 Alarm

The cabin shall be equipped with the alarm system. All alarm contacts shall be designed for -48V DC safe for low voltage. The contacts shall be normally closed and opened when an alarm occurs. The Licensee shall install the alarm cable and connect it to the distribution frame.

The Licensee shall be responsible to prove the correct operation of all the alarm connections prior to site acceptance.

7.14.9 M & E Control Signal Cabling

All wiring shall be terminated at the junction box. Wiring and termination from the junction box to the alarm termination frame shall also be provided.

8 Electrical Installation, Earthing and Lightning Protection
(Applicable to both Parts 1 & 2)

8.1 Scope

This section outlines the requirement on the electrical installations at the site. It includes among others the source of power supply, electrical distribution system, earthing and lightning protection system and lightning surge protection system. In relevant areas, consultation and endorsement from a professional engineer registered with the BEM shall be obtained prior to the commencement of the works.

8.2 AC Power Supply

8.2.1 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.

8.2.2 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**

8.2.3 Genset

In the event that the genset is to be deployed at site (for site without TNB/SESCO/SESB supply), two gensets in mutual standby configuration shall be provided. The requirement for the genset shall be as follow:

- Collector site: **20kVA diesel genset**
- Spur site: **15kVA diesel genset**

The genset shall be deployed on permanent basis and shall be of the package type mounted, sound proof complete with accessories, combined under one frame. The genset shall be of the full automatic starting “mains failure” type. The sound proof canopy shall be lesser or equal to 80dBA @ 1 meter.

A 12 Volts 120AH Lead Acid storage battery set of the heavy duty diesel starting type shall be provided. The battery set shall be of sufficient Ampere-hours rating to provide for six successive starts or attempts to start without re-charging within one and half minute total cranking time. A battery rack and necessary cables and clamps shall be provided.

The genset shall be equipped with a skid tank having a minimum capacity of 1000 litres of fuel for 15kVA genset and 2000 litres of fuel for 20kVA genset. This tank shall be complete with all necessary supporting structure and shall be fitted with filling, overflow, outlet drain and vent connections and a fuel level indicator to give actual fuel level in the tank at any given time. A low fuel sensor shall also be fitted for remote monitoring purpose. The piping scheme complete with stop cocks and check valves shall be provided to connect the service tank to inlet points. A rotary manual pump shall be provided to pump diesel fuel from barrels to the service tank. A full tank of fuel shall be supplied for testing and commissioning at site.

Standby genset for site with dedicated supply from TNB, SESCO or SESB is not permitted under this Invitation.

8.2.4 Hybrid Power System

In the event that hybrid power system is to be deployed at site (for site without TNB/SESCO/SESB supply), the useable load shall be as follow:

- Collector site: **6kW**
- Spur site: **2.5kW**

8.2.5 Emergency Power Socket

A socket for emergency power supply shall be provided at all sites. The standard type GEE 60Amp or 100Amp 5 pole with protective cover shall be used for this purpose.

8.2.6 Arrangement with Electrical Authorities

It is the responsibility of the Licensee to apply and arrange with the relevant Authorities for permission to install connection of supply and to test the installation after completion of the work.

The Licensee is responsible to engage with supplier for genset that is certified by ST and other relevant authorities for power supply.

The Licensee is responsible for the registration of the electrical installation with ST and also responsible for the certification and submission of Form G & H to the relevant Authorities.

The licensee is also encouraged to opt to the technology that preserves the environment friendly.

8.2.7 Take-Over Test

After the works have been completed and before the acceptance certificate is issued, the entire installation covered under this Invitation shall pass all tests deem necessary to ensure compliance with the requirements of the Specification. In addition, the Licensee shall furnish proof that the installation has passed the acceptance test required by the relevant Authorities, and that the supply to the installation has been turned on.

8.2.8 Supply Fusing

The electrical supply should be fused accordingly to ensure discrimination with the main switch fuse.

8.2.9 Metering Arrangement

The arrangement shall be done according to the specifications of TNB/SESCO/SESB.

8.2.10 Isolation of Supply

Isolation shall be provided at the source of the supply to enable complete disconnection of the mains power using a MCCB.

A weatherproof cabinet shall be provided for Greenfield sites to house the TNB/SESCO/SESB cut-out and metering equipment.

The meter cabinet should be located so that the meter can be read by the TNB/SESCO/SESB without them having to gain access to the compound. A locking mechanism that enables both the operator and the TNB/SESCO/SESB to gain access to the cabinet shall be provided.

