SUB-SECTION D

GENERAL ANNEXURE A

Equipment Inspection Category

All equipment is classified into three categories namely, Category – A, Category – B and Category – C on the basis of pre-dispatch inspection requirement by OWNER/EMPLOYER and EPC Contractor.

Category	**Stake holder**	**Pre-dispatch inspection**
Category – A	OWNER/EMPLOYER	Yes
	EPC Contractor	Yes
Category – B	OWNER/EMPLOYER	No
	EPC Contractor	Yes
Category – C	OWNER/EMPLOYER	No
	EPC Contractor	No

However, OWNER/EMPLOYER reserves the right to conduct pre-dispatch inspection for Category-B and Category-C equipment also.

S. No.	**Equipment Code**	**Equipment**
Category – A		
1.	PCU	Power Conditioning Unit
2.	ITR	Inverter Transformer
3.	HTP	HT Switchgear Panel
4.	MMS	Module Mounting Structure#
5.	SCADA	SCADA
6.	SVG	Static VAR Generator
7.	HF	Harmonic Filter
Category – B		
1.	SMU	String Monitoring Unit
2.	ATR	Auxiliary Transformer
3.	SC	Solar Cable (Module to SMU)

4.	DCC	DC Cable (SMU to PCU))
5.	LTC	LT Cable (PCU to Inverter Transformer)
6.	HTC	HT Cable (Inverter Transformer to Power Transformer)
7.	LTP	LT Panels (ACDB & DCDB)
8.	ABT	Metering Set (Main, Check, Standby)
9.	NIFPS	Nitrogen Injection Fire Protection System
Category – C		
1.	LDC	LT Distribution Cable
2.	UPS	Uninterrupted Power Supply
3.	BBC	Battery Bank and Battery Charger
4.	EES	Earth Electrode and Accessories
5.	LPS	Lightning Protection System
6.	CMC	Communication Cable
7.	TEA	Telemetry Equipment and accessories
8.	LED	Plant Illumination equipment and accessories
9.	WMS & AWS	Weather Monitoring Station Automatic Weather Station
10.	CCTV	CCTV Camera
11.	FAS	Fire Alarm System
12.	TI	Testing instruments
13.	CPC	Control and Power Cables
14.	SCC	Solar Cable Connector
15.	CTK	Cable Termination Kits

16.	TLT	Transmission Line Tower/Pole and Accessories
17.	FST	Fasteners
18.	OTR	Equipment Pre-Approved by DISCOM/TRANSCO

* Material inspection to be done prior to manufacturing

Proto-type inspection to be done prior to manufacturing

1. Category – A

The Contractor shall give inspection call to OWNER/EMPLOYER for pre-dispatch inspection of Category – A equipment at Manufacturer's/Supplier's factory. The inspection call shall be given only after the approval of equipment documents under Category – I as per Drawing and Document Control Index and be attached with internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. Inspection call should be given at least 7 working days before the scheduled start date of pre-dispatch inspection for a location within India and 15 working days in case of a foreign country. Based on the inspection report and compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by OWNER/EMPLOYER.

2. Category – B

For Category – B equipment, the Contractor shall intimate OWNER/EMPLOYER about the proposed inspection at least 3 working days before the scheduled start date of pre-dispatch inspection. Such intimation shall be given only after the approval of equipment documents under Category – I as per Drawing and Document Control Index and be attached with internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. OWNER/EMPLOYER will participate in the predispatch inspection, if required.

If OWNER/EMPLOYER participates in the pre-dispatch inspection, based on the inspection report and compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by OWNER/EMPLOYER. In case OWNER/EMPLOYER does not participate in the pre-dispatch inspection, the Contractor shall submit the Inspection Report signed by Contactor and Manufacturer/Supplier Representatives to OWNER/EMPLOYER for issuance of Material Dispatch Clearance Certificate (MDCC).

3. Category – C

For Category – C equipment, the Contractor shall submit internal routine test reports performed by the

Manufacturer/Supplier as per the approved Quality Assurance Plan. For all equipment inspected by the DISCOM, Inspection Report/Test Report signed by DISCOM shall be submitted to OWNER/EMPLOYER for information and payment recommendation.

The methodology proposed for conduct inspection and issuance of MDCC is as under:

Category	Inspection done by	MDCC issued by	
A	OWNER/EMPLOYER and / or Customer	OWNER/EMPLOYER	Inspector will submit the inspection report to OWNER/EMPLOYER along with his observations, if any. In case of any observation reported by Inspector, then Contractor shall submit compliance report for the same to OWNER/EMPLOYER. OWNER/EMPLOYER shall review the inspection report, along with the compliance report submitted by Contractor, in line with the approved QAP and Drawings/Documents and if found satisfactory, shall recommend issue of MDCC. MDCC shall be issued by OWNER/EMPLOYER/Owner.
B	EPC contractor (OWNER/EMPLOYER optional)	OWNER/EMPLOYER	Contractor shall submit all the test report / material certificates to OWNER/EMPLOYER. OWNER/EMPLOYER shall review these documents and if found satisfactory, shall recommend issue of MDCC. MDCC shall be issued by OWNER/EMPLOYER.
C	COC by Manufacture / Supplier	OWNER/EMPLOYER	EPC contractor will verify the CoC and issue the MDCC which will be verified by OWNER/EMPLOYER / Owner.

SUB-SECTION D

GENERAL ANNEXURE B

Mandatory Spares

S. No.	Equipment/Material	Quantity (For each type and rating)
1	MC4 compatible connectors (including Y-connector if used)	1% of total supply
2	String Combiner Box / String Isolator Box	0.5% of total supply
3	Power Conditioning Unit	
	(i) Central Inverter	Spares corresponding to 10% of each type / rating of inverter rounded off to the next higher integer for the following items - IGBT modules for one complete inverter - AC and DC fuses - air filters - cooling fans - electronic cards of each type - harmonic filter units - digital display units - switches, push buttons and indication lamps - diodes of each type & rating - resistors of each type & rating
	(ii) String Inverter (if applicable)	0.5% of total supply
4	Inverter Transformer	
	(i) HV bushing with metal parts and gaskets	2 set
	(ii) LV bushing with metal parts and gaskets	2 set
	(iii) WTI with contacts	2 set
	(iv) OTI with contacts	2 set
	(v) Buchholz relay	2 set
	(vi) Magnetic Oil Gauge	2 set
	(vii) Breather assembly	2 set
	(viii) Complete set of gaskets & valves	2 set
	(ix) Tap Changer Contact Assembly	2 set
5	Power Transformer	
	(i) HV bushing with metal parts and gaskets	1 set
	(ii) LV bushing with metal parts and gaskets	1 set
	(iii) WTI with contacts	1 set
	(iv) OTI with contacts	1 set
	(v) Buchholz relay	1 set
	(vi) Magnetic Oil Gauge	1 set

S. No.	Equipment/Material	Quantity (For each type and rating)
	(vii) Breather assembly of Main tank	1 set
	(viii) Cooler Fan with motor, Contactor, Relay and MCB	1 set
	(ix) Insulating Oil	10%
	(x) Complete set of gaskets & valves	1 set
	(xi) Tap Changer Contact Assembly Spares	1 set
	(xii) Pressure release device	1 set
6	33 kV Circuit breaker / switchgear assembly	
	(i) Circuit breaker pole	2 nos.
	(ii) Contact assembly (for indoor panels)/ Contact flange (for outdoor CB)	Suitable for one 3-phase CB
	(iii) Closing coil	2 nos.
	(iv) Tripping coil	2 nos.
	(v) Spring charging motor	2 nos.
	(vi) Relay (each type)	2 nos.
	(vii) Meter (each type)	2 nos.
	(viii) Current Transformer	2 nos.
	(ix) MCCB	2 nos.
	(x) MCB	2 nos.
	(xi) Fuse	10% of total supply
	(xii) Indicating lamp	10% of total supply
	(xiii) Rotary switch	10% of total supply
7	33 kV outdoor disconnector	
	One pole (metallics & insulators)	2 sets
	Fixed and moving contact assembly	4 sets
	Drive mechanism box	1 set
	Relays, contactors, switches and push buttons	Two of each type
8	33KV LA, CT & VT (indoor and outdoor)	One of each type together with terminal connectors
9	Control and Relay Panel	
	(i) Relay (each type)	1 no.
	(ii) Meter	1 no.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply

S. No.	Equipment/Material	Quantity (For each type and rating)
	(v) Indicating lamp	10% of total supply
	(vi) Rotary switch	10% of total supply
	(vii) BCU	1 no.
10	LT Switchgear	
	(i) ACB	1 no.
	(ii) MCCB	2 nos.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Relay	2 nos.
	(vi) Meter	2 nos.
	(vii) Current Transformer	2 nos.
	(viii) Voltage Transformer	2 nos.
	(ix) Contact Assembly	2 sets
	(x) Indicating lamp	10% of total supply
	(xi) Rotary switch	10% of total supply
11	DC Cable	1 Drum
12	AC Cable	1 Drum
13	Communication Cable	1 Drum
14	Control Cable	1 Drum
15	Fuse	10% of total supply
16	33 kV Transmission Line	
	(i) Line supports, MS Angle, Back Clamp, Top Clamp, Earthing Coil, Insulators	2 set
	(ii) Conductor	1 km
	(iii) Jointing Sleeves, Stay set complete with turn buckles, stay wire, stay insulators, Anti-climbing Devices, Danger Boards	2 set
17	220 kV Solar Park/Pooling Substation Equipment (as applicable to proposed model/make)	
	(i) SF6 Circuit Breaker	
	a) One complete pole of Circuit Breaker, pole column, Interrupter, with driving mechanism Box and MB but without support structure	1 no.
	b) Grading capacitors (if applicable)	1 no.

S. No.	Equipment/Material	Quantity (For each type and rating)
	c) Rubber gaskets, O rings and seals for SF6 gas (complete replacement for one breaker)	1 set
	d) Trip coils with resistor	2 nos.
	e) Closing coils with resistor	1 no.
	f) Molecular filter for SF6 Circuit for 1 Pole of CB	2 nos.
	g) Terminal pads and connectors	2 nos.
	h) Corona rings	1 no.
	i) Relays, power contactors, switch-fuse units, limit switches, push buttons, timers and MCBs etc.	1 set
	j) Pressure switches	1 set
	k) Auxiliary Switch Assembly	1 set
	l) SF6 gas	1 complete fill for at least two CBs
	(ii) Disconnector	
	a) One complete pole of disconnector including support insulator with 1 E/S with motor operating mechanism for main isolator and earth switch (excluding structure)	1 no.
	b) Copper contact fingers for female & male contacts	2 set
	c) Open/Close Contactor Assembly, Timer, Key Interlock push button switch & auxiliary switches	1 set
	d) Limit switch	2 nos.
	e) Terminal pads & Connectors	3 nos.
	f) Corona shielding ring	3 nos.
	(iii) Surge Arrester	1 no.
	a) Complete surge arrester excluding support structure	1 no.
	b) Surge counter / monitor	5 nos.
	(iv) Current Transformer (excluding support structure / common JB)	1 no.
	(v) Voltage Transformer (excluding support structure / common JB)	1 no.

S. No.	Equipment/Material	Quantity (For each type and rating)
	(vi) Bus Post Insulator	3 nos.
	(vii)Conductor	200 m of each type
	(viii) Erection Hardware Items (Insulator strings & Hardware, Clamps & Connectors)	3 nos. of each type
	(ix) Terminal Clamps	1 set
	(x) Lugs	20 of each type
	(xi) Heat shrinkable Termination and Jointing kits	5% of Total quantity used
18	220 kV Transmission Line	
	(i) Steel Tower - Transmission towers including body and leg extensions (complete) including stubs and hangers, cleats, Galvanized Steel Sections (for replacement), nuts and bolts	15% of each member / component used in each type of tower
	(ii) Conductor Joint Sleeve, Earth Wire Joints, Armor Rods, Suspension insulator string with fittings and clamp, Tension insulator string with fittings and clamp	2 set
	(iii) Conductor, Earth Wire and OPGW	1 km each

Spares, if used, during the O&M period shall be replenished by the Contractor. All the mandatory spares shall be handed over to the Employer in working condition at the end of O&M period along with list of utilized items and replaced items.

SUB-SECTION D

GENERAL ANNEXURE C

Plant Documentation, Commissioning & Test Procedure

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1 INTRODUCTION

This document lays down the procedures, requirements and templates for conducting commissioning tests and inspection of the Plant Facilities after installation and for subsequent re-inspection, maintenance or modifications in accordance with the Tender Specifications, IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection)- and industry best practices.

2 CODES AND STANDARDS

The Testing and Commissioning Procedures shall, in general, comply with the following standards:

1. IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection).
2. IEC 60364-6:2016 - Low voltage electrical installations - Part 6: Verification.
3. IEC 61829:2015: Photovoltaic (PV) array - On-site measurement of current-voltage characteristics.
4. IEC 60904-4:2019 Photovoltaic devices - Part 4: Reference solar devices - Procedures for establishing calibration traceability
5. IEC TS 60904-1-2:2019 - Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices
6. IEC 62305-3– Protection against lightning - Part 3: Physical damage to structures and life hazard
7. IS/IEC 61557 : Part 2 : 2007 - Electrical safety in low voltage distribution systems up to 1000 V ac and 1500 V dc - Equipment for testing, measuring or monitoring of protective measures: Part 2 insulation resistance

3 COMMISSIONING

3.1 GENERAL

3.1.1 Objective

The Commissioning Procedure defined in this document aims to:

- Verify that the power plant is structurally and electrically safe
- Verify that the power plant is structurally and electrically robust to operate for the specified lifetime of a project
- Verify that the power plant operates as designed and its performance is as

expected

3.1.2 General Requirements before Starting the Commissioning Process

- The modules shall be stabilized (sufficiently exposed after 200 kWh/m² reaching the PV plane)
- The tests shall be conducted under stable weather conditions
- The process shall be witnessed by the Owner or their duly appointed representative.
- Soiling losses shall not be accounted for in the assessment of Results. Therefore, adequate Module cleaning exercise shall be undertaken prior to commencement of Commissioning process.

- The following equipment shall be used during the commissioning process (Refer Section VII B:Technical Specifications for testing instruments):
  - Earth resistance tester
  - IV curve tracer
  - Insulation tester
  - Digital multi-meter
  - Clamp meter
  - Infrared camera
  - Digital lux meter
  - Electroluminescence camera, power supply and accessories
- All testing equipment shall possess valid calibration certificate issued from approved laboratories.

4 Cold Commissioning

4.1 DC COMMISSIONING

4.1.1 Visual Inspection

The visual inspection shall be conducted on 5% of the system split in subareas equally distributed in the field. Unless otherwise specified, Approved Cat I Drawings shall be referred for correctness/verification. At least following aspects shall be verified visually on the DC side:

- Sizing of the DC fuses for running conditions, for the maximum voltage and the maximum current.
- Sizing of the string cables including overcurrent protection considering the current carrying capacity under operating conditions

- Cables protected against mechanical damage
- Functionality of the main DC switch
- Fixation of the modules to the mounting structure
- Termination of the cables to the inverter
- Where the PV system includes functional earthing of one of the DC conductors, the functional earth connection shall be specified and installed to the requirements of IEC 62548.
- Laying and installation of cables
- Fixation of the grounding electrodes
- Grounding of all conductive parts and connected to the equipotential bonding system of the PV plant
- The torque values in the mounting structure, combiner boxes, bars and joints shall match the manufacturer specifications
- Where protective earthing and/or equipotential bonding conductors are installed, they shall be parallel to and bundled with the DC cables
- Electrical circuits and devices shall be labelled.
- The PV modules shall be in a good condition (no visible serial defects such as yellowing, delamination, scratches, etc.).
- Functioning of fire protection equipment.

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. All items shall be categorized as “critical”, “important” or “minor”.

4.1.2 Pre-Energizing Tests

4.1.2.1 Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the DC circuit forming the PV array in accordance with a Sampling Plan:

- Electrical Continuity test: This test shall be performed on the earthing and/or equipotential bonding conductors, in the PV array field. Connection of such conductors to earthing pit shall also be verified.
- Polarity test: Polarity of DC cables shall be verified. After verifying the correctness of

polarity, marking on cable shall be checked for correctness

Note: Polarity test shall be performed before closing the switches or string overcurrent protective devices are inserted

- Combiner box test: The purpose of this test is to ensure all strings are connected correctly to the combiner box. The test procedure is as follows and shall be performed before any string fuses / connectors are inserted for the first time:

i) Select a volt meter with voltage range at least twice the maximum system voltage.

ii) Insert all negative fuses / connectors so strings share a common negative bus.

iii) Do not insert any positive fuses / connectors.

iv) Measure the open circuit voltage of the first string, positive to negative, and ensure it is an expected value.

v) Leave one lead on the positive pole of the first string tested, and put the other lead on the positive pole of the next string. Because the two strings share a common negative reference, the voltage measured should be near-zero, with an acceptable tolerance range of ±15 V.

vi) Continue measurements on subsequent strings, using the first positive circuit as the meter common connection.

vii) A reverse polarity condition will be very evident if it exists – the measured voltage will be twice the system voltage.

- String open circuit voltage test, V_{oc} (under stable weather conditions): The purpose of this test is check the modules connection in string as per the design. The V_{oc} of PV string should be measured using suitable measuring device before closing any switch or string overcurrent protective devices, where fitted.

  The measured string V_{oc} will be assessed to ensure it matches the expected value (typically within 5 %) in one of the following ways:

  a) Compare with the expected value derived from the module datasheet or from a detailed PV model that takes into account the type and number of modules and the module cell temperature.

  b) Measure V_{oc} on a single module, then use this value to calculate the expected value for the string.

  c) For systems with multiple identical strings, voltages between strings can be compared.

- String circuit current test, Isc (under stable weather conditions): The purpose of this

test to check the correctness of system, operational characteristic and PV array wiring. These tests are not to be taken as a measure of module / array performance. The test procedure will be as follows:

i) Ensure that all switching devices and disconnecting means are open and that all PV strings are isolated from each other.

ii) Create a temporary short circuit into string under test by using any of the following method:

(a) use of a test instrument with a short circuit current measurement function (e.g., a specialized PV tester);

(b) a short circuit cable temporarily connected into a load break switching device already present in the string circuit;

(c) use of a “short circuit switch test box” – a load break rated device that can be temporarily introduced into the circuit to create a switched short circuit.

iii) Measure the short circuit current (Isc) using a suitably rated measuring instrument.

iv) After taking the reading, interrupt the short circuit using a suitable load break switching device and check the zero value of current before changing any other connections.

v) Compare the measure value of Isc with the expected value. For systems with multiple identical strings, measurements of currents in individual strings shall be compared. These values should be the same (typically within 5 % of the average string current). Note: An I-V curve test can be performed as an alternative to this test (see 4.3).

- Functional tests: The following functional tests shall be performed:

i) Switchgear and other control apparatus shall be tested to ensure correct operation and that they are properly mounted and connected.

ii) All inverters forming part of the PV system shall be tested to ensure correct operation. The test procedure should be as defined by the inverter manufacturer.

Functional tests that require the AC supply to be present (e.g., inverter tests) shall only be performed once the AC side of the system has been tested.

- Insulation resistance of the DC circuits: Test procedure to conduct this test will be as follows:

i) Before commencing the test adopt the following safety measure to avoid any potential shock hazard

(a) Isolate the testing area.

(b) Do not touch any metallic surface, module back sheet or the module terminals when performing the insulation test.

(c) Appropriate personal protective clothing / equipment should be worn for the duration of the test.

ii) Isolate the PV array from the inverter (typically at the array switch disconnector)

iii) Disconnect any piece of equipment that could have impact on the insulation measurement (i.e. overvoltage protection) in the junction or combiner boxes.

iv) The insulation resistance test device shall be connected between earth and the array cable(s) or combiner bus bar. Connections can be made between earth and array negative followed by a test between earth and array positive or between earth and short circuited array positive and negative.

v) Follow the IR test device instructions to ensure the test voltage and readings in megaohms. When the system voltage (Voc at STC X 1.25) is higher than 500V, the test voltage shall be 1,000V and the minimum insulation resistance 1 MΩ.

vi) Ensure the system is de-energized before removing test cables or touching any conductive parts.

4.1.2.2 Sampling Plan:

At least 2 strings from 2 SMUs shall be randomly chosen by the Owner connected to each Inverter.

Acceptance criteria

The DC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 62446:2016 – 6.