8.3 Electrical Installation

8.3.1 Cables

Cables used throughout the works shall be provided with high conductivity, annealed, copper conductors in accordance with BS 6360: 1969. Final sub-circuit cables, unless otherwise specified shall be PVC insulated cables of annealed copper conductors, 450/750 volt grade to MS 136 and BS 6004, 1995. PVC insulated, steel wire armoured, PVC oversheathed cables (PVC/SWA/PVC) shall be manufactured to MS 274 and BS 6346, 1989 with annealed copper conductors. XLPE insulated cable shall be manufactured in accordance to IEC 502 and BS 6469.

8.3.2 Conduit

Steel conduits and fittings shall be manufactured in accordance with BS 4568 and BS 31, 1988, heavy gauge galvanised. Conduits shall be of adequate capacity for the sizes and number of cables to be contained therein. Conduit systems shall be mechanically and electrically continuous and watertight throughout.

High impact PVC conduits and fittings shall be manufactured in accordance with BS EN 50086, high impact and flame retarding type. BOMBA approval certificate shall be submitted for Licensee's checking. Standard bends and preferably long bends shall be used. Connection to equipment shall be flexible conduits of equivalent material and purpose made fittings.

8.3.3 Steel Trunking

Steel trunking shall be constructed of at least 18 SWG and cover plates of 16 SWG with flanged edges and of best quality mild steel sheet. The trunking shall be painted with a primer and coated with orange epoxy paint. Trunking shall comply with BS 4678. For outdoor installation, the trunking shall be constructed of electrogalvanised steel sheet.

8.3.4 Cable Tray

Cable trays shall be of the perforated type and constructed of minimum 16 gauge hot-dip galvanised mild steel and shall not be painted. All cables trays shall be effectively bonded to earth with a suitably size copper tape running continuously for the whole length of the cable tray.

8.3.5 Distribution Board

All distribution boards shall conform to Malaysian standards. Distribution boards supplied shall be metalclad, cubicle construction and suitable for installation on the surface of walls. The boards may also be of the floor mounted or pedestal mounted type depending on the layout design. They shall be manufactured in accordance with BS 214 : 1973, wherever applicable.

Electro-galvanised steel sheet used in the construction of indoor distribution boards shall not be thinner than 14 S.W.G. and shall be manufactured complying with ingress protection of IP21.

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 tropicalied 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.

8.3.6 Transfer Switch (Isolator Switch or Automatic Changeover Contactor)

The transfer switch shall be fully rated, to protect all types of loads, inductive and resistive, from loss of continuity of power. The switch shall afford complete protection. The switch shall be rated as suitable for all classes of load without derating, whether open or enclosed.

8.3.7 Isolators

Isolators, if required, shall be of S.P. & N., D.P., T.P. or T.P. & N types. The units shall conform to the requirements of BS 861 and BS EN 60947-3, 1992 where applicable.

8.3.8 Miniature Circuit Breakers

Miniature circuit breakers (MCB) shall comply with BS 3871:Part 1 and BS EN 60898, 1991 and shall have a category of duty M3 unless otherwise indicated.

8.3.9 Moulded Case Circuit Breaker

Moulded case circuit breaker (MCCB) shall comply with BS 4752 : Part 1 and BS EN 60898, 1991.

8.3.10 HRC Fuse-Links

All fuse-ways of distribution fuse boards, cut-outs, switch-fuse and fuse-switch units installed for the works shall be fitted with HRC fuse-links affording close excess-current protection which will enable them to operate within four (4) hours at 1.5 times the designed load currents for the circuits which they protect. Such HRC fuse-links shall be those complying with BS 88:1975 and BS EN 60269 and fitted with fuse-links marked to indicate a Class`Q' fusing factor.

8.3.11 Earth-Fault Relays

If earth-fault relays are to be provided for earth-fault protection for circuits and are to be used in conjunction with circuit breakers controlling the relevant circuits, such relays shall be of the unrestricted type (unless otherwise stated on the Schematic Diagrams) and operated through a set of four (4) current transformers per relay. The relay units shall be suitable for either flush mountings or surface mounting on switchboard panels and manufactured in accordance with BS 142:1966 and BS EN 60255. Each relay unit shall be electronic type and provided with adjustable setting having a range of 10% to 80% in steps of 1%. In addition to the protection of the diesel engines against mechanical faults, the following electronic protection relays must also be provided for the alternator sets:

- IDMT overcurrent relay; and
- Instantaneous earth fault relay

8.3.12 Current Transformers (CTs)

Ring-type, current transformers of appropriate ratios, burdens and classes shall be provided for the position of ammeters, power factor indicators, kilowatt-hour meters, earth-fault relays and magnetic overcurrent tripping devices built-in with circuit breakers. For operation of ammeters, the C/Ts shall have a burden of 5VA unless when used in conjunction with kilowatt-hour meters when they shall be of 15 VA burden. All current transformers shall be of correct dimensions for fixing in busbars and shall be manufactured to BS 7625:1993. In particular, current transformers necessary for the operation of instruments and meters shall have accuracy of not less than Class 1 for measuring, Class 0.5 for metering and Class 5P for protection.

8.3.13 Voltmeters

Every voltmeter shall be of the M.I.S.C. type, of suitable voltage range of high degree of accuracy. The voltmeter shall be connected in circuit with a 7-position selector switch, and protective cut-outs fitted with 6A, MCB, giving the following indications:

- Off;
- 3 phase-to-phase voltages; and
- 3 phase-to-neutral voltages.

8.3.14 Ammeters

Each ammeter shall be of the M.I.S.C. type, of suitable range to suit the current rating of the circuit it is meant to operate on, through current transformers. It shall have a high degree of accuracy, provided with four (4) current transformers (fitted to the busbars of the circuit whose current is to be measured by the ammeters) of ratio as stated on the relevant Schematic Diagram. The ammeter shall be connected in circuit with a 4-position selector switch giving the following indications:

- Off;
- Red Phase Amps;
- Yellow Phase Amps; and
- Blue Phase Amps.

8.3.15 Indicator Lamps

Where indicator lamps are to be utilised on switchboards and elsewhere on the Contract Works, they shall be of the LED type, fitted with coloured lenses and flush-mounted in switchboard panels. The lamps shall be operated at 240V, single phase, 50 Hz, A.C. supplies.

8.3.16 AC Contactors for LV Circuits

Where contactors are to be utilised for controlling circuits connected to inductive or capacitive loads such as motors, fluorescent and other forms of gas discharge lighting fittings, capacitor units and small transformers, the contactors shall be of the heavy duty type with a making and breaking category of A4. They shall be of current rating as stated on the Schematic Diagrams, suitable for operation on the voltage ratings of the circuits they control and manufactured in accordance with BS 775:Part I:1969. A.C. operating coils of contactors shall be suitable for connection to the voltages and frequencies of the A.C. control circuit supplied which are connected to them. For D.C. operating coils, these shall be suitable for operation on the D.C. voltages connected to them.

8.3.17 Time Switches

If time switches are required for controlling lighting power circuits via operating coils of contactors, or connected directly in circuit, such time switches shall be current ratings to suit the circuits concerned, D.P. type, with built-in spring operating mechanisms to keep the timing devices in operation for a minimum of 150 hours, in the event of an electricity supply failure. They shall also be suitable for operation on the voltage and frequencies of the A.C. supply to which they are connected.

8.3.18 Lighting Switches

Lighting switches shall conform to BS 3676 Part 1, 1989 and BS EN 60669-1, 1996 and shall be 10A rated.

8.3.19 Switch-Socket Outlet

General-purpose switch socket outlets connected to 240V, A.C. supplies shall be 13A x 3-pin, metal-clad, surface-mounted type, manufactured to BS 1363:1984 and BS 546:1988.

8.3.20 Earth Leakage Circuit Breaker (ELCB)

Earth Leakage Circuit Breaker (ELCB) with a tripping sensitivity as specified shall be installed as shown in the Drawings. The ELCBs shall be carefully selected so that they provide high security against nuisance tripping in case of impulse currents such as transient switching operations or interfering impulses by thunderstorm.

All ELCBs shall be anti-nuisance tripping type. Special feature ELCB with time delay tripping type 'kV' or 'S' shall be provided for air-condition circuits.

8.3.21 Terminal Blocks

Terminal blocks shall be mounted on C or G-channels. Minimum rating of the terminals shall be 15 amps. A minimum of 10% spare terminals shall be provided in each terminal block. The minimum clearance between two rows of blocks and sides shall be 100mm.

Terminal blocks shall be numbered for identification and grouped according to the following:

- 24 VDC;
- 415/240 VAC; and
- 4-20 mA signal.