4.2 AC COMMISSIONING

4.2.1 Visual Inspection

The visual inspection shall be conducted on 5% of the system. In general, the requirements specified in the IEC 60364-6 -6.4.2 apply. At least following aspects shall be verified visually on the AC side:

4.2.1.1 General requirements

- Protective requirements against electric shock

- Protection against fire and heat
- Choice, setting, selectivity and coordination of protective and monitoring devices
- Sizing of cables regarding voltage drop and ampacity as per approved Drawings.
- Sizing of protective and monitoring devices as per approved Drawings
- The circuit breakers are correctly located
- Selection, location and installation of suitable isolating, overvoltage protective devices and switching
- The equipment and protective measures are appropriate for the external influences and mechanical stresses
- The diagrams, warning notices or similar information attached to the wall inside the inverter housing or the control room
- Proper fixation of the cables to the collector bars in the AC combiner box
- Proper labelling of all electrical circuits and devices including the neutral conductor and protective conductor as well as correct connection of single pole devices to the phase conductors
- Adequacy of termination and connection of cables and conductors
- The warning labels and technical documentation physically displayed
- Selection and installation of earthing arrangements, protective conductors and their connections
- The existence and correct use of protective conductors and protective equipotential bonding conductors (PEB)
- Measures against electromagnetic disturbances implemented
- Easy access to the operational devices for maintenance
- Any exposed conductive parts connected to the earthing system
- The RCD type has been selected according to the requirements of the IEC 62548
- The isolation means of the inverter on the AC side are functional and correctly sized
- The fire protection requirements according to the approved design shall be given

4.2.1.2 Requirements for the inverter

- Installation as per manufacturer's instructions and compliance with IEC 62548
- Inverters properly fastened to the ground
- Inverter properly earthed
- Inverter incoming/outgoing cables properly isolated, labelled and connected

- The connections for phase sequence L1, L2, L3 and N in the correct order
- All cable terminations properly done
- Nameplate data. The minimum requirements for the production of a name plate are –
    - name and origin of the manufacturer; –
    - model or type name;
    - serial number;
    - electrical parameters: Vdcmax, Vmppmin, Vmppmax, Idcmax, Pac,r, Vac,r, f r , Iacmax;
    - degree of protection;
    - overvoltage category;
    - safety class.
- The displays - check / readout show plausible results
- The filters are clean and properly maintained
- The cooling outputs of the inverters are free from obstruction
- The DC circuit breaker is functional
- The DC insulation monitoring correctly installed
- The fuses at the DC entrance correctly sized
- The location of the inverter(s) in the field matches the approved design
- Protection against self-loosening of clamps and screws
- The string inverter anchored to the mounting structure
- The mechanical assembly is robust
- The inverters are fixed to non-flammable mechanical elements

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as “critical”, “important” or “minor”.

4.2.2 Pre-Energizing Tests

Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the AC circuit forming the PV array:

- Continuity of conductors. The requirements in IEC 60364-6:2016 – 6.4.3.2 apply

- Insulation resistance of the electrical installation. The requirements in IEC 60364-6:2016 – 6.4.3.3 apply
- Insulation resistance testing to confirm the effectiveness of protection by SELV, PELV or electrical separation. The requirements in IEC 60364-6:2016 – 6.4.3.4 apply
- Insulation resistance/impedance of floors and walls. The requirements in IEC 60364-6:2016 - 6.4.3.5 apply
- Polarity test. The requirements in IEC 60364-6:2016 - 6.4.3.6 apply
- Testing to confirm effectiveness of automatic disconnection of supply. The requirements of the IEC 60364-6:2016 – 6.4.3.7 apply
- Testing to confirm the effectiveness of additional protection. The requirements of the IEC 60364-6:2016 – 6.4.3.8 apply.
- Test of phase sequence. The requirements of the IEC 60364-6:2016 – 6.4.3.9 apply
- Functional tests. The requirements of the IEC 60364-6:2016 – 6.4.3.10 apply
- Voltage-drop. The requirements of the IEC 60364-6:2016 – 6.4.3.11 apply

Acceptance criteria

The AC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 60364 – 6.

4.2.3 Additional Pre-Energizing Tests

All of the below tests shall be conducted in accordance with the supplier's installation/commissioning manuals.

4.2.3.1 Distribution boards and combiner boxes

Site testing on distribution boards shall include:

- Mechanical functional test of all components including mechanical interlocks
- Electrical functional test of all control and protection wiring against the approved switchgear schematics
- Power frequency overvoltage test (flash test) on the switchgear including circuit-breakers in the test circuit
- Low resistance duct or test on the switchgear including circuit-breakers in the test circuit
- Visual inspection

- Verification of earthing

4.2.3.2 Inverters

Site testing on inverters shall include:

- Full test procedure as defined by the inverter manufacturer
- A full mechanical functional test of all components including mechanical interlocks
- Verification that the inverter operational parameters have been programmed to local regulations
- Electrical functional test of all control and protection wiring against the approved switchgear schematics as per approved MQP/FQP
- Insulation resistance test and earth residual current monitoring test
- Anti-islanding functionality
- High Voltage overvoltage test
- SCADA and metering calibration & functionality test

4.2.3.3 HT Switchgear

Site testing on outdoor circuit-breakers shall include:

- Functional check of all wiring, interlocks, auxiliaries and pressure devices
- Timing test and travel curve
- Visual inspection

4.2.3.4 LV/MV transformers

Transformer commissioning shall include:

- Visual inspection, alignment, earthing and labelling
- Functional check of all wiring against the approved transformer schematics
- Testing and calibration of all transformer protection and monitoring devices
- Insulation resistance test
- Functional test of off-circuit/on Circuit tap changer and check of the continuity of all windings

4.2.3.5 Substation/Power Transformers

- Ratio measurement on all tap changer settings
- Winding resistance measurement on highest, lowest and nominal tap settings
- Insulation resistance between all windings, and each winding to earth
- Insulation resistance core-to-earth
- Oil sample tests: breakdown strength, moisture content, and dissolved-gas content

- Transformer differential protection scheme testing

Acceptance criteria

The test results shall be aligned with the manufacturer specifications stated in the installation manual.

4.3 IV CURVE TESTING

The requirements of the IEC 62446-1:2016 – 7.2 apply. Following normative references shall be considered while performing the IV curve test:

- IEC 61829:2015 Photovoltaic (PV) array - On-site measurement of current-voltage characteristics
- IEC 60891:2009 Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics

2 % of the module strings shall be measured. If $\Delta P_{stringN}$>5%, all the modules within that string shall be I-V characterized. Modules with ΔP_N>5% shall be replaced. If more than 5% of the measured strings of the first sample show ΔP_N>5%, another 2% shall be inspected. If more than 5% of the measured strings in the second sample show ΔP_N>5%, another 5% shall be inspected. If more than 5% of the measured strings in the third sample show ΔP_N>5%, another 10% shall be inspected. If more than 5% of the measured strings in the fourth sample show ΔP_N>5%, another 10% shall be inspected. The reference power value is the flash list value minus the light induced degradation (LID) value in the datasheet/module warranty.

Acceptance criteria

The power determination analysis will be passed when less than 5% of the modules measured in the last sample show ΔP_N<5%.

5 Hot Commissioning

5.1 INFRARED INSPECTION

Following normative references apply:

- PV array infrared camera inspection procedure **(**IEC 62446-1:2016 - 7.3) and IEC 62446-3 TS Ed.1.0 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 3: Outdoor infrared thermography of photovoltaic

modules and plants (draft)

- The infrared inspection shall be applied both to the PV modules and the BOS components

The inspection sample will depend on the project size and shall be agreed with the OWNER. The following values serve as an orientation:

- Large scale ground mounted PV plants
    - PV modules: 100%
    - Inverters: 100%
    - Combiner boxes: 100%

Acceptance criteria

The following conditions shall be met simultaneously:

- 0.2% or less of the inspected modules show thermal gradients at the cell level of T > 10 K
- 0.2% or less of the inspected modules show thermal gradients at the junction box level of T > 10 K
- 0.2% or less of the inspected modules show inactive cell strings
- No PID is detected
- All module strings are connected and producing
- All inverters are connected and producing

5.2 SOLAR INVERTER AVAILABILITY TEST

5.2.1 Calculation of the Operation Time

It shall be calculated on inverter level. The operation time starts as soon as the inverter switches on. Therefore, only the logged irradiation values during the operation time of the inverter shall be considered. Irradiation values logged before or after the inverter running time shall be disregarded.

5.2.2 Calculation of the Downtime

The downtime relevant for the availability calculation is any time in which a part or a subpart of the system is not operational. The outage periods shall be considered again on inverter level. Only complete outages shall be taken into consideration. System black-out periods due to following reasons shall not flow into the calculation (i.e., excluded events):

- A failure in the distribution grid or the transformer substation, making it impossible to transmit the generated power

- Solar radiation below the level needed to obtain the minimum operating voltage to start the inverter operation
- Causes of Force Majeure.
- Occurrences of anomalies in the power supply system (frequency differences or voltage surges) that trigger the protective systems of the plant or the limit settings of the inverter

Any forced disconnection shall be documented and recorded.

Acceptance criteria

The system availability shall be at least 99% during the testing period.

5.3 SINGLE AXIS TRACKER AVAILABILITY TEST (IF APPLICABLE)

The tracker availability test shall be carried out in parallel to the inverter availability test and shall have the same duration. During the test, all trackers shall follow the sun according to the angles established in the tracking mechanism. A loss of availability shall be considered when the angle of inclination of one or more trackers deviates by more than 2° from the theoretical angle. The angles of inclination of each tracker shall be recorded with a resolution of 1min via the SCADA system.

Acceptance criteria

The tilt angle of each tracker shall lie within a ±2° range during 99.5% of the operational time.

5.4 SCADA AND WEATHER STATION RELIABILITY

5.4.1 Visual Inspection

- Installation of the communication system architecture diagram according to the specifications
- Functional Tests conducted during FAT for Pre-Dispatch Inspection shall be repeated.
- SCADA shall be linked to all protection relays, disturbance recorders and other substation equipment using the communications protocol
- Visual check on the assembly of all joints and on the as-installed condition of all components, including:
    - The irradiation sensor is not shaded and is installed at the correct tilt angle and under CCTV coverage.

- Ambient temperature and module temperature sensor are installed properly (Reference IEC 61724)
- Mechanical anchorage of the sensors is robust

- Complete calibration certificates of all the instruments shall be provided

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as "critical", "important" or "minor".

6 Battery Energy Storage System (if applicable)

6.1 VISUAL INSPECTION

Before energizing the BESS, following visual checks shall be made to check the required design compliance:

- Installation of protective cover for live, hot and cold parts, and the adequate distance from the person;
- Installation of fence, wall, locking system of doors and access panels, and notice boards
- Installation of ventilation system;
- Installation of firefighting system;
- Installation of lightning protections devices.
- Wiring
  - All wiring shall be continuous and without splices.
  - Wiring that may be exposed to mechanical damage are placed in conduit or armoured.
  - Wires have permanent and durable identifying labels or markings on both ends.
  - Control and instrumentation wiring shall be separated from power and high-voltage wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips.
  - BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner.
  - Cable systems do not block access to equipment by personnel. There are no exposed current-carrying or voltage-bearing parts.

6.2 CONTINUITY TEST

Continuity of power, control and auxiliary circuit in the system shall be verified through visual inspection, continuity tester and insulation resistance test.

Phase sequence and terminal marking shall also be verified with drawing and design documents.

6.3 EARTHING TEST

Following element to be check according to the design and applicable standards:

- Proper connection of the earthing busbar to the local earthing busbar;
- Individual earthing connection of main equipment to the earthing busbar;
- Connection of earthing cables to structures via proper connectors to prevent corrosion from dissimilar metals.

6.4 INSULATION TEST

For low-voltage EES systems, the insulation resistance test and withstand voltage test shall be performed according to IEC 60364-6.

For EES systems exceeding 1 kV AC or 1,5 kV DC, the withstand voltage test shall be performed according to IEC 61936-1.

6.5 FUNCTIONAL TEST

6.5.1 Start and stop test

Check start and stop operation of BESS system with the startup/shutdown command manually and automatically.

6.5.2 Alarms Functional Test

Alarms initiation from the BESS in case of following conditions:

- Emergency trip switch.
- Loss of the low-voltage AC or utility grid voltage.
- An AC circuit breaker trip (either side of transformer).
- Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
- Smoke/fire alarm.
- Control logic trouble.
- A DC ground fault (simulated).
- Remote disable (no reset required).
- grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
- Abnormal voltage

- Islanding condition.
- Protection or control scheme failures, including the following:
  - Failure of local interconnection protection system
  - Failure of critical breaker trip coil or interrupting device
  - Loss of DC supply

6.5.3 Load tripping test

Check the interlock of BESS with the main

6.5.4 Operating cycle test

Check for any abnormalities such as rise in temperature, noise level and vibration in ESS system during rated input and output power operation.

6.5.5 Storage Settings

Verification of settings/control points and provision for modification of various set points and fixed operation/control settings associated with the various control functions.

Operator Controls:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.
- Reset cut-out selector switch to disable remote or local reset signals.
- A selector switch to manually set the operating state (that is, the shutdown, disconnect, or operate state) and to have the control system set the operating state automatically.
- A selector switch to manually set the operating mode and to have the control system set the operating mode automatically.

6.5.6 Communication test

Verified that measuring, alarm, fault indication, message and control and monitoring system operations are correct transmitted and received by the SCADA system.

6.6 BESS INVERTER AVAILABILITY TEST

6.6.1 Calculation of the Operation Time

It shall be calculated on inverter level. The operation time starts as soon as the BESS inverter is available for dispatch and capable of charging or discharging based on grid conditions and system commands. Therefore, only the periods when the BESS is operationally available and the grid connection permits power exchange shall be considered. Time periods when the system is intentionally idle due to State of Charge (SOC) limits, scheduled maintenance, or grid

disconnect commands shall be distinguished from actual downtime.

6.6.2 Calculation of the Downtime

The downtime relevant for the availability calculation is any time in which the BESS inverter is not operational when grid conditions would otherwise permit operation. The outage periods shall be considered on inverter level. Only complete outages shall be taken into consideration. System outages due to the following reasons shall not flow into the calculation (i.e., excluded events):

(i) A failure in the distribution grid or the transformer substation, making it impossible to transmit the generated power

(ii) Causes of Force Majeure

(iii) Battery Management System (BMS) protective actions due to temperature, voltage, or current limits that are outside normal operating parameters

(iv) Occurrences of anomalies in the power supply system (frequency differences or voltage surges) that trigger the protective systems of the BESS or the limit settings of the inverter

(v) Planned maintenance windows and scheduled testing periods as defined in the operation and maintenance agreement

(vi) SOC-based limitations when the battery reaches maximum or minimum state of charge limits as specified by the manufacturer

(vii) Any forced disconnection due to grid operator commands or market dispatch instructions

(viii) Thermal management system protective shutdowns within manufacturer specifications

Any forced disconnection shall be documented and recorded.

6.7 SCADA – EMS INTEGRATION

- Installation of the communication system architecture diagram according to the specifications
- Functional Tests conducted during FAT for Pre-Dispatch Inspection shall be repeated.
- SCADA shall be linked to all protection relays, disturbance recorders and other substation equipment using the communications protocol
- Demonstration that SCADA and EMS can transmit and receive tags, setpoints, and control commands to and from each other, and the PCS, BMS, and protection systems without loss or excessive delay. End-to-end Availability shall be >99% during testing period.

- Verification of time synchronization across devices.
- Visual check on the assembly of all joints and on the as-installed condition of all components, including:
- Ambient temperature sensors are installed properly (Reference IEC 61724)
- Mechanical anchorage of the sensors is robust
- Complete calibration certificates of all the instruments shall be provided

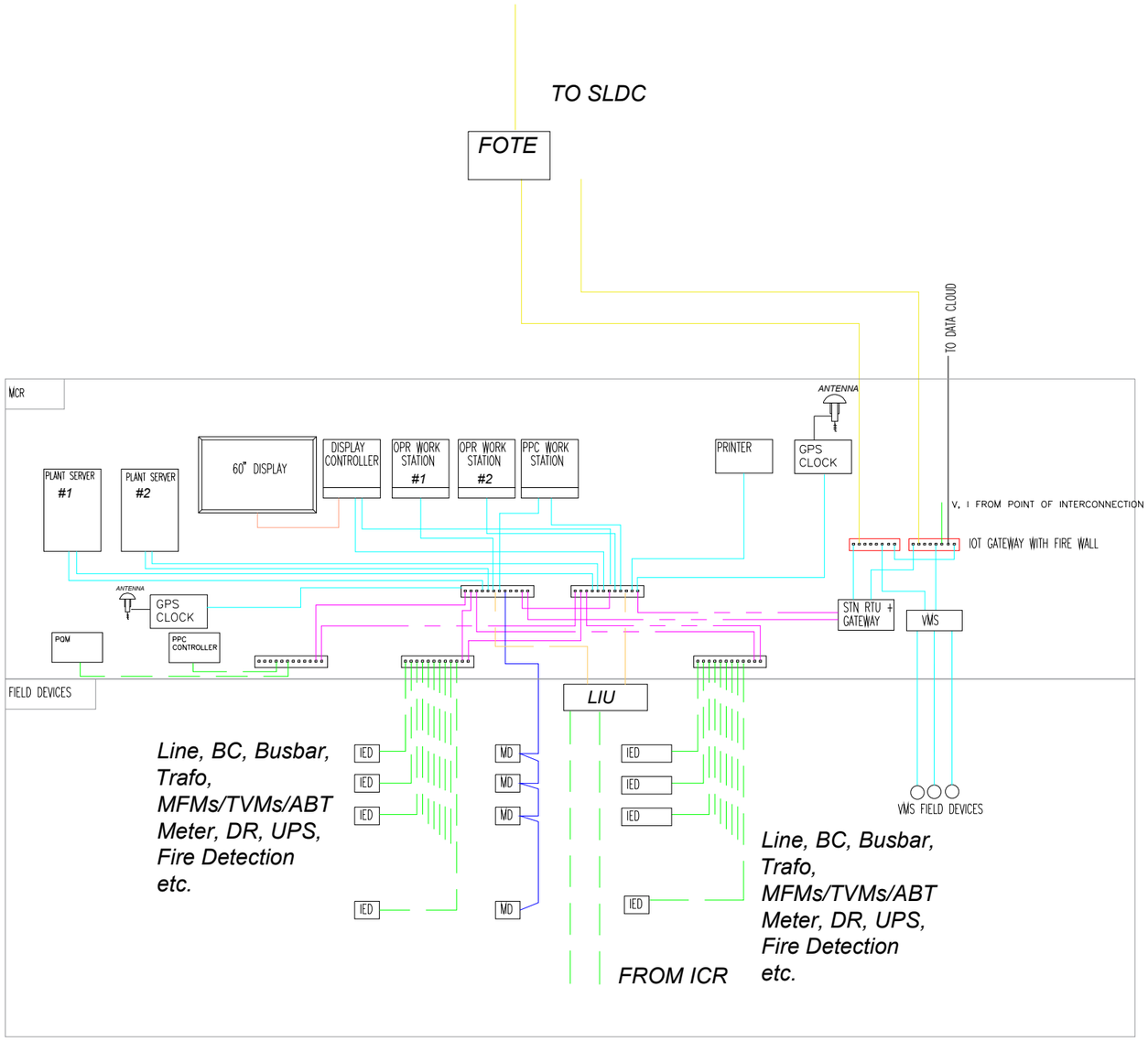
6.8 SYSTEM RATING VERIFICATION

BESS rating including rated power, energy available at rated power, and the performance of the BESS associated with different performance metrics mentioned herein taken at the beginning of life shall be based on a set of ambient operating conditions specified by the BESS Original Equipment Manufacturer (OEM) for the Project site. The Contractor shall also provide an indication of how the performance of the BESS with respect to the metrics is expected to change over time, to account for time and use of the system, and report the same periodically. The procedure and associated liquidated damages applicable in the event of a shortfall has been described in General Annexure: FG Test Procedure.

SUB-SECTION D

GENERAL ANNEXURE D

SCADA SCHEMATICS & I/O LIST (Indicative)



N

DEDICATED COMM LINK (IEC-60870-5-103/104)
FIBRE OPTIC (IEC-61850)
FO ETHERNET (IEC-61850)
ETHERNET (TCP-IP)
MODBUS (RS-485)
HARD-WIRING
PATCH CABLE
NETWORK ROUTER

SOLAR ENERGY CORPORATION OF INDIA

PREPARED BY	-------
PROJECT NAME	200 MW SPV PROJECT AT DHAR
DRAWING TITLE	IT ARCHITECTURE
DRAWING NO.	

ISSUED
☐ FOR REVISION ☐ FOR FABRICATION ☐ GOOD FOR CONSTRUCTION

	DRAWN BY	CHKD. BY	APPR. BY
	-------	-------	-------
DATE	-------	-------	-------

SHEET	SHEET SIZE	REV	SCALE
1 OF 1	A3	-------	1:40

INDICATIVE SCADA IO LIST

S No	Description		Signal Type	Signal Level	Unit	Alarm	SOE	Trend	Report
	220 kV Line Bay								
1	SF6 CB	Open/Close	DI	PF			Y		
2	SF6 CB	Auto Trip Operated/ Not Operated	DI	PF			Y		
3	SF6 CB Gas Pressure Low	SF6 Gas Pressure Low	DI	PF		Y			
4	CB L/R SWITCH	CB Local/Remote Mode	DI	PF			Y		
5	CB TRIP CIRCUIT SUPERVISION RELAY	Operated/Not Operated	DI	PF			Y		
6	CB TRIP CIRCUIT	Healthy/ Not Healthy	DI	PF			Y		
7	CB SPRING CHARGE	Charged/ Uncharged	DI	PF			Y		
8	CB D.C SUPPLY	Fail/ Not Fail	DI	PF		Y			
9	MASTER TRIP RELAY (86 RLY)	Operated/Not Operated	DI	PF		Y	Y		
10	MASTER TRIP RELAY RESET	Operated/Not Operated	DI	PF		Y			
11	Main -1 TRIP	Operated/Not Operated	DI	PF		Y			
12	Main -2 TRIP	Operated/Not Operated	DI	PF		Y			
13	OVER CURRENT/ EARTH FAULT (51N/ 50 RLY)	Trip/ Not Trip	DI	PF		Y			
14	OVER VOLTAGE/UNDER VOLTAGE (59/27 RLY)	Operated/Not Operated	DI	PF		Y			
15	DISTANCE RLY (21 RLY)	Operated/Not Operated	DI	PF		Y			
16	SYNCHRONISING RLY (25 RLY)	Fail/ Not Fail	DI	PF		Y			
17	BREAKER FAILURE RLY (50BF RLY)	Fail/ Not Fail	DI	PF		Y			
18	AC RECLOSING RELAY/AUTO RECLOSE RELAY (79 RLY)	Operated/Not Operated	DI	PF					
19	ISOLATOR	Open/Close	DI	PF			Y		
20	EARTH SWITCH	Open/Close	DI	PF			Y		
	220 kV - Transformer Bay	**Signal**							
1	Tr. BUCHHOLZ RLY	Alarm - Bucchoz Relay Operation	DI	PF		Y			
2	Tr. PR REL VLV	Alarm - Pressure Release Valve	DI	PF		Y			
3	Tr. LO OIL LVL	Alarm - Low Transformer Oil	DI	PF		Y			
4	Tr. WNDG TEMP	Alarm - Transformer Winding Temperature High	DI	PF		Y			
5	Tr. WNDG TEMP	Alarm - Transformer Winding Temperature Breach/Trip	DI	PF					
6	Tr. OIL TEMP	Alarm - Transformer Oil Temperature High	DI	PF		Y			
7	Tr. OIL TEMP	Alarm - Transformer Oil Temperature Breach/Trip	DI	PF					
8	Tr. WNDG TEMP	Transformer Winding Temperature	AI	4-20MA	DegC				
9	Tr. OIL TEMP	Transformer Oil Temperature	AI	4-20MA	DegC				
10	Tr. TAP POSITION	Transformer Tap Position	AI	4-20MA					
11	TAP	Increase Tap Position	DO	110V DC			Y		
12	TAP	Decrease Tap Position	DO	110V DC			Y		
13	DIFFERENTIAL RELAY(87T)	Operated/Not Operated	DI	PF					
14	GROUND PROTECTIVE RELAY (64 HV)	Operated/Not Operated	DI	PF					
15	GROUND PROTECTIVE RELAY (64 LV)	Operated/Not Operated	DI	PF					
16	R PH VOLTAGE	R Pahse Voltage	SOFT AI		KV			Y	
17	Y PH VOLTAGE	Y Phase Voltage	SOFT AI		KV			Y	
18	B PH VOLTAGE	B Phase Voltage	SOFT AI		KV			Y	
19	R PH CURRENT	R Phase Current	SOFT AI		A			Y	
20	Y PH CURRENT	Y Phase Current	SOFT AI		A			Y	
21	B PH CURRENT	B Phase Current	SOFT AI		A			Y	

S No	Description		Signal Type	Signal Level	Unit	Alarm	SOE	Trend	Report
	220 kV - Bus Bar and Bus Coupler Bay								
1	ACTIVE POWER	Active Power Generated	SOFT AI		KW			Y	
2	REACTIVE POWER	Reactive Power Generated	SOFT AI		KVAR			Y	
3	ENERGY	Energy Injected	SOFT AI		KWH			Y	
4	SF6 CB CMD	Close Command	DO	110V DC			Y		
5	SF6 CB \CMD	Open Command	DO	110V DC			Y		
6	ISOLATOR	Open/Close	DI	PF			Y		
7	EARTH SWITCH	Open/Close	DI	PF			Y		
	Energy Meters								
1	Energy Exported in 15 min to GRID	Plant End ABT Meter	SOFT AI	RS485	MWh				Y
	33 kV CB PANEL INCOMER FEEDER (FROM INVERTER TRANSFORMER)								
1	CB OPEN/CLOSE	VCB Open/ Close	DI	PF			Y		
3	CB IN REMOTE	VCB in Remote Mode	DI	PF			Y		
4	CB IN SERVICE	VCB in Service Mode	DI	PF			Y		
5	CB 86 OPERATED	VCB Master Trip Operated	DI	PF			Y		
6	CB TRIP CKT UNHEALTHY	CB Trip Circuit Unhealthy	DI	PF			Y		
7	CB SPRING CHARGED	VCB Spring Charged	DI	PF			Y		
8	CB PROTECTION TRIP	Protection Trip Operated	DI	PF			Y		
9	CB CONTROL SUPPLY HEALTHY	Control Supply Healthy	DI	PF			Y		
10	CB IN LOCAL	CB in Lcal Mode	DI	PF			Y		
11	CB IN TEST	CB in Test Mode	DI	PF			Y		
12	Tr. WNDG TEMP TRIP	Transformer Winding Temperature Tripped	DI	PF			Y		
13	Tr. WNDG TEMP ALARM	Transformer Winding Temperature Alarm	DI	PF		Y			
14	Tr. OIL TEMP TRIP	Transformer Oil Temperature Tripped	DI	PF			Y		
15	Tr. OIL TEMP ALARM	Transformer Oil Temperature Alarm	DI	PF		Y			
16	Tr. PRV TRIP	Pressure Release Valve Tripped	DI	PF			Y		
17	Tr. PRV ALARM	Pressure Release Valve Alarm	DI	PF		Y			
18	Tr. BUCHHOLZ TRIP	Buccholz Relay Tripped	DI	PF			Y		
19	Tr. BUCHHOLZ ALARM	Buccholz Relay Alarm	DI	PF		Y			
20	Tr. MOG TRIP	Magnetic Oil Gauge Trip	DI	PF			Y		
21	Tr. MOG ALARM	Magnetic Oil Gauge Alarm	DI	PF		Y			
22	R PH CURRENT	R Phase Current	SOFT AI	RS485	A			Y	
23	Y PH CURRENT	Y Phase Current	SOFT AI	RS485	A			Y	
24	B PH CURRENT	B Phase Current	SOFT AI	RS485	A			Y	
25	ACTIVE POWER	Active Power	SOFT AI	RS485	KW			Y	
26	REACTIVE POWER	Reactive Power	SOFT AI	RS485	KVAR			Y	
27	ENERGY	Energy Export	SOFT AI	RS485	MWH			Y	
28	CB CMD	CB Clode Command	DO	110V DC			Y		
29	CB CMD	CB Open Command	DO	110V DC			Y		

S No	Description		Signal Type	Signal Level	Unit	Alarm	SOE	Trend	Report
	33 kV OUTDOOR SWITCHYARD								
1	CB OPEN/CLOSE	CB Open/ Close	DI	PF			Y		
2	CB IN REMOTE	CB in Remote Mode	DI	PF			Y		
3	CB IN SERVICE	CB in Service Mode	DI	PF			Y		
4	CB TRIP CKT UNHEALTHY	CB Trip Circuit Unhealthy	DI	PF			Y		
5	CB SPRING CHARGED	CB Spring Charged	DI	PF			Y		
6	CB PROTECTION TRIP	Protection Trip Operated	DI	PF			Y		
7	CB CONTROL SUPPLY HEALTHY	Control Supply Healthy	DI	PF			Y		
8	CB IN LOCAL	CB in Lcal Mode	DI	PF			Y		
9	CB IN TEST	CB in Test Mode	DI	PF			Y		
10	ISOLATOR	Open/Close	DI	PF			Y		
11	EARTH SWITCH	Open/Close	DI	PF			Y		
12	OVER CURRENT/ EARTH FAULT (51N/ 50 RLY)	Trip/ Not Trip	DI	PF		Y			
13	AC DIRECTIONAL OVERCURRENT RELAY(67 RLY)	Trip/ Not Trip	DI	PF		Y			
14	BREAKER FAILURE RLY (50BF/50LBB RLY)	Fail/ Not Fail	DI	PF		Y			
15	DIFFERENTIAL RELAY(87T)	Operated/Not Operated	DI	PF					
	33 kV CB PANEL OUTGOING FEEDERS								
1	CB CLOSE/OPEN	CB Open or Close	DI	PF			Y		
3	CB IN REMOTE	CB in Remote Mode	DI	PF			Y		
4	CB IN SERVICE	CB in Service Mode	DI	PF			Y		
5	CB 86 OPERATED	CB Master Trip Relay Operated	DI	PF			Y		
6	CB TRIP CKT UNHEALTHY	CB Circuit Healthy/Unhealthy	DI	PF			Y		
7	CB SPRING CHARGED	CB Spring Charged Status	DI	PF			Y		
8	CB PROTECTION TRIP	Protection Trip Operated	DI	PF			Y		
9	CB CONTROL SUPPLY HEALTHY	Control Supply Healthy	DI	PF			Y		
10	CB IN LOCAL	CB in Lcal Mode	DI	PF			Y		
11	CB IN TEST	CB in Test Mode	DI	PF			Y		
12	CB UV PROTECTION OPTD	CB Undervoltage Protection Operated	DI	PF			Y		
13	R PH CURRENT	R Phase Current	SOFT AI	RS485	A			Y	
14	Y PH CURRENT	Y Phase Current	SOFT AI	RS485	A			Y	
15	B PH CURRENT	B Phase Current	SOFT AI	RS485	A			Y	
16	ACTIVE POWER	Active Power	SOFT AI	RS485	KW			Y	
17	REACTIVE POWER	Reactive Power	SOFT AI	RS485	KVAR			Y	
18	ENERGY	Energy	SOFT AI	RS485	MWH			Y	
19	CB CMD	Breaker Close Command	DO	110V DC			Y		
20	CB CMD	Breaker Open Command	DO	110V DC			Y		
	INVERTER TRANSFORMER & AUXILIARY TRANSFORMER								
1	TR WNDG TEMP (HV side)	HV Winding Temperature	AI	4-20MA	DegC				
2	TR WNDG1 TEMP (LV side)	LV Winding Temperature	AI	4-20MA	DegC				
4	TR OIL TEMP	Transformer Oil Temperature	AI	4-20MA	DegC				
	415V PANEL FOR ACDB								
1	ACDB CB	Operated/Not Operated/Ready Status	DI	PF			Y		
2	ACDB Bus Voltage								
3	ACDB R PH VOLTAGE (P-P)		SOFT AI	RS485	V			Y	Y
4	ACDB Y PH VOLTAGE (P-P)		SOFT AI	RS485	V			Y	Y
5	ACDB B PH VOLTAGE (P-P)		SOFT AI	RS485	V			Y	Y
6	ACDB R PH CURRENT (Incomer)		SOFT AI	RS485	A			Y	Y
7	ACDB Y PH CURRENT (Incomer)		SOFT AI	RS485	A			Y	Y
8	ACDB B PH CURRENT (Incomer)		SOFT AI	RS485	A			Y	Y
9	ACDB ACDB ENERGY (Incomer)		SOFT AI	RS485	MWH			Y	
10	ACDB ACDB POWER (Incomer)		SOFT AI	RS485	MW			Y	
	LT Panel at different locations								
1	CB Status		DI	PF			Y		

S No	Description		Signal Type	Signal Level	Unit	Alarm	SOE	Trend	Report
	PCU								
1	PCU IGBT Module Trouble	Yes/NO	DI	PF					
2	Input DC Voltage VOLT	DC Input Voltage	SOFT AI	TCP/IP	V			Y	Y
3	Input DC Current AMP	DC Input Current	SOFT AI	TCP/IP	A			Y	Y
4	Input DC Power KW	DC Input Power	SOFT AI	TCP/IP	KW			Y	Y
5	AC Voltage VOLT	AC Output Voltage	SOFT AI	TCP/IP	V			Y	Y
6	AC Current AMP	AC Output Current	SOFT AI	TCP/IP	A			Y	Y
7	AC Power KW	AC Power	SOFT AI	TCP/IP	KW			Y	Y
8	Frequency	Frequency	SOFT AI	TCP/IP	Hz			Y	Y
9	Power Factor	Power Factor							
10	Watt-hour meter KWH Export		SOFT AI	TCP/IP	KWH				Y
11	Reactive Power Output								
12	PCU Temperature		SOFT AI	TCP/IP	Deg C				Y
13	ON CMD	On Command	SOFT DO	TCP/IP					
14	OFF CMD	Off Command	SOFT DO	TCP/IP					
15	Active Power Limit		SOFT AO	TCP/IP					
16	Reactive Power Limit		SOFT AO	TCP/IP					
17	LVRT Start/End		SOFT AI	TCP/IP					
18	HVRT Start/End		SOFT AI	TCP/IP					
	Weather Monitoring Station (Nos. as per NIT)								
1	SOLAR Irradiance Horizontal		AI	4-20MA	W/M2			Y	Y
2	SOLAR Irradiance Tilted surface		AI	4-20MA	W/M2			Y	Y
3	SOLAR ENERGY Horizontal		SOFT AI					Y	Y
4	SOLAR ENERGY Tilted surface		SOFT AI					Y	Y
5	WIND VELOCITY AND DIRECTION		AI	4-20MA	kM/h			Y	Y
6	Ambient Temperature		AI	4-20MA	degC			Y	Y
7	Module Surface Temperature		AI	4-20MA	degC			Y	Y
	Other Signals (MCR/ ICR)								
1	FIRE ALARM PANEL		DI	PF		Y			
2	DC SYSTEM SIGNAL		DI	PF		Y			
3	UPS BATTERY		DI	PF		Y			
4	UPS INVERTER		DI	PF		Y			
5	UPS BATTERY		DI	PF		Y			
6	UPS CHARGER		DI	PF		Y			
7	UPS VOLTAGE		SOFT AI	RS485					
8	UPS CURRENT		SOFT AI	RS485					
9	GPS CLOCK STATUS	GPS Clock Status/Alarm	DI	PF		Y			
10	DFR STATUS	Disturbance Fault Recorder Status	DI	PF		Y			
11	PMU Status	PMU Status	DI	PF		Y			

PMU and Disturbance Recorder Data to be separately recorded and stored

The I/O List is indicative only and not exhaustive. The Contractor shall finalise the SCADA I/O list during detailed Engineering.

SUB-SECTION D

GENERAL ANNEXURE E

FQP & MQP for Civil & MMS Works

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Sr.No.**	**Activity & Operation**	**Instruments**	**Class of Check**	**Type of Check**	**Quantum of Check**	**Reference Documents & Acceptance Standard**	**Format of Record**	**D*** (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	**Cheking Agency**			**Remarks**
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		**M'fr/ Supplier or Sub-Contractor**	**EPC Contractor**	**SECI or Owner**	
3	**1**	**General Requirements**											
4	a	Availability of requisite test set-up and equipment in good working condition with valid calibration at site well before commencement of concerned activity	As required/ agreed	Critical	Physical	Once prior to start of work & Monthly there after	Tech. Specs, Construction Drawings	SR	√		**x**	**x**	**Min. list of equipment** - CTM, Set of Seives for CA & FA, Elcometer (digital), Micrometer, Multimeter, Meggar, Torque Wrench, Moulds for casting of concrete/ mortar test samples, Curing tank of adequate size, SS measuring tape - 50m, Theodolite, leveling staff and associated equipment etc. for day to day work with proper storrage racks. The equipment shall be in adequate no. matching the site progress requirements. Functioning of laboratory equipment in proper working condition to be verified on monthly basis
5	b	Submission of QA & QC manpower deployment schedule based on agreed L-2 network	As required/ agreed	Critical	Verification	Before start of work	Tech. Specs, Construction Drawings	SR	√		**x**	**x**	
6	c	Availability of QA & QC manpower deployment based on agreed deployment schedule, Periodic review for augmentation as per actual progress	As required/ agreed	Critical	Physical	Once prior to start of work & Monthly there after	Tech. Specs, Construction Drawings	SR	√		**x**	**x**	
7	d	Submission of schedule/ programme of tests and inspection of civil works (survey, excavation, concreting, backfilling, brickwork, finishing works, roads, drains etc.) to be done monthly and quarterly based on agreed schedule	As required/ agreed	Critical	Physical	Once prior to start of work & Monthly/ Quarterly there after	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
8	e	Submission of actual work programme min. 3 days (72 hours) in advance to facilitate planning for quality checks as per approved QP	As required/ agreed	Critical	Physical	48 hours before start of actual work	Master programme/ schedule	SR	√	**x**	**x**	**x**	
9	f	Stacking and storage of construction materials and components at site	IS: 4062	Critical	Physical	Random	Tech. Specs, Construction Drawings & IS: 4062	SR	√	**x**	**x**	**x**	
11	**2**	**Surveying (Execution phase)**											
12	a	Availability of Calibrated Instruments, qualified & experieced staff at site	As required/ agreed	Critical	Physical	100%	Tech. Specs, Construction Drawings, Agreed deployment schedule	Calibration Report	√	x	x	x	
13	b	Ensure correct Boundary Layout and Latitude-Longitude Coordinates,True North	construction Drawings	Critical	Measurement	100%	Tech. Specs, Construction Drawings	SR	√	x	x	x	
14	c	GL (ground level), FGL (finished ground level) and Plinth Level, Check PBM(permanent bench mark) with Total Station/ Theodolite and after conformation carryout Peg marking	As required/ agreed	Critical	Measurement	100%	Construction Drawings	SR	√	x	x	x	
16	**3**	**Materials**											
17	A	*Cement*											
18	i	Fineness	As per IS: 4031	Critical	Review of MTC/ Physical	One test at Lab to corelate with MTC	IS:456,IS:269,IS:8112, IS:12269,IS:1489, Tech. Specs	Manufacturers Test Certificate (MTC's) and Laboratory Test results	√	**x**	**x**	**x**	Each consignment/ lot of cement shall be duly correlated with MTC If cement stored is more than 60 days in godown the same shall be re-tested for conformation with MTC
19	ii	Compressive Strength											
20	iii	Initial & final setting time											
21	iv	Chemical composition of Cement											
22	B	*Coarse Aggregates (CA)*											

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23	i	Determination of Particle size (Sieve Analysis), Flakiness index, Elongation index	As per IS: 2386	Major	Visual	Once per 100 cum or part thereof (During monsoon moisture content to be checked every day)	IS:383,IS:2386, Tech. Specs	Lab Test results	√	**x**	**x**	**x**	Water content of concrete to be corrected as per results of moisture content
24	ii	Moisture content											
25	iii	Crushing Value, Impact value, Abrasion value		Critical		One test at Lab for each source/ on every change of source			√	**x**	**x**	**x**	These tests shall be carried out while establishing design mix. In case of change of source the design mix shall be re-validated for new source
26	iv	Specific Gravity, water absorption											
27	v	Bulk Density											
28	vi	Soundness											
29	vii	Presence of deleterious materials											
30	C	*Fine Aggregate (FA)*											
31	i	Gradation/Determination of Particle size (Sieve Analysis)	Balance, Oven etc. As per IS: 2386, 383	Major	Visual	Gradation - Once per 1000 cum or part there of Mosture content - Every day	IS:383,IS:2386,IS:456 , Tech. Specs	Lab Test results	√	**x**	**x**	**x**	Water content of concrete to be corrected as per results of moisture content
32		Moisture Content											
33	ii	Specific Gravity and density (for design mix concretes only)	As per IS: 2386, 383	Major	Visual	One test at Lab for each source/ on every change of source							
34	iii	Water absorption (for design mix concretes only)											
35	iv	Presence of deleterious materials											
36	D	*Concrete Admixture*											
37	i	Type of admixture			Review of MTC		IS: 9103, Approved design mix		√	**x**	**x**	**x**	Admixture shall be of brand and type as per approved design mix.
38	ii	Physical & Chemical properties			Review of MTC		IS: 9103, Manufacturer's Brochure						Each lot/ batch of admixurture shall acompany the Manufacturer's Brochure and shall be correlated with MTC
39	iii	Suitability											
40	E	*Bricks*											
41	i	Dimensional Tolerance, shape			Measurement/ Physical	As per relevant IS code/ one sample for 30,000 nos. or part there of	IS: 1077, IS: 13757, IS: 12894, Tech. Specs, Construction Drawings	Lab Test results	√	**x**	**x**	**x**	Efflorescence shall be checked at each source
42	ii	Compressive Strength											
43	iii	Water Absorption											
44	iv	Efflorescence			Visual								
45	E	*Water*											
46	i	Cleanliness - Test for ascertaining limit of solids		Major		One per 3 months for each source	IS:456,IS:3025 (part 18), Tech. Specs, Construction Drawings specification	Lab Test reports	√	**x**	**x**	**x**	Water to be used for concrete shall be of potable quality and shall meet requirements specifed in IS: 456
47	ii	Chemical Tests to ascertain the suitability for construction purposes - pH Value, Sulphate & Chloride content					IS:456,IS:3025 (part 22, 23), Tech. Specs, Construction Drawings	Lab Test reports	√	**x**	**x**	**x**	
48	F	*Reinforcement Steel*											
49	i	Identification & Size		Major	Visual	Each batch of delivery	IS:432,IS:1786,IS:1852, Tech Specs	SR	√	**x**	**x**	**x**	Reinforcement steel shall be stored properly at site to avoid rusting
50	ii	Freedom from cracks, surface flaws, lamination				Random in each shift			√	**x**	**x**	**x**	
51	iii	Tensile Test		Critical	Review of MTC	Each batch of delivery	IS:432,IS:1566,IS:1786, Tech Specs	Manufacturers Test Certificate (MTC's)	√	**x**	**x**	**x**	
52	iv	Yield stress/proof stress											
53	v	Percentage Elongation							√	**x**	**x**	**x**	
54	vi	Bend/Rebend Test											
55	vii	Reverse Bend Test for HDS wire					IS:432, Tec. Specs		√	**x**	**x**	**x**	
57	**3**	**Structural Steel Work {Example: Chequered plate cover, Panel supports, Rungs, Cat lader, Inserts, Fencing gate (MS) etc.}**											
58	i	Strutural Steel (Raw material)-Chemical Properties, Ultimate Tensile Strength(UTS), Yield Strength (YS), Percentage Elongation, Bend test		Critical	Review of MTC	For each batch of each section	IS: 2062, IS: 8500, Tech. Specs, Construction Drawings	Manufacturers Test Certificate (MTC's)	√	**x**	**x**	**x**	MTC to be correlated
59	ii	Dimensional Check - Secition dimensions, thickness		Critical	Measurement	10% of total quanity at Random			√	**x**	**x**	**x**	For Fencing gate - dimensional check 100%