8.3.22 Self-Contained Emergency and "KELUAR" Lighting Luminaries

The Emergency light shall have a sealed heavy duty nickel cadmium battery, a constant current charger, a silicon transistor inverter with a solid state changeover circuit and a 8W fluorescent tube (emergency light) and be virtually maintenance free. The unit shall be mounted in a metal housing stove enamelled to BS 4533 and with prismatic diffuser. The unit shall be provided with a mains healthy light emitting diode, indicator and a test button to simulate mains failure. In the event of mains failure, it shall be able to provide a minimum of 3 hours emergency lighting after a 12 hour recharging. All self-contained emergency lighting luminaries must be of types approved for use by the BOMBA and ST.

Each "KELUAR" sign shall be illuminated by super bright LED specially designed for the purpose. The sign illumination shall be maintained constant under both mains and internal battery operation. It shall be able to provide power for a minimum of 3 hours after a 12 hour recharging. All self-contained "KELUAR" lighting luminaries must be of types approved by the BOMBA and ST. "KELUAR" luminaries shall comply with MS 983, 1999.

8.3.23 Compound/Perimeter Lighting

250W high pressure sodium vapour flood lights 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.

8.3.24 Fluorescent Fittings

The construction of the fluorescent light fittings shall comply with BS 3820. The fluorescent lamps shall be of 38mm diameter with bi-pin cap complying with BS 1853.

Plastic diffusers shall be of acrylic material of approved manufacture that is recommended for lighting service. The diffuser shall be of opallic white pattern unless otherwise specified.

All ballast shall be of the best quality type from approved manufacture and comply with BS 2818, Part 1. They shall be suitable for operation in circuit with tubular fluorescent lamps that comply with BS 1853. All ballast shall be of polyester filled, low power loss, silent, operation type and fitted with terminal block for easy wiring.

All capacitors shall comply with BS 2818 Part ll and suitable for operating in circuit with tubular fluorescent lamp which comply with BS 1853.

All starters complete with starter bases shall comply with BS 3772 and suitable for use with tubular fluorescent lamp B.S. 1853.

8.4 Lightning Surge Protection System

8.4.1 General

This section describes the specification of heavy-duty and reliable type of lightning and surge protection system for essential and critical equipment as shown on the design drawings.

The supplier/local agent of the protection equipment shall be able to provide full technical and continuous engineering support in the event of any lightning/surge/power problems. As such it is mandatory that the local agent must have at least 10 years proven experience in the lightning and surge protection field or hold an agency/representation in lightning surge products for at least 10 years.

It is also important that they must have qualified engineers, trained technicians, and appropriate laboratory equipment to ensure that their products are compatibly matched with power supply safety requirements. The supplier shall submit their company profile in terms of technical support personnel, availability of laboratory equipment and schedule of proven past relevant projects.

A warranty certificate shall be obtained from the local authorised agent stating clearly a full 2-year warranty against both materials and workmanship defects.

All stages of equipment shall comply with the specifications. The suppressor units shall be tested in accordance to ANSI/IEEE C62.41, IEEE 587, VDE 0675, IEC 61024-1/IEC 61312-1/IEC 61643-1.

In meeting with Malaysia safety standards, the lightning surge protection devices shall also be tested by international laboratories that are recognised by the Electrical & Electronics Association of Malaysia and ST. All surge suppressors installed in all boards in a particular site must be of the same brand and fully coordinated to provide maximum protection to the equipment.

8.4.2 Primary Surge Voltage Arrestor (PSVA)

The primary surge voltage arrester (PSVA) shall be designed to withstand multiple strikes and able to survive tropical intense lightning environment in order to provide maximum protection against lightning and surges for main electrical LV service entrances at each type of distribution board. To ensure maximum protection and compatibility of performance of system, the lightning and surge module shall come from the same original manufacturer.

The components of the arrestor unit shall be heavy-duty Metal Oxide Varistor (MOV) and physically shielded in metal enclosure. The lightning component of the PSVA unit shall provide all mode protection and low let-through voltages well below the equipment susceptible level.