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60	iii	Visual checks for damages, rusting, pitting, scaling etc.		Major	Visual	100%	IS: 822, Tech. Specs, Construction Drawings, MTC, relevant BIS standards for painting	Manufacturers Test Certificate (MTC's)/ SR	√	**x**	**x**	**x**	
61	iv	Visual checks for welding defects, painting (surface preparation, primer coat, and Finishing coat - make and shade of paint, DFT) as applicable.		Major	Visual/ Measurement/ Review of MTC	10% of total quanity at Random			√	**x**	**x**	**x**	MTC to be correlated
62	v	Acceptance ofStructural steel works		Major	Physical/ Acceptance	Random	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
64	**4**	**Foundation System**											
65	**A**	**Bored Cast in-situ Concrete Piling (for MMS support)**											
66	**a**	**Execution**											
67	i	Ensuring correctness of layout		Critical	Physical	100%	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
68	ii	Checking of pile making as per drawing	Total Station	Major	Vsual								
69	iii	Checking of Centre line of Pile Group	Total Station	Critical	Physical								
70	iv	Check Pile Location	Total Station										
71	v	GL, Pile depth, diameter and alignment	As required		Measurement								1. During boring of pile, record SPT/ core recovery to ensure socketing length in the hard strata equivalent in terms of pile diameter in hard rock zone as per tech Specs and approved construction drawings. 2. In case of collapse of pile bore during drilling temporary MS lining shall be used. 3. Lines and levels to be checked 4. Each bore shall be cleaned of any loose materail by pressure jet washing/ cleaning by air jet 5.The column section shall pe placed and held in position in true vertical alignment using template/ tripod till initial setting of concrete 6. Concrete garde - as per Construction Drawing
72	vi	Cleaning/ flushing of pile bore	As required	Major	Visual		IS 2911, Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
73	vii	Insertion & positioning of Column post in the bore hole (in case of embeded col. Leg) Placement of reinforcement and foundation bolts with template (inacse of fixing of col. with base plate & foundation bolt assembly)	As required	Critical	Visual/ Measurement								
74	viii	Acceptance of Pile casting - Shape, reinforcement or col. leg embedment (as aplicable), concreting, compacting with use of needle vibrator etc.	As required/ Agreed	Major	Visual								
75	ix	Grouting u/s of base plate	As required/ Agreed	Critical	Visual	100%	Tech. Specs & Construction drawings	SR	√	**x**	**x**	**x**	The type, grade and thickness of grout shall be as per approved drawing
76	**b**	**Testing**											
77	i	Initial pile load test - Compression (Vertical), Lateral (Horizontal), & Pull out (Tension)	Calibrated dial gauges, jack of required capacity, datum bars etc.	Critical	Physical	100% for 3 no. for each type of test or as specified in Tech Specs, Approved test pile layout	IS 2911, Tech Specs, Construction Drawings	Test Report	√	**x**	**x**	**x**	1. The R/F details shall be as per approved drawing for test plie (if applicable), 2. The test load shall be up to 2.5 times of required pile capacity in case of Compression and Lateral load and 2 times in case of Pull out test as per IS: 2911 (Pt. 4), 3. The location shall be as per approved pile test programme/ layout drawing 4. The test shall be carried out as per approved methodology 5. Test report along with test records shall be submitted in standard format as per IS:2911
78	ii	Routine pile tests - Pull out and Lateral		Critical	Physical	100% for 0.5% of total no. of working piles for each type of test	IS 2911, Tech Specs, Construction Drawings	Test Report					1. The piles for routine tests shall be selected at Random to represent total no. of job piles insalled 2. The test load for vertical and pull out shall be 1.5 times the required pile capacity 3. The test shall be carried out as per approved methodology. 4. The Test report along with test records shall be submitted in standard format as per IS:2971 (Pt. 4)

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80	**B**	**Cable Trench/ Building & Equipment Foundations**											
81	**a**	Before Excavation											
82	i	Ensuring correctness of layout		Critical	Physical	100%	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
83	ii	Checking of trench marking & alignment		Major	Visual		Tech Specs, Construction Drawings						
84	**b**	Excavation											
85	i	Dimensional conformity including diagonal check		Ctitical	Visual / Measurement	100%	IS:3764, Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
86	ii	Excavated earth kept away from edges		Minor	Visual	Random		SR	√	**x**	**x**	**x**	
87	**c**	Acceptance of Trench/ Foundation casting - Shape, reinforcement, shuttering, concreting, etc.		Minor	Physical	100%	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
89	**5**	**Foundation Bolts / Inserts/ Concrete embedments**											
90	i	Visual check of mechanical damage and galvanising painting if applicable on inserts			Visual / Measurement	100%	As per Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
91	ii	Bolt and assecories, inserts - Dimensions (total & threaded length & dia of bolt, size & thk of embedment and lugs etc.), Nos											
92	iii	Verticality, alignment, levels, pitch distance, embeded and projected length of bolt											
93	iii	Use of template for Alignment and Level checking											
94	iv	Acceptance of foundation bolt assembly / inserts in postion											
96	**6**	**Formwork**											
97	i	Materials & Accessories	As agreed/ required	Major	Visual	Once before start of work	IS :456 , Other relevant BIS Standard, Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
98	ii	Soundness of staging, shuttering and scaffolding including application of mould oil/ release agent	As agreed/ required	Major	Visual	Once before start of work	Manufacturer's specs, IS :3096, IS:4014, IS: 4990, Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
99	iii	Dimensional Check, alignment & levels as per drawing and tolerences		Major	Visual/ Measurement	100%	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
100	iv	Proper sealing of joints, Acceptance of formwork before concreting		Major	Physical/ Visual	Before start of concreting	As per provisions, tolerences, Tech. Specs, Construction drawings		√	**x**	**x**	**x**	
102	**7**	**Placement of Reienforcement Steel**											
103	i	Check whether Bar bending schedule (BBS) with necessary lap, spacers & chairs is available before start of cutting & bending of bars	As agreed/ required	Major	Visual/ physical	Random in each shift at each work site	Tech. Specs, Construction Drawings, IS: 2502	SR	√	**x**	**x**	**x**	
104	ii	Check whether cutting and bending of bars is as per BBS and placement conforms construction drawings			Visual/ measurement								
105	iii	Check whether all joints and crossing of bars are tied properly with right gauge and annealed wire			Visual								

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106	iv	Check for proper cover,spacing of bars, spacers & chairs after the reinforcement cage has been put inside the foundation			Visual								
107	v	Check whether lapping of bars are tied properly with right gauge and annealed wire			Visual								
109	**8**	**Concrete**											
110	i	Availability of approved Design Mix (for all specified grades)		Critical	Physical	For each specified grade of concrete	IS :456, Tech Specs, Construction Drawings	Approved mix design	√		**x**	**x**	The concrete shall be as per approved design mix and the materials (cement, coarse and fine aggregate shall be from the same source considered during mix trials. The mix design shall be verified and approved in case of change of source of any of the matearials
111	ii	Minimum cement content (as applicable in MMS piling and foundation/ below ground works)		Critical	Physical	For piling and foundation works	IS: 456, Tech. specs, Construction drawings	SR	√		**x**	**x**	The minimum cement content shall correspond to exposure conditions and/ or, suplphate contents in ground water/ soil
112	iii	Trial mixes to ascertain the workability and cube strength	As per recommended mix design from specialist agency	Critical	Physical/ Testing	One for each mix proportion	Tech. Specs, IS: 456	Lab Test Reports	√	**x**	**x**	**x**	Necessary correction for moisture content and water absoption according to mix design recommendations may be carried out during trial mix
113	iv	Mixing of concrete- check for quanities of cement, CA, FA and water used, Concrete shall be homogenous	Mixing shall be done in a approved mixer/ batching plant (conforming to IS: 4926/ 4925)	Major	Physical	Mixer/ Batcher to be calibrated at the time of starting and subsequently once in tree months	IS: 4925, IS: 4926	Calibration Report/ Certificate	√	**x**	**x**	**x**	Review of calibration chart/ Certificate as per IS: 4926 Qty. of materials including cement consumptionshall be available through on line printer
114	v	Handling & trasportation	As required	Major	Physical	100%	As per approved/ agreed construction methodology	SR		**x**	**x**	**x**	Concrete shall be placed within 30 minutes of its removal from mixer
115	vi	Placement of concrete	As required	Major	Visual/ Physical	100%			√	**x**	**x**	**x**	
116	vii	Compacting	As required	Major	Physical	At Random			√	**x**	**x**	**x**	
117	viii	Curing	As required	major	Physical	At Random	IS: 456	SR		**x**	**x**	**x**	
119	**9**	**Concrete Testing & Acceptance**											
120	i	Workability - Slump Test		Critical	Physical	At the time of concrete pouring at site every 2 hrs	IS:456, IS:516,IS:1199, Tech Specs, Construction Drawings	Test Results / SR	√	**x**	**x**	**x**	
121	ii	Crushing strength - (Works test cubes)		Critical	Physical	Testing	IS:456, IS:516,IS:1199, Tech Specs, Construction Drawings	Test Results/ SR	√	**x**	**x**	**x**	**MMS Pile** - 6 cubes (3 for 7 day test & 3 for 28 day strength) per sample for each 5 cum or part there off **Building work and Equipment/ Misc foundations etc.** - 6 cubes (3 for 7 day test & 3 for 28 day strength) per sample for each 25 cum or part there off
122	iii	Acceptance of concrete work - Dimensional check (dimensions, levels etc), placement of bolts, inserts, pockets, pitch distance for bolts etc.	As required & dimensional tolerences	Major	Visual/ Measurement	100%		Joint Protocol between Civil Conractor, EPC Vendor and SECI/ Owner where applicable/ SR	√	**x**	**x**	**x**	
124	**10**	**Acceptance of Hardened Concrete**											
125	i	Dimensional check (dimensions, levels etc), workmanship, finsishing after removal of shuttering	As required & dimensional tolerences	Major	Visual/ Measurement	At Random			√	**x**	**x**	**x**	

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126	ii	Water tightness test for liquid retaining structures/ tanks	As required	Critical	Physical/ Testing	100%	IS: 3370 (Pt.4), Tech Specs, Construction Drawings	SR/ Test Records	√	**x**	**x**	**x**	Water tightness test shall be performed for Under ground (UG) water tank, Septic tank
128	**11**	**Excavation & filling in foundations, trenches, plinth & grading works**											
129		**Excavation**											
130		Nature, Type of soil/ rock before and during excavation		Major	Visual	Random in each shift	Tech. Specs., Construction Drawings	SR		**x**	**x**	**x**	
131		Initial GL before start of excavation		Major	Measurement	100%		SR	√	**x**	**x**	**x**	
132		Final shape/ size & dimensions of excavation		Major	Measurement	100%		SR	√	**x**	**x**	**x**	
133		Final excavation levels		Major	Measurement	100%		SR	√	**x**	**x**	**x**	
134		Side slope of final excavation		Major	Measurement	Random in each shift		SR		**x**	**x**	**x**	
135	**12**	**Fill / Backfill**											
136	i	Suitability of borrowed earth for filling (if applicable) - Grain size analysis, Atterberg limits, Free swell index, Organic matter		Major	Physical	One in every 2000 cum or part there of for each type and source of fill material subject to min. 2 samples	IS: 2720 (Pt. IV), IS: 2720 (Pt. XI), Tech Specs, Construction Drawings	Lab Test Results/ SR	√	**x**	**x**	**x**	The parameter should not be worse than the parameter of the existing soil in plant area
137	ii	Optimum moisture content (OMC), Max. dry density (MDD) before fill		Critical	Visual	At Random	IS: 2720 (Pt. I), IS: 2720 (Pt.VII), Tech Specs, Construction Drawings	Lab Test Results/ SR	√	**x**	**x**	**x**	
138	iii	Layer thickness, Compaction procedure		Major	Visual	At Random	Approved Methodology, Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	The layer thickness, Type & Capacity of roller, No. of passes shall be as per approved methodology, Construction Drawing, Tech. Specs
139	iv	Degree of compaction - 1. Dry density by proctor needle penetration 2. Earth filling - In-situ Dry density (core cutter or sand replacement method) or Sand Filling - In-situ Relative density (Density Index)		Critical	Physical	(i) For foundation fill/ backfill - One for every 10 foundations at Random for each compacted layer (ii) For area grading/ filling - one every 1000 sqm area for each compacted layer	IS: 2720 (Pt. XXIX), IS: 2720 (Pt. XXVIII), IS: 2720 (Pt. XIV), Tech Specs, Construction Drawings	Test Results/ SR	√	**x**	**x**	**x**	
141	**13**	**Brick masonry work**											
142	i	Soaking of Bricks before use		Major	Physical	100%	IS: 2250	SR		**x**	**x**	**x**	
143	ii	Grading of sand, Mortar mix / proportion, Compressive strength, Consistency		Major	Physical/ Test	At Random	IS: 2250, IS: 2116, Tech Specs, Construction Drawings / As per Design Specification	Lab Test Results/ SR		**x**	**x**	**x**	The sand grading shall conform to IS: 2116
144	iii	Workmanship, Verticality (Plumb) / Alignment		Major	Physical/ Measurement	100%	IS: 2212, IS: 1905, Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
145	iv	Check for Bond/closers, joints		Major	Visual	At Random	IS: 2250	SR		**x**	**x**	**x**	
146	v	Curing		Major	Visual	100%	IS: 2250 / As perTech. Specification	SR		**x**	**x**	**x**	
148	**12**	**Cement Plaster**											

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149	i	Quality & Grading of sand, Check for mix proportion, wetting the surface etc		Major	Physical	At Random	IS: 2116, IS: 2386 (Pt. I & II), IS: 1542, Tech Specs	Lab Test Results/ SR		x	x	x	Sand to be used shall be free from deleteriousmaterials, Grading shall conform to Table-I of IS: 2116
150	ii	Plaster & grooves - Thickness, Evenness & Finishing, Trueness os palstering system		Major	Visual/ Measurement	At Random in each shift	Tech Specifications, Construction Drawings	SR	√	x	x	x	Trueness - Deviation not more than 4mm when checked with straight edge of 2m length
151	iii	Hacking, Raking of joints, Cleaning the surface, Removing all loose particles, Wetting the surface etc		Major	Visual	At Random in each shift	IS 1661, Tech Specs	SR		x	x	x	
152	iv	Curing		Minor	Physical	100%	IS 1661, Tech Specs	SR		x	x	x	
154	**14**	**Painting System - Plastered Masonry & Concrete surface**											
155	i	Materials & accessories - Approval for Paint, Color shade and Brand- Dry distemper, Oil Bound Distemeper, Acrylic Emulsion, Chemical resistant, Oil resistant Paint, Weather proof acrylic exterior paint, water proof cement paint etc.	As approved by SECI/ Owner	Critical	Review of MTC	Each batch of delivery	Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	MTC shall be correlated with the material received
156	ii	Surface preparation	As required	Minor	Physical	Random in each shift	IS: 2935 (Pt.1), Tech Specs, Construction Drawings	SR	x	x	x	x	
157	iii	Number of coats	As required	Major	Physical	Random in each shift	Tech Specs, Construction Drawings	SR	x	x	x	x	
158	iv	Application and Acceptance of painted surface	As required	Major	Physical	Each surface at Random							
160	**15**	**Floor finishes & Alied works**											
161	i	Preperation of Sub-grade			Physical	At Random for each building	Tech. Specs, Construction Drawings	SR	√	x	x	x	
162	ii	Plinth filling in layers (stone agrregates/ rubble with interstices filled with sand), ramming & compaction			Physical	At Random for each building	IS: 2720, Tech. Specs, Construction Drawings		√	x	x	x	Quality Checks as aplicable to Fill/ Back fill
163	iii	Check providing shuttering, reinforcement (if applicable)			Physical	At Random for each building	Tech. Specs, Construcion Drawings			x	x	x	Quality Checks as aplicable to Shuttering/ Reinforcement placement
164	iv	Checking the Panel size (as applicable)			Physical	At Random for each building	IS: 5491, Tech. Specs, Construcion Drawings			x	x	x	The concrete shall be cast in alternate panels in chess board fashion, panel size as specified in Construction Drawing or 25 sqm
165	v	Availability of Design mix (if applicable)			Visual	At Random for each building	Tech. Specs, Construcion Drawings	Mix Design Report/ SR		x	x	x	
166	vi	Clearance for concreting (as applicable)			Physical	100%	Tech. Specs, Construction Drawings	Joint Protocol between Civil Contractor, Eqpt. Supplier/ EPC Vendor & SECI/ Owner SR		x	x	x	
167	viii	Performing concreting ensuring Grade/Mix Proportions, Compaction, Thickness and Finish			Physical	At Random per shift	IS; 456, Tech. Specs, Construction Drawings	SR	√	x	x	x	Quality Checks as aplicabel to Concrete Work
168	viii	Curing			Visual	100%	IS: 456, Tech. Specs	SR		x	x	x	Minimum up to 10 days from date of casting
169	ix	Testing of Concrete Cubes for Flooring			Physical	One sample for every 20 Cum of concreting or part thereof for each days concreting (one sample consists of min 3 test cubes for 28 days strength)	IS:456, IS:516,IS:1199 and Design specification	Lab Test Reports					
170	x	Tiled flooring/ dado											

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171	a	Material - Glazed ceramic Tiles, Vitrified Ceramic Tiles, Mosaic Tailes, Acid alkali Tiles, Heavy duty cement concrete tiles	As agreed/ required	Critical	Review of MTC & Test Reports	Each lot of material received	IS:13755, IS:1237, IS:8042, Tech Specs, Construction Drawings	MTC/ SR	√	x	x	x	MTC shall be correlated for all the parameters specified in Tech. Specs, BIS Standard
172	b	Finishing & Acceptance		Major	Physical	100%	IS: 1443, Tech Specs, Construction Drawings						
173	xi	IPS with or without IRONITE (as aplicable)		Major	Physical	At Random per shift	IS: 5491, Tech. Specs, Construction Drawings	SR	√	x	x	x	
174	xi	Fixing of Panel Dividers for finishing course (3 mm Thk Glass/ 2mm Thk Aluminium strip) (if applicable)		Major	Physical	At Random per shift	Tech Specs, Construction Drawings	SR	√	x	x	x	
175	xii	Anti abrasion/ anti wearing epoxy coating (if aplicable)											
176	a	Material	As agreed/ required	Critical	Approved Make and Type	Each lot of material received	Tech Specs, Construction Drawings, Manufacturer's Brochure/ Recommendations	manufacturer's Brochure/ SR	√	x	x	x	Material specifications to be correlated with Manufacturer's Brochure
177	b	Finishing & Acceptance		Major	Physical	100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
178	xiv	Kota stone flooring and skirting (as aplicable)											
179	a	Material	Quality, Texture, Thickness, Colour fro approved source	Major	Physical	Each batch of delivery	Tech Specs, Construction Drawings	SR	√	x	x	x	
180	b	Finishing & Acceptance		Major	Physical	100%	Tech Specs, Cosntruction Drawings	SR	√	x	x	x	
181	xv	Acid/ Alkali resistant tile flooring/ dado											
182	a	Material -Tiles, Mortar, Sealing, Fillers etc.	Thickness, Quality,	Critical	Approved source, Review of MTC/ Test Report	Each batch of delivery	Tech Specs, Construction Drawings	SR	√	x	x	x	The acid alkali resistant tile flooring nd dado shall be provided in battery room as per approved Arch finishing details
183	b	Finishing & Acceptance	Workmanship	Major	Physical	100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
184	xvi	Interlocking Blocks											
185	a	Materials	Size/ Shape, colour shade, Grade of Concrete	Critical	Approved source, Review of MTC/ Test Report	Each batch of delivery	BS: 6717, Tech Specs, Construction Drawings	SR	√	x	x	x	
186	b	Final finishing & Acceptance	As agreed/ required	Major	Physical	100%	BS: 7533 (Pt.3), Tech Specs, Construction Drawings	SR	√	x	x	x	
188	**16**	**Damp Proof Course**											
189	i	Material - Hot bitumen & water proofing materials etc.	As agreed/ required	Critical	Review of MTC	Each batch of delivery	IS: 702, Tech. Specs, Cosntruction Drawings	SR	√	x	x	x	
190	ii	Acceptance of Damp Proof Course - Thickness, Grade of PCC, Application of Bitumen layer etc.	As agreed/ required	Major		100%	Tech Specs, Construction Drawings	SR	√	x	x	x	
192	**17**	**Grouting of pockets/ underside of base plate**											
193	i	Material	As required/ Agreed	Critical	Review of MTC/ Physical	Each batch of delivery	Tech. specs, Construction Drawings, Manufacturerr's catelogue	SR	√	x	x	x	In case of ready mixed grout MTC to be correlated with Manufacturerr's catelogue
194	ii	Type of Mix	Anti shrink cement grout/ Ready mixed - Fluid mix, stiff mix as required	Major	Physical	At Random prr shift of grout application	Tech. specs, Construction Drawings	SR	√	x	x	x	In case of cement grout anti shrink compound shall be added as per provisions of relevant IS/ Cosntruction Drawing
195	iii	Mixing, placement, application	As required	Major	Visual	At Random prr shift of grout application	Tech. Specs, Construction Drawings	SR	√	x	x	x	
196	iv	Crushing Strength - Test cubes	As required	Major	Physical/ Testing	3 cubes for entire grouting work	IS: 4031 (Pt.6), Tech Specs, Construction Drawings	SR/ Lab Test Report	√	x	x	x	

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197	v	Acceptance of Grouting	Thickness, Finished level etc.	Major	Physical	!00% of 20 % of grout work at Random	Tech. Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
199	**18**	**Precast Concrete**											
200	**a**	**Bought Out Units (Precast boundary wall units - Slab Panels, Column etc., Trench Covers , Manhole Covers, Paver Blocks etc.)**											
201	i	Crushing strength	As required	Critical	Review of MTC/ Test Reports	100% for Each batch of delivery	IS: 456, IS:516, IS: 1199, Tech Specs, Construction Drawings	MTC	√	**x**	**x**	**x**	Sampling as per IS: 456, Vendor record review
202	ii	Workmanship, dimentions, R/F	As require/ agreed	Major	Review of MTC/ Physical	Each batch of delivery at Random	Tech Specs, Construction Drawings	MTC/ SR	√	**x**	**x**	**x**	Vendor record review, Physical check at Random
203	**b**	**Cast at site (if applicable)**											
204	i	Crushing strength - Test Cubes	As required	Critical	Testing		IS: 456, IS:516, IS: 1199, Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	1 sample of 6 cubes (3 for 7 days strength, 3 for 28 days strength) for each 5 cum of concrete with minimum 1 sample per shift of concrete work
205	ii	Workmanship, dimentions, R/F	As required/ agreed	Major	Physical	At Random	Tech Specs, Construction Drawings	SR		**x**	**x**	**x**	
206	**c**	**Acceptance of pre-cast concrete units**											
207	i	Bought Out Units - Check for any breakage, damage during handing & trasport, erection at site (levels) etc.	As required/ Agreed	Major	Visual	At Random	Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
208	ii	Cast at site (if applicable) - Check for curing, damage during handling, erection at site (level) etc.	As required/ Agreed	Major	Visual	100% of 10% at Random	Tech Specs, Construction Drawings	SR	√	**x**	**x**	**x**	
210	**19**	**Joints In concrete**											
211	i	Joint Material - Bitumen inpregnataed fiber board, PVC water stop, Sealing compound - Bitumastic/ polysulphide, Hydrophilic strip, Expanded polysterene (thermocol) board etc.	As per manufacturer's standards	Critical	Review of MTC	Each batch of delivery	Tech. Specs, Construction Drawings, IS: 1838, IS:1834, IS:2200	MTC	√	**x**	**x**	**x**	
212	ii	Acceptance of installation	As agreed/ required	Major	Physical	Each installation at Random	Tech. Specs and Construction Drawings	SR	√	**x**	**x**	**x**	
214	**20**	**Underdeck Insulation Works**											
215	i	Insulation material - Mineral/ Glass wool, galvanized wire neting, Aluminium foil, fasteners etc.	As agreed/ required	Critical	Review of MTC/ Test Reports	Each lot received at site	Tech. Specs and Construction Drawings	MTC/ Test Reports/ SR	√	**x**	**x**	**x**	All tests as per Tech. Specifications
216	ii	Acceptance of installation	As agreed/ required	Major	Physical	Each installation	Tech. Specs and Construction Drawings	SR	√	**x**	**x**	**x**	
218	**21**	**False Ceiling**											
219	i	Materials - Gypsum board/ Tiles, Particle board tiles, Al tiles/ Strips, GI hangers, AL/ GI Tee support, AL/ GI Edge angle, Fasteners etc.	As agreed/ required	Critical	Visual/ Physical, Review of MTC	Each lot received at site	IS:2095, IS:8183, Tech. Specs and Construction Drawings	MTC/ SR	√	**x**	**x**	**x**	Compare MTC with Tech. Specifications and requirements
220	ii	Acceptance of Installation	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		**x**	**x**	**x**	
222	**22**	**Doors, Windows, Ventilators, Glass/ Glazing and Grill**											

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223	i	Door Frame (Hollow steel metal, Aluminium, Wooden etc. including fittings such as hold fasts etc.)	As agreed/ required	Critical	Visual, Physical, Reviewof MTC/ Test Reports	Each lot received at site	Tech. Specs and Construction Drawings	MTC/ Lab Test Reports/ SR	√	x	x	x	
224	**a**	**Steel Doors**											
225	i	Materials (MS sheet & Stiffeners, fasteners,hinges, jambs, lock strike plate, hydraulic door closer, fittings and fixtures etc)	As agreed/ required	Critical	Visual/ Physical/ Review of MTC, Test Report	Each lot received at site	IS:2062, Tech. Specs and Construction Drawings	MTC/ Lab Test Report/ SR	√	x	x	x	Review of MTC/ Test Report
226	ii	Finishing & Acceptance - Surface preperation for painting, primer & finishing coat, DFT	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR	√	x	x	x	
227	**b**	**Flush Doors**											
228	i	Shutters, Teak beading	As agreed/ required	Critical	Review of MTC/ Test Report	Each lot received at site	IS:2202, Tech. Specs and Cosnstruction Drawings	MTC/ Lab Test Report/ SR	√	x	x	x	
229	ii	Acceptance	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
230	**c**	**Aluminium doors and Partition works**											
231	i	Materials- Aluminium sections (average thickness, alkali resistant, anodisation, power coating and colour shade etc.), fittings and fixtures. floor spring, hydraulic door closer, hinges, etc.	As agreed/ required	Critical	Visual/ Physical/ Review of Test Report	Each lot received at site	IS:1948, IS;1949, IS:733, IS:1285, IS:1868, IS:11857, Tech. Specs and Construction Drawings	SR/ Lab Test Reports	√	x	x	x	Review of Test Report For anodization check as per Tech. Specs and Construction Drawings Power coating, colour shade as applicable as per Tech. Specs and Construction Drawings
232	ii	Finishing & Acceptance - fabrication & erection, fitting etc..	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
233	**d**	**Grill**											
234	i	Materials - Aluminium, MS, Anodization in case of aluminium	As agreed/ required	Critical	Visual/Physical/ Review of Test Report	Each lot received at site	Tech. Specs and Construction Drawings	SR/ Lab Test Reports	√	x	x	x	Review of Test Reports
235	ii	Finishing & Acceptance - erection, fitting, painting in case of MS grill etc.	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
236	**e**	**Rolling Shutters**											
237	i	Surface finish, Thickness of plate, mechanically operated	As agreed/ required	Critical	Visual/ Physical/ review of MTC	Random for each lot of delivery	IS:8248, Tech. Specs & Construction Drawings	SR	√	x	x	x	
238	ii	Finishing and Acceptance -Painting , DFT	As agreed/ required	Major	Visual/ Physical	Random	Tech. Specs and Construction Drawings	SR		x	x	x	
239	**f**	**Glass and Glazing**											
240	i	Material - Clear float glass, wired glass, tinted glass, ground glass, figured glass, thickness	As agreed/ required	Major	Review of MTC/ test reports	For each lot received at site	IS: 14900, IS:1081, IS: 3548, IS:5437 Tech Specs and Construction Drawings	SR	√	x	x	x	
241	ii	Installation, finishing and acceptance	As agreed/ required	Major	Visual/ Physical	Random	Tech Specs and Construction Drawings	SR	√	x	x	x	
243	**23**	**Precast Concrete Boundary Wall**											
244		Acceptance of boundary wall- Finising, Alignment Dimensions etc.	As agreed/ required	Major	Physical		Tech Specs and Construction Drawings	SR		x	x	x	For inspection of precast concrte units -refer S.No. 18
246	**24**	**Roof Water Proofing**											
247	i	Methodology for the application of water proofing system	As required	Critical	Review	for each type of treatment	Tech Specs and Const. Drawings						
248	**a**	Materials											

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249	i	Polyurethene based coating, polyester scrim cloth, extruded HD dimpled polyurethene	As agreed / required	Critical	Review of MTC/ test reports	For each lot received at site	ASTM C-836, ASTM C898 and Tech Specs /Const. Drawings	MTC/ SR	√				
250	**b**	Roof											
251	i	Graded under bed - Slope/ Level	As agreed / required	Major	Physical	100%	Tech Specs and Construction Drawings	SR		**x**	**x**	**x**	
252	ii	Elastomaric coatings -Primer coat, Finishing coat	As agreed / required	Major	Review of MTC/ test reports	Each lot of delivery	Tech Specs and Construction Drawings	MTC/ Test Reports/ SR	√	**x**	**x**	**x**	
253	iii	Wearing Course - PCC-Grade, chicken wire mesh, elastomeric sealant	As agreed / required	Major	Visual/ Review of MTC	Each lot of delivery of material/ Review of Test Report	Tech Specs and Construction Drawings	MTC/ Test Reports SR	√	**x**	**x**	**x**	2 samples of 3 no. of test cube each shall be taken for PPC work for testing of crushing strength of concrete mix, Review of MTC for Chicken wire mesh, waterproof sealant
254	c	Acceptance of Water proofing treatment	As agreed/ required	Major	Visual/ Physical	100%	Tech Specs and Construction Drawings	SR		**x**	**x**	**x**	
256	**25**	**Water Supply and Sanitary Installations**											
257	**a**	**Water Supply Fittings and Fixtures**											
258	i	Materials - GI/ MS/ C-PVC/ uPVC/PPR/HDPE pipes and fittings	As agreed / required	Critical	Review of MTC/ test reports	Each lot of delivery as per Specifications	IS:1239, IS:4736, IS:4985, IS:6745, IS: 4984, IS:2633, IS:2629, IS:15778, IS:15801, Tech Specs and Construction Drawings	MTC/ SR	√	**x**	**x**	**x**	
259	ii	Disinfection - Before use	As agreed / required	Major	Physical	Each installation	IS:2065, Tech specs and construction Drawings	SR		**x**	**x**	**x**	
260	iii	Hydraulic test - Before use/ Leakage	As agreed / required	Critical	Physical	Each installation	Tech Specs and Construction Drawings	SR		**x**	**x**	**x**	
261	iv	Acceptance & Working	As agreed / required	Major	Physical	Random	Tech Specs and Construction Drawings	SR		**x**	**x**	**x**	
262	**b**	**Sand Cast Iron/ Cast iron Pipes**											
263	i	Material - SCI / CI pipes and fittings / joints	As agreed / required	Critical	Review of MTC/ test reports	Each lot of delivery (as applicable)	IS: 1729, IS:1536, IS:1538, Tech Specs and Construction Drawings	MTC/ SR	√	**x**	**x**	**x**	
264	ii	Acceptance and leakage	As agreed / required	Major	Physical	Random	Tech Specs and Construction Drawings	SR		**x**	**x**	**x**	
265	**c**	**HDPE Pipes for Sewerage**											
266	i	Material- HDPE pipes and fittings/ joints	As agreed/ required	Critical	Review of MTC/ test reports	Each lot of delivery (as applicable)	IS:14333, Tech. Specs	MTC/SR	√	**x**	**x**	**x**	
267	ii	Acceptance & leakage	As agreed / required	Major	Physical	Random	Tech Specs and Const. Drawings	SR		**x**	**x**	**x**	
268	**d**	**HDPE Pipes for Rain water Downcommer**											
269	i	HDPE pipes and fittings/ joints	As agreed/ required	Critical	Review of MTC/ test reports		IS:4984, Tech. Specs	MTC/SR	√	**x**	**x**	**x**	
270	ii	Acceptance & leakage	As agreed / required	Major	Physical	Random	Tech Specs and Const. Drawings	SR		**x**	**x**	**x**	
271	**e**	**Sanitary fitting and fixtures**											
272	i	Sanitory items and fixtures i.e. water closets, urinals, wash basins, sinks, mirrors, shelves, towel rail, soap containers, geyser, water cooler, etc, water supply / sanitation pipes, manhole cover and frames etc	As agreed / required	Major	Review of MTC/ Test reports	Each lot of delivery as per Specifications	Tech Specs and Const. Drawings	MTC/Test Reports/ SR	√	**x**	**x**	**x**	

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273	ii	Acceptance of installations of all sanitory items and fixtures	As agreed / required	Major	Acceptance	100%	Tech Specs and Const. Drawings	SR		x	x	x	
274	**f**	**RCC Pipes**											
275	i	Material - RCC pipes	As agreed / required	Major	Review of MTC/ test reports	Each lot of delivery as per Specifications	IS: 458, Tech Specs and Const. Drawings	MTC/Test Reports/ SR	√	x	x	x	
276	ii	Acceptance and leakage	As agreed / required	Major	Physical	Random	Tech Specs and Const. Drawings	SR		x	x	x	
277	**g**	**Water Storage Tank**											
278	i	Over head / loft type	As agreed / required	Critical	Physical, review of MTC/ test reports	Each lot of delivery as per Specifications	IS:12701, Tech Specs and Const. Drawings	MTC/Test Reports/ SR	√	x	x	x	
279	ii	Aceptance and leakage	As agreed / required	Major	Acceptance	Random	IS:12701, Tech Specs and Const. Drawings	SR		x	x	x	
281	**26**	**Special Items (Switch Yard)**											
282	**a**	**Earthing Mat (Grounding System)**											
283	i	Earthing mat	As agreed / required	Critical	Physical, review of MTC/ test reports	Each lot of delivery as per Specifications	As per relevant IS and Tech. Specs / Manufacturer's, IS 3043	SR/MTC	√	x	x	x	
284	ii	Weld sizes & length	Visual/Tape	Major	Visual/ Measurement	100%	Tech Specs and Const. Drawings	SR		x	x	x	Low hydrogen electrode as per approval shall be used.
285	iii	D P test	DP test Kit	Critical	Physical	10% at random	Tech Specs and Const. Drawings	TR	√	x	x	x	
286	iv	Earth test	Earthing test kit	Critical	Physical	100%	IS:3043, Tech Specs and Const. Drawings, Relevant IS 3043	SR/ Test Report	√	x	x	x	
287	**b**	**Anti Weed Treatment**											
288	i	Anti-weed treatment materials	As agreed / required	Critical	Physical, review of MTC	Each batch of delivery	Tech Specs and Const. Drawings	SR/ MTC	√	x	x	x	
289	ii	Execution of treatment	As agreed / required	Major	Physical	Random check for each treatment	Tech Specs and Const. Drawings	SR		x	x	x	
291	**27**	**Road Work**											
292	**a**	**Construction of Sub-Grade and earthen/hard soulders**											
293	i	Standard proctor Test	As per IS: 2720	Critical	Physical	One in every 2000 cum for each type and source of fill materials	As per Tech Specs and Const. Drawings,Section 900 of MORTH specification, IS 2720 (Pt.VII)	SR	√	x	x	x	In cutting or existing levelled ground - quantum of check shall be one per 1000 SQM
294	ii	Moisture content of fill before compaction	As per IS: 2720	Major	Physical	One in every 2000 cum for each type and source of fill materials	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification, IS 2720 (Pt.II)	SR		x	x	x	In cutting or existing levelled ground - quantum of check shall be one per 1000 SQM
295	iii	Dry density by core cutter method ---- OR---- Dry density in place by sand displacement method	As per IS: 2720	Critical	Physical	One in every 500 SQM area for each compacted layer.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification, IS 2720 (Pt. XXIX)/ IS 2720 (Pt. XXVIII)	SR	√	x	x	x	Both for embankment and cut formation quantum of check - One in every 1000 SQM area for each compacted layer.
296	iv	Lines, grade and cross section	As required / agreed	Major	Physical	One in every 500 SQM area	As per Tech Specs and Const. Drawings	SR	√	x	x	x	Template, straight edge

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297	**b**	**Water Bound Macadam (Non-Bituminous) for base course and sub-base course**											
298	i	Aggregate Impact value	Agrregate Impact value Test Apparatus	Critical	Physical	One test per 200 cum of Test aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
299	ii	Grading	Set of IS Sieves	Major	Physical	One test per 100 cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
300	iii	Flakiness index and elongation index	Flakiness test gauge	Major	Physical	One test per 200cun of agregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
301	iv	Atterberg Limits of binding material	Atterberg limits determination	Critical	Physical	One test per 25 cum of binding material	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
302	v	Atterberg Limits of portion of agreggate passing 425 micron sieve	Atterberg limits determination	Critical	Physical	One test per 100cum of aggregate	As perTech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
303	vi	Camber, surface, slope	As required / agreed	Major	Physical	One in every 500 SQM area	As per Tech Specs and Const. Drawings	SR	√	**x**	**x**	**x**	Template, straight edge
304	**c**	**Bituminous Macadam for base and binder course**											
305	i	Quality of binder	Penetrometre with St. needle	Critical	Physical	No. of samples per Lot & tests as per IS:73, IS:217, IS:8887 as applicable	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification, IS 73	SR	√	**x**	**x**	**x**	
306	ii	Aggregate Impact Value / Los angeles abrasion value	Aggregate Impact ValueTest apparatus	Major	Physical	Once per source	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
307	iii	Flakiness Index and elongation index of aggregates	Flakiness test gauge	Major	Physical	One test per 50 cum of aggregate	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
308	iv	Stripping value of aggregate (Immersion tray test)	As required / agreed	Major	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
309	v	Water sensitivity of mix	As required / agreed	Critical	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
310	vi	Grading of aggregates	Set of Sieves	Major	Physical	Two test per day per plant both on individual constituents and mixed aggregate from dryer	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR		**x**	**x**	**x**	
311	vii	Water absorption of aggregate	As required / agreed	Major		Initially one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR		**x**	**x**	**x**	

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312	viii	Soundness (Magnesium and Sodium Sulphate)	As required as per IS:2386	Critical	Physical	Once per source by each method and on every change of source	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR	√	**x**	**x**	**x**	
313	ix	Percentage of fractured faces	As required / agreed	Major	Physical	When gravel is used one test per 50cum of aggregates	As per Tech Specs and Const. Drawings, Section 900 of MOSRTH specification	SR		**x**	**x**	**x**	
314	x	Binder content and aggregate grading	Bitumen extractor	Critical	Physical	Periodic, subject to a min of two tests per day per plant	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
315	xi	Control of Temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	Thermometer	Major	Physical	At regular close intervals	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
316	xii	Rate of spread of mixed materials	As required / agreed	Major	Physical	Regular control through checks of layer thickness	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
317	xii	Density of compacted Layer	As required / agreed	Critical	Physical	One test per 250 sqm of area	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
318	**c**	**Bituminous Surfacing - Open graded premix carpet and Seal coat**											
319	i	Quality of binder	Penetrometre with St. needle	Critical	Physical	No. of samples per Lot & tests as per IS:73, IS:217, IS:8887 as applicable	IS 73,Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
320	ii	Aggregate Impact Value / Los angeles abrasion value	Aggregate Impact ValueTest apparatus	Major	Physical	One test per 50 cum of aggregate	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
321	iii	Flakiness Index and elongation indexof aggregates	Flakiness test gauge	Major	Physical	One test per 50 cum of aggregate	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
322	iv	Stripping value of aggregate (Immersion tray test)	As required / agreed	Major	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
323	v	Water absorption test		Critical	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
324	vi	Water sensitivity of mix	As required / agreed	Critical	Physical	Initialy one set of 3 representative specimen per source, and on every change of source.	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
325	vii	Grading of aggregates	Set of Sieves	Major	Physical	One test per 25 cum of aggregates	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	