Both the lightning and surge element units is preferred to be standard Din rail mountable with reliable electronics type visual indicators to show each phase protection status. The PSVA shall have built-in auxiliary contact and integrated to act as a remote warning switch in the event of arrestor failure.
The PSVA unit shall provide sufficient protection level and it shall conform to the following specification:

- Nominal rated voltage — 240/415V AC
- Suppressor type — Heavy-duty/high surge rating MOV
- Mode of protection — All mode (L-E, L-N, N-E)
- Max surge rating — 80kA per mode, 160kA per phase
- Surge test waveform — 20kA and 3kA of 8/20us waveform
- Let-through voltage — < 1.2V at 20kA, 8/20us waveform
< 800V at 3kA, 8/20us waveform
- Residual current — < 200uA
- Status Display — Individual LED for each phase
- Auxiliary contact — Normally Open/ Normally Close
- Construction — Din rail mounted
- Enclosure — Metal

8.4.3 Secondary Surge Voltage Arrestor (SSVA)

The secondary surge voltage arrestor (SSVA) unit is preferred to be a Din rail mountable, non-modular construction type with full mode configuration suitable for protection of distribution boards and its loads.

The SSVA shall be equipped with reliable electronic indicator to display the status of the components and a remote warning contact shall also be integrated in the arrestor unit to act as a remote warning switch in the event of arrestor failure.

The secondary surge voltage arrestor (SSVA) unit shall be suitable for TT-system and configured to match installation option before the Earth Fault device.

The SSVA unit shall be specified to provide sufficient protection level and it shall conform to the following specifications:

- Nominal rated voltage — 240/415V AC
- Suppressor type — Heavy-duty/high surge rating MOV
- Mode of protection — All mode (L-E, L-N, N-E)
- Max surge rating — 40kA per mode, 80kA per phase
- Surge test waveform — 20kA and 3kA of 8/20us waveform
- Let-through voltage — < 1.2V at 20kA, 8/20us waveform
< 800V at 3kA, 8/20us waveform
- Residual current — < 200uA
- Status Display — Individual LED for each phase
- Auxiliary contact — Normally Open/ Normally Close
- Construction — Din rail mounted

8.4.4 Series Surge Suppressor – Pluggable (SSS-P)

The pluggable series surge suppressor is preferred to be a multistage design, rail mountable type and of a two-piece construction. It shall consist of a base element and protection plug module with non-meshed structure of the protection plug, offers particular advantages with regard to testing and system interchangeability. Alternative construction will be considered.

It shall normally be connected in series for optimum protection of sensitive electronic or microprocessor-based equipment. It shall provide surge voltage protection for both normal and common modes.

It shall be designed to provide indication of component failure and shall be able to be unplugged and tested for component failure without interrupting the operation. It shall not have exposed live parts during unplugging for testing and basically be touch-safe.

The SSS-P unit shall conform to the following specifications:

Maximum operating voltage

- (a) 230V AC suppressor 253V AC
- (b) 48V DC suppressor 60V DC
- (c) 12V DC suppressor 14V DC

- Rated current (a) 26A, (b)&(c) 300mA
- Leakage to ground =< 1 uA
- Operating current =< 1.5 mA
- Max. withstand back-up fuse 25A
- Surge current exposure (a) =<10kA (b)&(c) =<20kA(8/20us)
- Protection level (a) =< 1.1kV, (b)=< 120V, (c) =<18V
- Response time (a) =< 25ns, (b) & (c) =<1ns

8.4.5 Automatic Restoration System (ARS)

The automatic restoration system (ARS) shall be installed for the rectifier circuits so that it can work together with the ELCB or RCCB to provide the facility to reclose or normalize the power system for ensuring minimum system downtime and site attendance.

The automatic restoration unit (ARS) shall conform to the following specification.

Motorised Switch:

- Nominal rated voltage 240V AC
- Construction Din mounted, attachable with ELCB/RCD, bidirectional motorised arm & come with maintenance bypass feature
- Mechanical switching 10,000 times
- Minimum opening time 50ms
- Minimum restoration time 50ms
- Remote warning signalling Dual contact rated 5A/240VAC

Controller Unit:

- Nominal rated voltage 240V AC
- Construction Din mounted
- Controller Programmable relay with central processing unit
- Interfacing Digital & analogue signal control for motorised switch (min. up to 2 sets of motorised switch)
- Optional power quality analysis Interface with digital power
- meter

8.5 Earthing and Lightning Protection

8.5.1 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. Where connections are made at switchgear and such items of electrical equipment, the conductors shall terminate in soldered or compression-type sockets. In the case of MICC / PVC cables, the copper outer sheaths of the cables may be utilised as earth continuity conductors, provided that at the termination of each cable-run the copper sheaths (or sheaths in the case of single-core, multiple runs of MICC / PVC cables) shall be effectively bonded to earth. Every circuit of a switchboard, distribution board, control board, tap-off unit and splitter switch fuse unit shall be provided with its own earth-continuity conductor.