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326	viii	Soundness (Magnesium and Sodium Sulphate)	As required as per IS:2386	Critical	Physical	Once per source by each method and on every change of source	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
327	ix	Polished stone value	As required as per BS:812(Part 114)	Major	Physical	As required	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
328	x	Temperature of binder at application	Thermometer	Major	Physical	At regular close intervals	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
329	xi	Binder content	Bitumen extractor	Critical	Physical	One test per 500 cum& not less than two tests per day	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
330	xii	Rate of spread of materials	As required / agreed	Major	Physical	One test per 500 cum and not less than 2 tests per day	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
331	xiii	Percentage of fractured faces	Bitumen extractor	Critical	Physical	When gravel is used one test per 50cum of aggregates	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
332	**d**	**Tack Coat/ Prime coat/ fog coat**											
333	i	Quality of binder	Penetrometre with Standard needle	Critical	Physical	No. of samples per Lot & tests as per IS:73, IS:217, IS:8887 as applicable	IS 73,Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
334	ii	Temperature of binder at application	Thermometer	Major	Physical	At regular close intervals	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
335	iii	Rate of spread of binder	As required / agreed	Major	Physical	One test per 500 cum and not less than 2 tests per day	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
336	**e**	**Alignment, Level, Surface regularity and rectification**											
337	i	Horizontal alignment, Surface levels and Surface regularity	As required / agreed	Major	Physical	At Random	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR	√	**x**	**x**	**x**	
338	ii	Rectification	As required / agreed	Major	Physical	Each rectification	As per Tech Specs and Const. Drawings, Section 900 of MORTH specification	SR		**x**	**x**	**x**	
340	**28**	**Geotechnical Investigations**											
341	i	Deployment of approved Geotechnical Investigation Agency - Equipments, Manpower etc	As required / agreed	Critical	Physical	Once before commencement of work	As per technical specifications and relevant IS Codes	SR	√	**x**	**x**	**x**	
342	ii	Execution of Geotechnical Investigation - locations, type etc as per scheme	As required / agreed	Major	Physical	Each Location	As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
343	iii	Collection of disturbed and undisturbed samples , their packing and storage	As required / agreed	Major	Physical	each sampling	As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
344	iv	Conducting filed tests as per investigation scheme- such as, SPT/ERT/SCPT/PLT/PMT etc	As required / agreed	Major	Physical	each field test	As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	

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345	v	Submittion of Field Borelogs in approved format	As required / agreed	Major	Review	Within 24 hours after completion of each BH	As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
346	vi	Submittion of laboratory test schedule and selection of samples for laboratory testing	As required / agreed	Critical	Review and acceptance	as per consultation with engineer during dispatch of samples to approved laboratory	As per technical specifications and relevant IS Codes	SR	√	**x**	**x**	**x**	
347	vii	Submission of Final Geotechnical investigation report along with recommendations	As required / agreed	Critical	Physical	After completion of investigation work and review of draft reports	As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
349	**29**	**Topographical Survey Works**											
350	i	Deployment of approved Topographical Surveying Agency - Equipments, Manpower etc	As required / agreed	Critical	Physical	Once before commencement of work	As per technical specifications and relevant IS Codes	SR	√	**x**	**x**	**x**	
351	ii	Transfer of Permanent Bench mark to site from known location	As required / agreed	Major	Physical	Before commencement of work	As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
352	iii	Establishment of boundary pillers and survey grid, Temporary bench Marks, Measurement & recording spot levels	As required / agreed	Major	Physical		As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
353	iv	Recording features like trees, roads, transmission lines, lake, nala, river, temple, house, culverts etc. with coordinate locations	As required / agreed	Major	Physical		As per technical specifications and relevant IS Codes	SR		**x**	**x**	**x**	
354	vi	Submission of final Counter map showing all topographical features, record of spot levels	As required / agreed	Critical	Physical	After completion of investigation work and review of draft reports	As per technical specifications and relevant IS Codes	SR	√	**x**	**x**	**x**	
356	**30**	**Internal Switchyard - Site Leveling & Grading**											
357	i	Leveling Switchyard area	As required / agreed	Major	Visual / Physical	100%	As perTech. Specification and Approved Drawing	SR		**x**	**x**	**x**	
358	ii	Grading of 20/40mm stone / Gravel Spreading in sitchyard area	As required / agreed	Major	Physical	100%	As per Tech. Specification & Approved Drawing	SR		**x**	**x**	**x**	
360	**31**	**Plant Boundary Fencing (if applicable) & Gate (Also refer S.No. 3 for Steel works as applicable)**											
361	i	Fence posts (Intermediate, Stay & Corner Posts etc.) - Section size, Length, Galvanization - Grade/ Thickness, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC	Each lot received at site Random	IS:226; IS:2721; IS:278; IS:480; IS:4826 , Tech. Specs & Construction Drawings	MTC/ SR	√	**x**	**x**	**x**	For Structural steel checks refer S.No. 3
362	ii	Barbed wire - Dia. of line wire and barb wire, Grade of galvanization etc, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	**x**	**x**	**x**	
363	iii	Tie wire - Diameter, Galvanization-Grade, tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/				√	**x**	**x**	**x**	
364	iv	Blade barbed/ Concertina Wire - Thickness/ Diameter, galvanization, Diameter of concertina coil, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	**x**	**x**	**x**	

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365	v	Fence Fabric- Mesh size, Wire Diameter, Galvanization-Grade, Selvage, Knuckling, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
366	vi	MS Gate - Caster weels, ball & bearings, Fixtures & fasteners etc.	As agreed/ Required	Major	Visual	100%	Tech. Specs & Construction Drawings	SR		x	x	x	
367	vi	Acceptance of Boundary Fence and gate	As agreed/ Required	Major	Physical	100%	Tech. Specs & Construction Drawings	SR		x	x	x	
369	**32**	**Tranformer Yard Fencing & Gate (Also refer S.No. 3 for Steel Works as applicable)**											
370	i	Fence posts (Intermediate, Stay & Corner Posts), Concertina Wire Support Angles - Section size, Length, Galvanization, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC	Each lot received at site Random	IS-226; IS 2721; IS-4948 , IS:480; IS:4826 Tech. Specification and Approved Drawing	MTC/ SR	√	x	x	x	For structural steel checks refer S.No. 3
371	ii	Tie wire (as aplicable) - Diameter, Galvanization, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
372	iii	Fence Fabric (chain link/ welded wire as aplicable)- Mesh size, Wire Diameter, Galvanization, Selvage, Knuckling, Tensile strength etc.	As agreed/ Required	Critical	Physical/ Measurement/ Review of MTC				√	x	x	x	
373	iv	MS Gate - Fixtures and fasteners	As agreed/ Required	Major	Visual	100%	Tech Specs andAproved Drawings	SR		x	x	x	
374	v	Acceptance of Fence & Gate	As agreed/ Required	Major	Physical	100%	Tech Specs and Approved Drawings	SR		x	x	x	
376	**33**	**Installation of Pre Engineered Building (PEB) - Security Cabin**											
377	**a**	**Receipt**											
378	i	Receipt of materials and Checking as per packing list	As agreed/ Required	Major	Visual	100%	As per Approved Drawings & Method Statement, Relevant BIS standards	SR	√	x	x	x	
379	iii	Dimensional Check	As agreed/ Required	Major	Measurement	100%			√	x	x	x	
380	iv	Visual checks for damages, rusting, pitting etc.	As agreed/ Required	Major	Visual	100%				x	x	x	
381	v	Visual checks for defects, primer coating and painting/galvanising as applicable.	As agreed/ Required	Major	Visual	100%				x	x	x	
382	vi	Nut/Bolt/Washers Checks	As agreed/ Required	Major	Visual	100%				x	x	x	
383	**b**	**Pre-Installation**											
384	i	Check that the work area is ready and safe to start installation	As agreed/ Required	Major	Visual / Dimension					x	x	x	
385	ii	Check readiness of Foundations	As agreed/ Required	Major		100%				x	x	x	
386	**c**	**Installation (as aplicable)**											
387	i	Readyness of concrete platform, foundations for installation- Size, Location, Level etc.	As agreed/ Required	Major	Visual					x	x	x	
388	ii	Check PUF side walls/ roof are installed properly	As agreed/ Required	Major	Physical					x	x	x	
389	iii	Check tightening of all Nut/Washers/Bolts	As agreed/ Required	Major	Physical					x	x	x	
391	**34**	**Structural Work for Module Mounting Structure (MMS)**					Tech. Specification, Approved Drawing & Method Statement						
437	a	**Manufacturing**											

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438		**Strucural Steel (Raw Material)** Hot rolled & cold formed sections - Angle, Channel, Z-section, Box section, Plate, rod & bar											
439	i	Ultimate Tensile Strength (UTS), Yield Strength (YS), Percentage Elongation, Bend Test, Chemical Composition, Section dimensions	As agreed/ Required	Critical	Chemical composition, Mechanical, Measurement	1 Sample per 50 MT or part thereoff/ for every heat no.	IS 2062, IS 513, IS 811, IS 1079, IS 808, IS 1852, IS 1730 -Part I	MTC	√				Raw material to be procured from reputed manufacturers - like SAIL, RINL, JSPL, JSW, TISCO, ISSAR
440	ii	Visual Examination - Cracks, Scaling, Rust, Pitting, Lamination etc.	As agreed/ Required	Major	Visual	10% IS 2500, Level II, AQL 1.5	IS 2062, IS 513, IS 811, IS 1079, IS 808, IS 1852, IS 1730-Part I	SR	√	**x**	**x**	**x**	Material shall be free from surface defects like cracks, lamination,roughness, imperfect edges, rust, pitting & other harmful defects. Removal of minor surface defects as per IS;2062 is acceptable. Witness for 10% sample. Record review for every material
441		**Boughtout Items (Hardware - Nuts, Bolts and Washers - plain, spring)**											
442	i	Mechanical & Chemical Properties	As agreed/ Required	Critical	Chemical composition, Mechanical	1 sample per 5 MT or part thereoff	IS 1327 (Part 17) eq./ ASTM standard	MTC/ Lab test Report	√	**x**	**x**	**x**	
443	ii	Dimensional check (Dia., Thickness, Total stem length & Threaded length etc.)	As agreed/ Required	Major	Measurement	IS 1327 (part 17) eq 10 pieces per lot per member type	IS 6639, IS 2016,IS 6610 & IS 3063 / ASTM standard	Vendor Records	√	**x**	**x**	**x**	Witness for sample. Record review for every material
444	iii	Galvanizing - Mass per Sqm, Thickness (DFT)	As agreed/ Required Alcometer	Major	Visual, Measurement	IS 1327 (part 17) eq 10 pieces per lot per member type	For Hot dip galvanizing should be maintained 43 microns (min) and average 54 microns as per IS 1367 (part XIII) eq.	Vendor Records	√	**x**	**x**	**x**	Record review Random sample inspection/ measurement
445	b	**In Process Inspection**											
446		**Structural Item Fabrication**											
447	i	Straightening	As agreed/ Required	Major	Visual	100%	0.2% of total length	Vendor Records	√	**x**	**x**	**x**	Record review
448	ii	Cropping (Cutting)	As agreed/ Required	Major	Visual	100%	Approved drawing	Vendor Records	√	**x**	**x**	**x**	Record review
449	iii	Identification/ Marking	As agreed/ Required	Major	Visual	100%	Approved drawing Marking Shall be done with the help of permanent paint marker using stencil as per Drawing	Vendor Records	√	**x**	**x**	**x**	Record review Random sample inspection
450	iv	Punching/ Drilling of Holes	As agreed/ Required	Critical	Measurement	1 piece per 25 pieces	IS 802/ Approved drawing	Vendor Records	√	**x**	**x**	**x**	Record review
451		Edge Security							√	**x**	**x**	**x**	
452	v	Overall Length	As agreed/ Required	Major	Measurement	1 piece per 25 pieces	IS 802/ Approved drawing	Vendor Records	√	**x**	**x**	**x**	Record review Random sample measureemnt
453	vi	Bending	As agreed/ Required	Critical	Measurement	100%	IS 801, 811/ Approved drawing	Vendor Records	√	**x**	**x**	**x**	
454		Cross Section Dimensions							√	**x**	**x**	**x**	Record review
455	vii	Welding	As agreed/ Required	Major	Visual	100%	Approved Welding Procedure & Welder Qualification	Vendor Records	√	**x**	**x**	**x**	Record review Random sample ispection
456	viii	Visual Examination - Black spots, Porosity, Spatter, Rust bleed points, Weld dimensions	As agreed/ Required	major	Visual	100%	Tech. Specification, Approved Drawing	Vendor Records	√	**x**	**x**	**x**	Record review Raddom sample inspection (The fabricated material shall be free from
457	ix	DP Test (as necessary)	As agreed/ Required	Major	Chemical	Shift wise/ random	As and when required	Vendor Records	√	**x**	**x**	**x**	
458	x	Final Inspection of Fabricated Parts - Cross section dimensions, Thickness (before galvanization)	As agreed/ Required	Critical		10 % in lot size of 100 nos.	IS- 802, IS 807, IS 811 and relevant applicable eq. standards , approved drawings, Tech spec	Vendor Records	√	**x**	**x**	**x**	
459		**Galvanizing**											
460	i	Zinc - Ingot, Molten metal in galvanizing bath	As agreed/ Required	Critical	Chemical	1 sample from each batch of ingot supply	IS 2629	MTC Lab test report	√	**x**	**x**	**x**	Purity of Zn 98.5%, MTC to be correlated. Molten metal in the galvanizing bath ≥ 98.5 % by mass of zinc.
461		**Pre Galvanizing**											

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462	i	Degreasing	Acid base cold degreaser	Major	Chemical	One sample daily	Sp. Gravity 1.1 to 1.2, ph Value 2 to 3	Vendor Records	√	x	x	x	Record review
463	ii	Pickling - Acid & Iron content	Lab test	Major	Chemical	One sample daily	Acid Content-Concentration 18% to 4% min, Sp. Gravity 1 to 1.3 Iron Content -120g/litre (max)	Vendor Records	√	x	x	x	Record review
464	iii	Rinsing	pH meter	Major	Chemical	One sample daily	Rinsing water ph value 5 to 7	Vendor Records	√	x	x	x	Record review
465	iv	Pre-fluxing in ZnCl solution - Specific gravity, pH	pH meter	Major	Measurement	One sample daily	Sp Gr - 1.10 to 1.26 pH - 3 to 5	Vendor Records	√	x	x	x	Record review
466	v	Pre-heating	Pyrometer	Major	Measurement	One sample daily	Above 50^0 C	Vendor Records	√	x	x	x	Record review
467	vi	Dipping - Zinc bath temperature, Imersion & withdrawl time	Continuous recording & verification by Pyrometer	Major	Measurement	Hourly check	Zn bath temp - 440^0 C to 460^0 C Article to be immersed till reaction	Vendor Records	√	x	x	x	Record review
468	vii	Quenching	Plain water	Minor			Bath in plain water for cooling & Cleaning. Temp. Below 65°	Vendor Records	√	x	x	x	Record review
469	viii	Di-chromating	Di-chromate solution	Major	Chemical	One sample daily	strength of the solution to be maintained as 0.7 to 1% of sodium dichromate, temperature of solution should be less than 65°	Vendor Records	√	x	x	x	Record review
470		**Post Galvanizing**											
471	i	Surface Defects/Finish - Dross, Pimples, Black marks, Ash deposition	As agreed/ Required	Major	Visual	100%	IS 2633	Vendor Records	√	x	x	x	Record review Random samples to be inspected during
472	ii	Thickness of Zinc Coating	Alcometer	Critical	Measurement	3 samples per dip	As Per IS 4759 , 6745 , Minimum 80micron or as per spec.	Vendor Records	√	x	x	x	Record review Random samples to be measured during factory visit by Owner/PMC
473	iii	Mass of Zinc Coating		Critical	Chemical	1 sample per shift	As Per IS 6745	Vendor Records	√	x	x	x	Record review
474	iv	Uniformity of Zinc Coating (Preece Test)		Major	Chemical	1 sample per shift	No red stains after 4 dippings	Vendor Records	√	x	x	x	Record review/ Sample test if deemed necessary
475	v	Adhesion of Zinc Coating (Pivote Hammer Test/ Knife Test)		Major	Physical	1 sample per hour	No Removal or lifting in areas between hammer impression/coating should not peel off. As per IS 2629	Vendor Records	√	x	x	x	Record review Random samples to be inspected during factory visit by Owner/PMC. Sample test if deemed necessary
476		**Proto Assembly**											
477	i	Proto Assembly check - Fitment, Dimensions, Alignment, Overall Stability	Prototype of one mounting table with	Critical	Physical/ Measureemnt	100%	Cut lengths of all members, Fitment (dia. of holes, end security, c/c distance between holes etc. shall be checked for correctness wrt permissible tolerence through in postion ispection of assembled proto), Fasteners (bolts, nuts and washers), Cleats, Gussete plates shall be as per Approved drawing/ specifications. The proto assembly shall be checked for overall stability for design verification of various conenctions and col. support system.	IR	√	x	x	x	The general quality of fabrication and galvanization of members, straightness of members, overall stability of prototype etc. shall be checked for design verification. Any suggestions for design changes etc. shall be properly recorded in the inspection report for implimentation in mass production of MMS members
478		**Marking/ Packaging**											
479	i	Marking	As agreed/ Required	Major	Visual	100%	Aprroved drawing/ marking scheme	IR	√	x	x	x	Record review Random sample shall be checked during facroty visit by Vendor and SECI/ Owner representative

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Sr.No.**	**Activity & Operation**	**Instruments**	**Class of Check**	**Type of Check**	**Quantum of Check**	**Reference Documents & Acceptance Standard**	**Format of Record**	**D*** (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	**Cheking Agency**			**Remarks**
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		**M'fr/ Supplier or Sub-Contractor**	**EPC Contractor**	**SECI or Owner**	
480	ii	Packaging, Storing, Bundling, Handling	As agreed/ Required	Major	Visual	100%	As per IS-802. Packing of Column. Bracing, Rafters and Purlins shall be done by strapping. Packing of smaller items by wires or in gunny bags/ or as per approved procedure	IR	√	x	x	x	Separate packaging for different type of members like Col, Purlin, Rafter, Front/ rear/ diagonal bracings, fasteners, cleats etc. Small members shall be bundled with wire. Damage to galvanization and form (shape) of the member during handling and trasporting shall be controlled
481		**Site Installation**								x	x	x	
482	i	Receipt of materials and Checking as per packing list	As agreed/ Required	Critical	Visual	Random	Tech. Specification, Approved Drawing & Method Statement.		√	x	x	x	
483	ii	Fabricated members - Dimensional Check	As agreed/ Required	Major	Visual	100%				x	x	x	
484	iii	Visual checks for defects/damages, rusting, pitting, galvanising etc.	As agreed/ Required	Major	Visual	Random				x	x	x	
485	iv	Nut/Bolt/Washers	As agreed/ Required	Major	Measurement	100%				x	x	x	
486	v	Mounting of structures & Accessories - Coordinates, Levels, Fitment, Alignment etc.	As agreed/ Required	Critical	Visual /Measurement	100%			√	x	x	x	
487	vi	Torque Checking - Daily calibration check, Bolt installation	As agreed/ Required	Major	Measurement	100%				x	x	x	
489	**35**	**Module Mouting - Pre Installation Check**			Visual	100%							
490	i	Check for site physical layout as per drawing / Design Specification		Major	Physical	100%				x	x	x	
491	ii	Check for Structure, Mounting readiness		Major	Physical					x	x	x	
493	**36**	**String Combiner Boxes (SCB) - Mouting - Pre Installation Check**											
494	i	Check for foundation readyness - location & coordinates, dimensions & levels, foundation bolts etc.		Major	Physical	100%				x	x	x	
496	**37**	**Inverter Panel**					Design Specification, Drawings, Manufacturer Manual Method Statement	SR					
497		**Pre Installation**											
498	i	Check for site physical layout as per drawing.		Major	Visual	100%			√	x	x	x	
499	ii	Ensure that no fouling with civil/structural		Major	Physical	Random				x	x	x	
500	iii	Check for Foundation readiness and level of foundation.		Major	Physical	100%				x	x	x	
502	**38**	**Burried Cables**					Design Specification, Drawings, Manufacturer Catalogue Method Statement (SW-SEPC-MS-CAB-006)						
503	i	Cable Trench - Dimensions, alignment		Critical	Physical	100%	Design Specification, Drawings, Manufacturer Catalogue Method Statement	SR		x	x	x	
504	ii	Sand filling before cable laying, sand filling after cable laying, placing of precast concrete slabs/ bricks, backfilling with soil		Major	Visual	100%				x	x	x	
586													
587													
588													
589													
590													
591													

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Sr.No.**	**Activity & Operation**	**Instruments**	**Class of Check**	**Type of Check**	**Quantum of Check**	**Reference Documents & Acceptance Standard**	**Format of Record**	**D*** (Records identified with (√) shall be issentially included by EPC vender in QA documentation)	**Cheking Agency**			**Remarks**
2								SR - Site Register SECI-SPV-QA-F-XXX SECI-SPV-QA-T-XXX (XXX - Inspection record form No. or Test report format no.)		**M'fr/ Supplier or Sub-Contractor**	**EPC Contractor**	**SECI or Owner**	
592			**LEGEND**: D * Records, indentified with "Tick" (√) shall be essentially included by supplier in QA documentation.							**DOC. NO**.: SECI - XXX - XXX -XXX - FQP & MQP - 001		**REV**: 0	
593			**Legend to be used:**										
594			**Class # : A** = Critical, **B**=Major, **C**=Minor										
595			**Format of Record #** : **SR**=Site Register, **TR**=Lab Test Report, **IR**=Inspection Report, **MTC**=Manufacturer's Test Certificate										
596			All **MTC**'s shall be correlated with batch of material supply, Tech specs and drawings										
597			**Category 'A'** - Sub-contractor/ sub-vendor, EPC Vendor, SECI/ Owner										
598			**Category 'B'** - Sub-Contractor/ Sub-Vendor, EPC Vendor, SECI										
599			**Category 'C'** - Sub-Contractor/ Sub-Vendor										
600										**Reviewed By**	**Approved By**	**Approval Seal**	
601			This document shall be read in conjunction with Tech. Specifications and Drawings										

SUB-SECTION D

GENERAL ANNEXURE F

Pile Test Methodology

1.0 GENERAL

This specification deals with the testing of bored cast in situ piles by the application of an axial load or force. It covers vertical piles tested in compression (i.e. subjected to loads or forces in a direction such as would cause the pile to penetrate further into the ground) and vertical piles tested in tension/ pull-out (i.e. subjected to forces in a direction such as would cause the piles to be extracted from the ground).

2.0 DEFINITIONS

Compression pile: A pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.

Tension pile: A pile which is designed to resist an axial force such as would cause it to be extracted from the ground.

Initial Test pile (or test pile): A pile installed before the commencement of the main piling works or specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimension and load capacity

Kentledge: The dead weight used for applying a test load on pile

Reaction system: The arrangement of kentledge, piles, anchors or rafts that provide a resistance against which the pile is tested.

Maintained load test: A load test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.

Failure load test: a load test applied to an initial test pile. Maximum test load for this test should not normally be less than 250% of the estimated safe load capacity worked out as per static formula for estimation of pile capacity, but the possibility of failure load test carried well beyond 300% of the predicted working load should not be ruled out if otherwise specified. This test serves as a design check and confirmation or validation of safe load capacity of working piles through field test

Ultimate load capacity: the max load which a pile or pile cap can carry before failure of ground (when soil fails by shear as evidenced from the load settlement curve) or failure of the pile

Allowable or safe load: the load on a pile derived by applying a factor of safety on ultimate load capacity of pile as determined by load test.

Working load: design load to be carried by the working pile without exceeding the allowable settlement requirement

3.0 SAFETY PRECAUTIONS

General

While casting the test pile, conducting the test and dismantling the test pile after the test is complete, the contractor shall follow all applicable precautions, statutory provisions and directions of Engineer for maintenance of safe working conditions, and shall in addition make such other provisions as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

The Contractor shall be responsible for the design of the reaction system (e.g. kentledge or reaction piles/ground anchors, foundation of the kentledge system etc.) As required, the design of the reaction system including the design calculations shall be endorsed by the Chartered Engineer registered with Institution of Engineers, India, who will be responsible for the safety of the whole reaction & testing

system and fulfill the Health & Safety Acts.

Personnel

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

Kentledge

Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any beams or other supporting structures in such a manner that there will not be any differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it from falling apart, or becoming unstable because of deflection of the supports.

The weight of kentledge shall be at least 1.2 times m or e than the maximum test load and if the weight is estimated from the density and volume of the constituent materials, an adequate factor of safety against error shall be considered. The Contractor shall take all reasonable steps to ensure that sufficient excess load capacity is at all times available for the uninterrupted execution of a load test.

Reaction Piles and Ground Anchors

Where tension piles or ground anchors are used (subject to approval of the Engineer), the Contractor shall ensure that the load is correctly transmitted to all the tie rods or bolts. The extension of rods by welding shall not be permitted unless it is known that the steel will not be reduced in strength by welding. The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.

The reaction piles or ground anchorages shall be so designed that they will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles or anchorages shall be placed in the specified positions, and bars, tendons or links shall be aligned to give a stable reaction in the direction required.

Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable up to the maximum test load to be applied. Means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure or any other cause that might constitute a hazard to personnel. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum workingpressure without possible leaking.

The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.

4.0 MATERIALS AND LABOUR

The Contractor shall supply all labor, materials and other equipment necessary for the performance, recording and measurements of the test loads and settlement including the supply

and placing in position of kentledge used in the tests. The Contractor shall subsequently dismantle and remove all the material and equipment used.

Throughout the duration and operation of the test loading the Contractor shall place competent men to operate, watch and record the test.

5.0 INITIAL TEST PILES

In order to confirm the design type, size, length and load capacity of pile through field tests, the Contractor shall install and test specially installed initial piles in advance of the main piling operation for *working piles*. The locations, sizes, lengths, test loads and instrumentation required for the initial piles shall be submitted by the contractor for approval before start of the work.

Initial piles shall be installed within the same plant and in a similar manner as that to be used in the construction of the working piles.

All initial test piles shall be instrumented in accordance with that indicated in the drawings and specification. After testing, the Contractor shall be responsible to hack away the initial test pile if it is obstructing the construction of other foundation works.

6.0 MEASURING DEVICES

Load measuring devices shall be calibrated before and after each series of tests, whenever adjustments or replacements are made to the devices or at the intervals recommended by the manufacturer of the equipment. All measuring equipment and gauges shall be calibrated together. Certificates of calibration from an approved laboratory shall be supplied to the Engineer for acceptance.

The Contractor's proposed method of measuring the movement of pile heads and load shall be submitted to the Engineer for approval.

7.0 SUPERVISION

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use. Load testing shall be carried out in the presence of the Engineer or Engineer's Representative.

8.0 LOADING TEST PILES

The rate of application of the test load is specified in the specification for general guidance. The rate of application and removal of the load may be altered or modified solely by the Engineer. Unless otherwise decided by the Engineer the load steps and duration are as indicated in approved Test Procedure.

9.0 READINGS

Take readings of time, load and settlement and record immediately before and after the application of each load increment or decrement, or as directed by the Engineer. A minimum of another two readings shall be recorded at intermediate intervals.

10.0 INSTALLATION OF A TEST PILE

Inclusive Works

The works for the load tests shall include the construction and subsequent demolition of all necessary pile caps to the contractor's design which shall be subjected to the Engineer's approval.

Notice of Construction

The Contractor shall give the Engineer at least 48 hours' notice prior to commencement of casting of any initial test pile.

Method of Construction

Each initial test pile shall be constructed in a manner similar to that to be used for the construction of the working pile, and by the use of similar equipment and materials. Any variation will only be permitted with prior agreement.

Extra reinforcement and concrete of increased strength shall be provided as required in the shaftsor initial piles as per approved design of test piles to this effect.

Boring Record

For each initial test pile which is to be tested, a detailed record of the conditions experienced during boring shall be made and submitted daily, not later than the next working day. Where the Engineer requires soil samples to be taken or in-situ tests to be made, the Contractor shall present the results without delay. All submission shall also include a scan copy (in PDF format) to be emailed to the Engineer's office.

Concrete test cubes

At least 1 sample (six test cubes) shall be made from the concrete used in the initial test pile If a concrete pile is extended or capped for the purpose of testing, a further 1 sample (six test cubes) shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with IS: 516

The pile test shall not start until the compressive strength of pile concrete is established equal or greater than the design strength through tests on the test cubes. As a general rule the pile test shall be carried out after 28 days of casting the pile without special permission for early testing obtained from Engineer.

Pile Head for Compression Test

For a pile that is tested in compression, the pile head or cap may be formed as required to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement-measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

The pile cap shall be concentric with the test pile. The joint between the cap and the pile shall have a strength equivalent to that of the pile.

Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at maximum expected settlement, load is not transmitted to the ground except through the pile.

Pile Connection for Tension Pile

For a pile that is tested in tension, means shall be provided for transmitting the test load axially to the pile.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load which is to be applied to the pile during the test

with an appropriate factor of safety on the structural design.

11.0 REACTION SYSTEMS

Compression Tests

Compression tests shall be carried out using kentledge only. Unless instructed, approved or specified by the Engineer, tension piles, ground anchors or otherwise specially constructed anchorage shall not be used.

Where kentledge is to be used, it shall be supported on cribwork, disposed around the pile head so that its center of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer in writing only. The kentledge may consist of concrete blocks, steel piles etc., but must be of uniform size so that weight of the kentledge can be easily calculated.

Tension Tests

Tension tests shall be carried out using compression piles or rafts constructed on the ground. The use of inclined reaction piles, anchors or rafts is not precluded, subject to agreement. In all cases the resultant force of the reaction system shall be co-axial with the test pile.

Spacing

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3m.

The center-to-center spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2m whichever is the greatest.

Where a pile to be tested has an enlarged base (under reamed pile), the same criterion shall be applied with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall be closer to the base of the test pile than one and half of the enlarged base diameter.

Where vertical reaction piles penetrate deeper than the test pile, the center-to-center spacing of the reaction piles from the test pile shall be not less than five times the diameter of the test pile or the reaction piles whichever is the greatest unless the base capacity of the test pile is less than 20% of the total ultimate capacity.

Where ground anchorages are used to provide a test reaction for loading in compression, no section of fixed anchor length transferring load to the ground shall be closer to the test pile than three times the diameter of the test pile. Where the pile to be tested has an enlarged base the same criterion shall apply with regard to the pile shaft, with the additional requirement that no section of the fixed anchor transferring load to the ground shall be closer to the pile base than a distance equal to the base diameter.

Adequate Reaction

The size, length and number of reaction piles or the area of the rafts, shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

Care of Piles

The method employed in the installation of any reaction piles or rafts shall be such as to prevent

damage to any test pile or working pile.

Working Piles as Reaction Piles

The Contractor shall not use working piles as reaction piles.

Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

Pile caps and Structural Elements

Temporary pile caps and other structural elements forming part of the reaction system proposed by the Contractor shall be designed and built by the Contractor, and to the approval of the Engineer. The cost of building and demolishing such pile caps and structural elements shall be borne by the Contractor.

12.0 EQUIPMENT FOR APPLYING LOAD

General

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The rams or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the test. The contractor shall prepare sufficient spare steel plate to drop or raise the jack after each sequence of test after the pile had settled with allowed tested total settlement of pile.

Jack Capacity

The total capacity of the jacks shall exceed by 50% or more the required maximum test load, thereby avoiding heavy manual pumping effort when nearing maximum load and minimizing the risks of any leakage of oil through the seals.

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained load test.

The length of stroke of a ram shall be sufficient to cater for deflection of the reaction system under load plus a deflection of a pile head up to 15% of the pile shaft diameter unless otherwise specified.

13.0 MEASUREMENT OF LOAD

Load Measurement Procedure

The load shall be measured by a load measuring device and by a calibrated pressure gauge included in the hydraulic system. The technical specifications of the load cell and pressure gauge shall be submitted to the Engineer prior to the test. The load cell and pressure gauge shall be of appropriate range of the testing load. Reading of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used. The pressure gauge readings are required as a check for gross error. The pressure gauge shall have been recently calibrated.

The load measuring device may consist of a proving ring, load measuring column, pressure cell, vibrating wire load cell or other appropriate system. The load cells or proving ring shall be calibrated immediately prior to the test and a certificate shall be submitted to the Engineer.

A spherical seating shall be used in conjunction with any device that are sensitive to eccentric loadings; care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in axial length in order to achieve the best possible stability. The Contractor shall pay attention to details in order to ensure that axial loading is maintained.

Any increment of load shall not be allowed to fall below 1% of the specified load.

The Engineer's agreement shall be obtained in writing prior to any modification of this procedure.

Calibration of Load Measuring Devices

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together.

Certificates of calibration performed by an NABL accredited testing laboratory shall be supplied to the Engineer prior to carrying out the load test.

Measurement of Settlement

Settlement shall be measured by use of a reference beam or wire supported independently of the test pile, reaction pile or piles supporting reaction loads. Settlements shall be measured to the nearest 0.1mm for reference beams or 0.5mm of reference wires. A precise optical level shall also be used to check movements of the reference frame against an independent datum. The reference beam supports shall be located at least 3m from the test pile, reaction pile or piles supporting reaction loads. The reference beams or wires shall be protected from the effects of temperature changes. Construction equipment and persons not involved in the test shall be kept well clear to avoid disturbance of the measuring system. Pile driving or similar operations will not be permitted in the vicinity of the test unless the Engineer is satisfied that the measuring system will not be affected.

Deflections shall be precisely measured by min. two dial gauges placed diagonally opposite on the pile head with sensitivity of 0.01mm to give useful information on pile bending as well as axial movement. These dial gauges shall be firmly attached to the reference beams (datum beams), so that the plungers are parallel to the pile axis. The plunger points shall bear onto reference plates by means of machined plates or glass slides attached to the pile head. The reference plates shall be equidistant from the center of the pile, diametrically opposite, and carefully aligned so that they are perpendicular to the pile axis in order that sideways movements do not produce any axial components.

Before stacking up of the Kentledge or construction of the reaction piles / ground anchors, the preparation of the pile head shall be carried out and the reduced level of the pile head surveyed and recorded.

Initial Zero Load Readings

Before the first increment of test load is applied, all gauges shall be read at 30 minutes intervals over a period of 12 hours under zero load to determine the effect of variable site conditions on the test pile. Air temperature shall be recorded with each set of readings. The test set- up shall be exactly as during the test proper, with the loading jack in position but clear of the loading frame.

14.0 MEASURING MOVEMENT OF PILE HEADS

Maintained Load Test

In a maintained load test, movement of the pile head shall be measured by one of the primary systems and one of the secondary systems described in this section.

Primary System

An optical or any other leveling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readingsto be made within an accuracy of 0.5mm. A scale attached to the pile or pile cap may be used instead of a leveling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed, so that any one datum point can be re-established in case it is inadvertently demolished. Each datum point shall be situated so that only one setting of the level is needed.

No datum point shall be affected by the test loading or other operations on the Site. Where

another method of leveling is proposed, this shall be agreed in writing.

Independent Reference Frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance fromthe test pile, kentledge support cribs, reaction piles, anchorages and rafts that movements of the ground in vicinity of the equipment do not cause movement of the reference frame during the test which will affect the required accuracy of the test.

Observations of any movements of the reference frame shall be made and a check shall be made of the movement of the pile head relative to an external datum during the progress of the test. Supports for the reference frame shall be placed not less than three test pile diameters or 2 meters, whichever is the greater, from the center of the test pile, and not less than 1 metre from the nearest corner of the kentledge support crib.

The measurement of pile movement shall be made by min. 2 dial gauges equally spaced around the pile and equidistant from the pile axis. Dial gauges shall be rigidly mounted on the reference frame and bear on surfaces which are normal to the pile axis and fixed to the pile cap or head.

Alternatively, the gauges may be fixed to the pile and bear on surfaces on the reference frame. The dial gauges shall have a travel of 50mm and shall be accurate to 0.01mm.

The reference frame shall be protected from direct sunlight, wind and rain.

Secondary Systems

Reference Wire

A reference wire shall be held under constant tension between two rigid supports founded as in the method used for the primary Reference Frame system. The wire shall be positioned against a scale fixed to the pile and the movement of the scale relative to the wire shall be measured.

Observations of any movements of the supports of the wire shall be made or a check shall be made of the movement of the pile head as in the method used for primary Reference Frame systems. Readings shall be taken to within an accuracy of 0.5mm.

The reference wire shall be protected from direct sunlight, wind and rain.

Other Methods

The Contractor may propose and implement any other suitable and adequate method of measuring the movement of pile heads subject to the prior agreement of the Engineer.

Instrument Calibration

Prior to carrying out the load test, the Contractor shall submit to the Engineer the calibration certificates of dial gauges performed by NABL accredited testing laboratory.

Night Readings

The entire test area shall be adequately lighted up during the night to facilitate taking readings.

15.0 PROTECTION OF TESTING EQUIPMENT

Protection from Weather

Throughout the test period, all equipment for measuring load and movement shall be protected from direct exposure to sunlight, wind and rain.

Prevention of Disturbance

Construction equipment and persons who are involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

16.0 SUPERVISION

Notice of Test

The Contractor shall give the Engineer at least 24 hours of notice prior to commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test as required under the section headed 'Presentation of Results' in this specification shall be available for inspection by the Engineer.

17.0 TEST PROCEDURE

Failure Load Tests (Initial Tests)

Failure Load Tests shall be performed following maintained load procedure on initial piles designated by the Engineer at the commencement of the contract to verify the design parameters used and to confirm the lengths of subsequent working piles. The initial test piles shall be the only ones made in the first instance, and the load tests carried out prior to the installation of any other piles. Piling works shall not commence until after the failure load test results have been analyzed, and upon instruction by the Engineer.

The provisional number of Failure Load Test shall be as agreed subject to min. of 3 numbers of tests under each type (compression or tension). The locations of initial test piles shall be so chosen to properly represent the total plant site and shall be subject to the approval of the Engineer. However, the Engineer reserves the right to alter the number of tests subject to the nature of subsoil conditions encountered and the pile system adopted vis-a-vis the method of installation, material and plant usage.

The test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load taken as 100%. In case of any variation with respect to approved pile

test procedure, the approved procedure shall have the precedence.

LOADING CYCLES FOR INITIAL TEST PILES

Load Stage (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till the movement of the pile top is not more than 0.2mm/hour or until 2 hours have elapsed, whichever is earlier, subject to min. 1 hour	
20		
40		
60		
80		
100		
120		
140		
160		
180		
200		
220		
250	24 hr. (after application of max. test load)	The vertical loading (shall be continued till one of the following takes place Compression: (a) The applied load reaches 250% of estimated safe load or (b) Max. settlement of pile exceeds 10% of diameter in case of uniform diameter pile and 7.5% of bulb diameter in case of under reamed pile. Pull out: (a) The applied load reaches 250% of estimated safe uplift load or (b) until the load displacement curve shows a clear break (downward trend).
200	01 Hour	
150	01 Hour	
100	01 Hour	
50	01 Hour	
0	01 Hour	

The test schedule for compression test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

The procedure for tension pile tests shall be exactly as described in this section for compression pile test; for tension test, the words "settlement" and "rebound" should be read a s "displacement" in the column "action to be taken after Load Stage."

For failure load tension pile test, the Contractor shall provide adequate reinforcement in the test pile to carry the ultimate tension load.

All loading and unloading operations shall take place during the day. Pressure gauge readings shall be recorded at each load increment or at each decrease in load. During waiting periods at various loading stages, all readings shall be recorded after the load has been applied and before the commencement of next loading stage. Take readings at 15-minute intervals at 100%, 200% and 250% of working load.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

Working Load Test on Working Piles

A number of working load tests on 0.5 % of the total working piles shall be carried out at test load of 1.5 times the working load on piles to be designated by the Engineer, and in accordance with IS:2911 or as specified in Tech Specifications. In case of discrepancies the provision of this specification and Tech Specifications the Tech Specifications shall take precedence. The Contractor shall submit a detailed proposal of load tests to the Engineer, and shall obtain his approval in writing before carrying them out the test. On completion of the test, the Contractor shall submit to the Engineer the test results, including graphs showing load and settlement versus time and settlement versus load.

The provisional number of working load tests to be carried out shall be as specified in Tech. specifications. The Engineer may reduce the number of tests if a consistent high quality of workmanship and pile material is well established and if the nature of soil conditions encountered does not vary substantially, Conversely, the Engineer reserves the right to increase the number of tests either to verify the quality of workmanship and pile material or in response to variable subsoil conditions.

Unless otherwise specified by the Engineer, the test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load, taken as 100%:

LOADING CYCLES FOR WORKING PILES

Load (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till the movement of the pile top is not more than 0.2mm/hour or until 2 hours have elapsed, whichever is earlier, subject to min. 1 hour	
20		
40		
60		
80		
100		
120		
140		
150	24 hr. (after application of max. test load)	The vertical loading shall continue till one of the following takes place

		Compression: (a) The applied load reaches 150% of the safe load or (b) max. settlement of the pile exceeds 12mm Pull out: (a) The applied load reaches 150% of the safe load or (b) total settlement reaches 12mm
115	01 Hour	
75	01 Hour	
35	01 Hour	
0		

(NOTE: Pull out test on routine (working) pile shall be carried out only in case it is found be necessary to conduct the same based on construction quality and the soil strata variation observed during working pile installation or any other reason as found necessary by the engineer.
While conducting the routine test for pull out, it shall be ensured that the displacement is within elastic deformation of the pile during the test as observed from initial failure test graph or 8mm whichever is early).