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 resistance of any earth-continuity conductor or earthing lead measured from its connection with the main earth electrode system of a building to any other position in the complete installation in the building shall not exceed **five (5) Ohms.**

The main earthing leads of the installation shall be taken from the earth connection of each Main Switchboard or Sub-Switchboard or Motor Control Centre as directly as possible without looping into any accessory or equipment, to the earth electrodes. Such earthing lead shall be mechanically protected by means of conduit or similar means, which shall be surface-run on walls and buried in the ground at a depth of not less than 460 mm below finished ground level.

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. Every connection clamp shall be provided with Regulation-type concrete inspection chamber and cover.

The total earth resistance measured at the main earthing bar for electrical installation with the equipment and cable armouring earth connections disconnected shall not exceed 1 ohm. The minimum number of electrodes installed for each earthing point shall be three (3) 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 1 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 500mm below finished ground level protected by cable tiles or bricks. Such cables shall be of sizes to suit the main earthing leads electrode system, in which case the earth-continuity conductors between electrodes shall be in accordance with the “Size of earthing” (column 3 and 4) of Table D.2M of the I.E.E. regulations (17th Edition). Neutral earthing leads from the Star “points” of transformer to their respective earth electrode systems shall be in accordance with the types and sizes of cables stated on the relevant Schematic Diagrams.

8.5.2 Materials

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

8.5.3 Lightning Protection of Greenfield sites

8.5.3.1 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 upper part of the tower no more than 1000mm below the lower support bracket for the antenna. The bar shall be fitted such that there is sufficient space between the bar and tower to allow bolts to be fitted from behind. The location of the earth bar will be below the connection point of the feeder cable grounding kits and preferably no more than 400mm from the feeder cable grounding kits.

A similar bar shall be fitted to the tower at the lower part, in a location adjacent to the feeder cable tray/ladder, but preferably not more than 400mm from the feeder cable grounding kits. The feeder cable grounding kits and cable ways shall be connected to this bar.

8.5.3.2 Ground Tape

A protection ring tape shall be installed around the base of the tower at a preferred depth of at least 1.0m 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.
The ends of the tape shall terminate into an inspection pit on to an earth rod.

8.5.3.3 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 or building;
- Equipotential Bonding Conductor; and
- Cabins - 4 No. of bonds.

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

8.5.3.4 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 complete with inspection pit and be 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.

9 Mechanical Installation
(Applicable Only to Part 2)

9.1 Scope

The mechanical services installation shall consist of a compact air conditioning unit or split unit and an emergency ventilation type cooling system operating in the event of mains failure.

Under this Invitation, the mechanical installation shall be provided by Part 2 Licensee for its collector site with cabin.

9.2 Air Conditioning for Cabin

9.2.1 Environmental Conditions

Normal operating temperature shall be 25°C and normal operating relative humidity shall be 60% RH.

The short-term temperature range of the equipment shall be between 2 and 49°C the short-term relative humidity shall be between 0 and 90% non- condensing.

In this clause, short-term shall mean for no more than 96 consecutive hours and no more than 5.5 days per 3 years.

9.2.2 Air Conditioning System

The proposed air-conditioning system shall be able to keep the inside temperature and relative humidity stated in 9.2.1 above.

The total cooling capacity is proposed to be 25,000 BTU/hr for the 4.8m x 3m x 3m cabin. When calculating the cooling capacity for the unit, the maximum heat dissipation from the radio equipment installed by the Licensee shall be taken into account. The Licensee shall confirm that the proposed cooling capacity is sufficient based on the radio equipment installed.

The air-conditioning system shall operate in such a way that the interior air pressure of the cabin will always be higher than the outside pressure.

For the cooling output, the air-conditioning system shall be set to operate when the temperature reaches 25°C and cut out when the temperature drops below 20°C.

10 CME Requirement for Natural Disasters

10.1 CME Works for Cabin/ Outdoor Base And Genset/ Fuel Tanks Base

The Licensee shall propose any work deemed necessary for special requirement cause of natural disasters e.g. flooding.

11 As Built Documentation

11.1 As-Built Drawing

The contractor shall allow for the preparation of any as-built drawings required by the Contract Document (Architectural works, Civil 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.

11.2 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