The test schedule for compression or pull-out test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

The procedure for working load tension pile tests shall be exactly as described in this section for compression pile tests; for tension test, the words "settlement" and "rebound" should be read as "displacement" in the column "action to be taken after Load Stage".

All loading and unloading operations shall take place during the day. Minimum three (3) sets of readings shall be taken in each loading stage: one set each at the beginning, middle and end of each loading or unloading stage. When a test load is maintained for more than 30 minutes, readings shall be taken at maximum half-hourly intervals thereafter unless otherwise specified by theEngineer.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

18.0 ABANDONMENT OF PILE TEST

Test shall have to be discontinued if any of the following occurs:

- faulty jack or gauge,
- instability of kentledge,
- improper setting of datum, or
- unstable Bench Marks or Scales,
- measuring instruments used are found to have been tampered with by anyone,
- pre-jacking or pre-loading before commencement of the test.
- Insufficient steel plate to compensate for settlement of the pile after each sequence of loading (shall allow up to 150mm settlement).

Should any test be abandoned due to any of the above causes, the Contractor shall carry out further tests to the Engineer instructions after rectification of the errors.

19.0 PRESENTATION OF RESULTS

Results to be Submitted

A written summary to the Engineer within 24 hours (or unless otherwise directed) of the test, which shall give:

(i) For each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

(ii) Load vs Settlement curve.

The completed schedule of recorded data (hard & softcopy) as described hereunder in this section shall be submitted to the Engineer within seven days of completion of the test in the format

generally, as specified in IS: 2911 (part 4) and approved by the Engineer.

Schedule of Recorded Data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

General

* Site location
* Contract identification
* Proposed structure
* Name of EPC Contractor
* Name of Piling Contractor & Testing Agency
* Name of SECI/ Owner Engineer
* Name of EPC Contractor's Engineer
* Name of Testing Agency/ Piling Contractor Engineer
* Data of test

Pile Details

All piles
* Identification (no. and location)
* Position relative to adjacent piles
* Brief description of location (e.g. in marshy land, rocky area, high water table etc.)
* Existing Ground level at pile location
* Head level at which test load is applied
* Type of pile (e.g. bored cast in situ, pre-cast driven etc.)
* Compression or tension
* Shape and size of cross-section of pile (diameter), position of change in cross-section (in case of under reamed pile – the position and dimensions of the bulb)
* Shoe or base details
* Head details
* Length in ground
* Level of toe

Installation Details

* Test cube results
* Design grade of concrete
* Reinforcement
* Whether construction under water

Test Procedure

* Weight of kentledge.
* Tension pile, ground anchor or compression pile details
* Plan of test arrangement showing position and distances of kentledge support, rafts, tension orcompression piles and reference frame to test pile
* Jack capacity
* Calibration certificates of pressure gauges and dial gauges
* Method of load measurement
* Method(s) of penetration or uplift measurement
* Proof test by maintained loading
* Relevant dates and times

Test Results

* In tabular form
* In graphical form: log P plotted against log S (only for Failure Load Tests), load plotted against settlement (or uplift load and settlement or uplift) plotted against time,
* Ground heave

Site Investigation

* Site Investigation report reference number and coordinate or grid reference
* Nearest Borehole reference

20.0 COMPLETION OF A TEST

Measuring Equipment

On completion of a test, all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in future tests or removed from the Site.

Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in future tests or removed from the Site.

Ground Anchors and Temporary Piles

On completion of a Failure Load Test, temporary pile and ground anchors shall be cut off below ground level, removed from the Site and the ground made good with approved material.

The pile cap, if formed in concrete, shall be broken up and removed from the Site. If the pile cap is made of steel, it shall be cut off and either stored so that it is available for use in further tests or removed from the Site.

Initial Test Pile

Test piles which are not to be incorporated into the permanent works shall be broken down to 2m below ground level or as required, and the ground backfilled to the original level with approved material. For test piles which are to be incorporated into the permanent works, the pile head shall be made good or extended to the cut off level

1.0 GENERAL

This specification deals with the testing of bored cat in situ piles by the application of a lateral load or force. It covers vertical piles tested under lateral load (i.e. subjected to loads or forces in a horizontal direction such as would cause the pile to displace laterally under the action of horizontal load or force)

2.0 DEFINITIONS

Initial Test pile (for failure load test): a pile installed before the commencement of the main piling works or specific part of the Works to assess the load carrying capacity of the pile. This pile tested to its ultimate load capacity or to twice it's estimated safe load.

Reaction system: the arrangement of piles, pedestals, or rafts that and loading system to provide a resistance against which the pile is tested.

Ultimate bearing capacity: the load at which the resistance of the soil becomes fully mobilized.

Allowable load: the load which may be safely applied to a pile after considering its ultimate bearing capacity, negative skin friction, pile spacing, overall bearing capacity of the ground below and allowable settlement. Allowable load is load defined as per IS: 2911 (part 2).

Working load: designed load to be carried by the working pile without exceeding the allowable lateral displacement requirement (5mm unless specified otherwise

3.0 SAFETY PRECAUTIONS

General

While casting the test pile, conducting the test and dismantling the test pile after the test is complete, the contractor shall follow all applicable precautions, statutory provisions and directions of Engineer-in-charge for maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

The Contractor shall be responsible for the design of the reaction system (e.g. reaction piles, reaction pillars, installation of loading jack system etc.). As required, the design of the reaction system including the design calculations shall be endorsed by the Chartered Engineer registered with Institution of Engineers, India, who will be responsible for the safety of the whole reaction & testing system and fulfill the Health & Safety Acts.

Personnel

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

Reaction Piles/ Reaction Pedestals

Where reaction pile or reaction pedestal are used (subject to approval of the Engineer), the Contractor shall ensure that the load is correctly transmitted to the test pile.

The reaction pile or pedestal shall be so designed that it will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles or anchorages shall be placed in the specified positions, and bars, tendons or links shall be aligned to give a stable reaction in the direction required.

Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head, the whole system will be stable up to the maximum test load to be applied. Means shall be provided to enable dial gauges to be read from a position clear of the test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure or any other cause that might constitute a hazard to personnel. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum test pressure without possible leaking.

The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.

4.0 MATERIALS AND LABOUR

The Contractor shall supply all labour, materials and other equipment necessary for the performance, recording and measurements of the test loads and settlement including the supply and placing in position of the reaction system used in the tests. The Contractor shall subsequently dismantle and remove all the material and equipment used.

Throughout the duration and operation of the test loading the Contractor shall place competent men to operate, watch and record the test.

5.0 INITIAL TEST PILES

In order to confirm the load bearing capacity of the design pile the Contractor shall install and test specially installed initial piles in advance of the main piling operation for installation of working piles. The locations, sizes, lengths, test loads and instrumentation required for the initial piles shall be submitted by the contractor for approval before start of the work.

Initial piles shall be installed with the same plant and in a similar manner as that to be used in the construction of the working piles.

All initial piles shall be instrumented in accordance with that indicated in the drawings and specification. After testing, the Contractor shall be responsible to hack away the initial test pile if it is obstructing the construction of other foundation works.

6.0 MEASURING DEVICES

Load measuring devices shall be calibrated before and after each series of tests, whenever adjustments or replacements are made to the devices or at the intervals recommended by the manufacturer of the equipment. All measuring equipment and gauges shall be calibrated together. Certificates of calibration from NABL approved laboratory shall be supplied to the Engineer for acceptance.

The Contractor's proposed method of measuring the movement of pile heads and load shall be submitted to the Engineer for approval for start of load test.

7.0 SUPERVISION

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use. Load testing shall be carried out in the presence of the Engineer or

Engineer's Representative.

8.0 LOADING TEST PILES

The load steps and duration as per IS: 2911(Part-4) are given in the specification for guidance. The rate of application and removal of the load may be altered or modified solely by the Engineer. Unless otherwise decided by the Engineer the load steps and duration are as indicated in approved Test Procedure.

9.0 READINGS

Take readings of time, load and settlement and record immediately before and after the application of each load increment or decrement, or as directed by the Engineer. A minimum of another two readings shall be recorded at intermediate intervals.

10.0 INSTALLATION OF A TEST PILE

Inclusive Works

The works for the load tests shall include the construction and subsequent demolition of all necessary pile caps to the contractor's design which shall be subjected to the Engineer's approval.

Notice of Construction

The Contractor shall give the Engineer at least 48-hour notice prior to commencement of casting of any initial test pile.

Method of Construction

Each initial test pile shall be constructed in a manner similar to that to be used for the construction of the working pile, and by the use of similar equipment and materials. Any variation will only be permitted with prior agreement.

Extra reinforcement and concrete of increased strength shall be provided as required in the shafts or initial piles as per approved design of test piles to this effect.

Boring Record

For each initial test pile which is to be tested, a detailed record of the conditions experienced during boring shall be made and submitted daily, not later than the next working day. Where the Engineer requires soil samples to be taken or in-situ tests to be made, the Contractor shall present the results without delay. All submission shall also include a scan copy (in PDF format) to be emailed to the Engineer's office.

Concrete test cubes

At least 1 sample (six test cubes) shall be made from the concrete used in the initial test pile If a concrete pile is extended or capped for the purpose of testing, a further 1 sample (six test cubes) shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with IS: 516

The pile test shall not start until the compressive strength of pile concrete is established equal or greater than the design strength through tests on the test cubes. As a general rule the pile test shall be carried out after 28 days of casting the pile without special permission for early testing obtained from Engineer.

Pile Connection for Lateral Test

For a pile that is tested under lateral load, means shall be provided for transmitting the test load horizontally to the pile along its center line.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load which is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

11.0 REACTION SYSTEMS

Lateral load Test shall be carried out using reaction pile or pedestal constructed on the ground. The reaction pile or pedestal shall be designed for adequate strength and shall be founded firmly in to the ground. In all cases the resultant force of the reaction system shall be co-axial with the diametrical axis of test pile.

Spacing

The distance of the vertical reaction pile/ pedestal from the test pile shall be not less than one and half time the diameter of the test pile or the reaction pile or 1m whichever is the greatest.

Where a pile to be tested has an enlarged base (under reamed pile), the same criterion shall be applied with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall becloser to the base of the test pile than one and half time the enlarged base diameter.

Where vertical reaction pile penetrates deeper than the test pile, the center-to-center spacing of the reaction pile from the test pile shall be not less than two and half times the diameter of the test pile or the reaction pile whichever is the greatest.

Adequate Reaction

The size, length and number of reaction piles/ pedestals or reaction beam if so provided shall be adequate to transmit the maximum lateral test load to the ground in a safe manner without movement or influence on the test pile.

Care of Piles

The method employed in the installation of any reaction piles/ pedestals or beam shall be such as to prevent damage to any test pile or working pile.

Working Piles as Reaction Piles

The Contractor shall not use working piles as reaction piles.

Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

Pile caps and Structural Elements

Temporary pile caps and other structural elements forming part of the reaction system proposed by the Contractor shall be designed and built by the Contractor, and to the approval of the Engineer. The cost of building and demolishing such pile caps and structural elements shall be borne by the Contractor.

12.0 EQUIPMENT FOR APPLYING LOAD

General

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The rams or jacks shall be arranged in conjunction with the reaction system to deliver a lateral load to the test pile. The complete system shall be capable of transferring the maximum load required for the test. In case the test load is applied by jack located between the reaction and the test pile, the full load imposed by the jack shall be taken as the lateral resistance of each pile. If the load is applied by installation of two jacks placed diametrically opposite at 45^0 inclinations with respect to the axis of the test pile the value of net applied test load along the test pile axis shall be worked out accordingly.

Jack Capacity

The total capacity of the jacks shall exceed by 50% or more the required maximum test load, thereby avoiding heavy manual pumping effort when nearing maximum load and minimizing the risks of any leakage of oil through the seals.

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of load test.

The length of stroke of a ram shall be sufficient to cater for deflection of the reaction system under load plus a deflection of a pile head up to 15% of the pile shaft diameter unless otherwise specified.

13.0 MEASUREMENT OF LOAD

Load Measurement Procedure

The load shall be measured by a load measuring device and by a calibrated pressure gauge included in the hydraulic system. The technical specifications of the load cell and pressure gauge shall be submitted to the Engineer prior to the test. The load cell and pressure gauge shall be of appropriate range of the testing load. Reading of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used. The pressure gauge readings are required as a check for gross error. The pressure gauge shall have been recently calibrated.

The load measuring device may consist of a proving ring, load measuring column, pressure cell, vibrating wire load cell or other appropriate system. The load cells or proving ring shall be calibrated immediately prior to the test and a certificate shall be submitted to the Engineer.

A spherical seating shall be used in conjunction with any device that are sensitive to eccentric loadings; care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in their length in order to achieve the best possible stability. The Contractor shall pay attention to details in order to ensure that lateral loading is properly maintained.

Any increment of load shall not be allowed to fall below 1% of the specified load.

The Engineer's agreement shall be obtained in writing prior to any modification of this procedure.

Calibration of Load Measuring Devices

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together.

Certificates of calibration performed by an NABL accredited testing laboratory shall be supplied to the Engineer prior to carrying out the load test.

Measurement of Deflection/ Displacement

Deflection/Displacement shall be measured by use of a reference/datum beam supported independently of the test pile, reaction pile or piles supporting reaction loads. Settlements shall be measured to the nearest 0.1mm A precise optical level shall also be used to check movements of the reference frame against an independent datum. The reference beam supports shall be located at least 3m from the test pile, reaction pile or piles supporting reaction loads. The reference beam shall be protected from the effects of temperature changes. Construction equipment and persons not involved in the test shall be kept well clear to avoid disturbance of the measuring system. Pile driving or similar operations will not be permitted in the vicinity of the test unless the Engineer is satisfied that the measuring system will not be affected.

Deflections shall be precisely measured by min. two dial gauges of 0.01 mm sensitivity spaced at 300 mm and kept horizontally one above the other on the test pile and the displacement interpolated at cut-off level from similar triangles where cut-off level is unapproachable. For approachable cut-off level one dial gauge placed diametrically opposite to the jack shall directly measure the displacement. The dial gauge shall be firmly attached to the reference beam (datum beam), so that the plungers are perfectly horizontal and are aligned along pile axis. One of the methods for keeping the dial gauge on pile surface is to chip off uneven concrete on the side of the pile and to fix a piece of glass 20 to 30 mm square. The dial gauge tips shall rest on the central portion of the glass plate.

Initial Zero Load Readings

Before the first increment of test load is applied, all gauges shall be read at 30 minutes intervals over a period of 3 hours under zero load to determine the effect of variable site conditions on the test pile. Air temperature shall be recorded with each set of readings. The test set- up shall be exactly as during the test proper, with the loading jack in position but clear of the loading frame.

Instrument Calibration

Prior to carrying out the load test, the Contractor shall submit to the Engineer the calibration certificates of dial gauges performed by NABL accredited testing laboratory.

Night Readings

The entire test area shall be adequately lighted up during the night to facilitate taking readings.

14.0 PROTECTION OF TESTING EQUIPMENT

Protection from Weather

Throughout the test period, all equipment for measuring load and movement shall be protected from direct exposure to sunlight, wind and rain.

Prevention of Disturbance

Construction equipment and persons who are involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

15.0 SUPERVISION

Notice of Test

The Contractor shall give the Engineer at least 24 hours of notice prior to commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test as required under the section headed 'Presentation of Results' in this specification shall be available for inspection by the Engineer.

16.0 TEST PROCEDURE

Failure Load Tests (Initial Tests)

Failure Load Tests shall be performed on initial piles designated by the Engineer at the commencement of the contract to verify the design pile capacity the initial test piles shall be the only ones made in the first instance, and the load tests carried out prior to the installation of any other piles. Piling works shall not commence until after the failure load test results have been analyzed, and upon instruction by the Engineer.

The provisional number of Failure Load Tests shall be as agreed subject to min. of 3 numbers. The locations of initial test piles shall be so chosen to properly represent the total plant site and shall be subject to the approval of the Engineer. However, the Engineer reserves the right to alter the number of tests subject to the nature of subsoil conditions encountered and the pile system adopted vis-a-vis the method of installation, material and plant usage.

The test procedure shall be as follows, with the percentage for loading and unloading operations given in terms of the working load taken as 100%. In case of any variation with respect to approved pile test procedure, the approved procedure shall have the precedence.

LOADING CYCLES FOR INITIAL TEST PILES

Load (% of Working Load)	Time of Holding the Load (Minutes)	Remarks
0	Each stage of loading shall be maintained till rate of lateral displacement of pile head is less than or equal to 0.1mm/per 30 minutes subject to min. 30 minutes.	
20		
40		
60		
80		
100		
120		
140		
160		
180		
200		
220	12 hr from start of first stage loading	
250	12 hr from start of first stage loading	Test loading shall continue till one of the following take place (a) Max. test load reaches 250% of the safe load or (b) Total lateral displacement reaches 18mm.
200	10	
150	10	
100	10	
50	10	
0	0	

(NOTE: Unloading stages stated above are indicative and shall be per approved test procedure)

LOADING CYCLES FOR ROUTINE TEST PILES

Load %	Time of Holding the Load (Minutes)	Remarks
0		
20		
40		
60		
80		
100		Test load shall be carried out till one of the following takes place (a) Max. test load reaches the safe load or (b) till the total displacement is less than 5mm
75	10	
50	10	
25	10	
0		

The test schedule for Lateral Load test is for guidance only. It is subject to variation by the Engineer to meet site conditions.

For failure load test, the Contractor shall provide adequate reinforcement in the test pile to carry the ultimate lateral load.

All loading and unloading operations shall take place during the day. Pressure gauge readings shall be recorded at each load increment or at each decrease in load. During waiting periods at various loading stages, all readings shall be recorded after the load has been applied and before the commencement of next loading stage. Take readings at 15-minute intervals at 100% and 200% of working load.

If large discrepancies occur between different measurement systems, the test shall be halted and the cause for the discrepancy corrected. The test shall be restarted from the beginning in this instance.

17.0 ABANDONMENT OF PILE TEST

Test shall have to be discontinued if any of the following occurs:

- faulty jack or gauge,
- improper setting of datum, or
- unstable Bench Marks or Scales,
- measuring instruments used are found to have been tampered with by anyone,
- pre-jacking or pre-loading before commencement of the test.

Should any test be abandoned due to any of the above causes, the Contractor shall carry out further tests to the Engineer instructions after rectification of the errors.

18.0 PRESENTATION OF RESULTS

Results to be Submitted

A written summary to the Engineer within 24 hours (or unless otherwise directed) of the test, which shall give:

(i) For each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

(ii) Load vs Settlement curve.

The completed schedule of recorded data (hard & softcopy) as described hereunder in this section shall be submitted to the Engineer within seven days of completion of the test in the format generally as specified in IS: 2911 (part 4) and approved by the Engineer.

Schedule of Recorded Data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

General

* Site location
* Contract identification
* Proposed structure
* Name of EPC Contractor
* Name of Piling Contractor & Testing Agency
* Name of SECI/ Owner Engineer
* Name of EPC Contractor's Engineer
* Name of Testing Agency/ Piling Contractor Engineer
* Data of test

Pile Details

All piles
* Identification (no. and location)
* Position relative to adjacent piles
* Brief description of location (e.g. in marshy land, rocky area, high water table etc.)
* Existing Ground level at pile location
* Head level (cut-off level) at which test load is applied
* Type of pile (e.g. bored cast in situ, pre-cast driven etc.)
* Shape and size of cross-section of pile (diameter), position of change in cross-section (in case of under reamed pile – the position and dimensions of the bulb)
* Shoe or base details
* Head details
* Length in ground
* Level of toe

Installation Details

* Test cube results
* Design grade of concrete
* Reinforcement
* Whether construction under water

Test Procedure

* Max. test load
* Reaction pile details
* Plan of test arrangement showing position and distances of reaction piles and reference frame to test pile
* Jack capacity

* Calibration certificates of pressure gauges and dial gauges
* Method of load measurement
* Method(s) of lateral displacement measurement
* Proof test by maintained loading
* Relevant dates and times

Test Results

* In tabular form
* In graphical form: log P plotted against log S (only for Failure Load Tests), load plotted against settlement
* Ground heave

Site Investigation

* Site Investigation report reference number and coordinate or grid reference
* Nearest Borehole reference

19.0 COMPLETION OF A TEST

Measuring Equipment

On completion of a test, all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in future tests or removed from the Site.

Temporary Piles/ Pedestals

On completion of the Load Test, temporary pile shall be cut off below ground level, removed from the Site and the ground made good with approved material.

The pile cap, if formed in concrete, shall be broken up and removed from the Site. If the pile cap is made of steel, it shall be cut off and either stored so that it is available for use in further tests or removed from the Site.

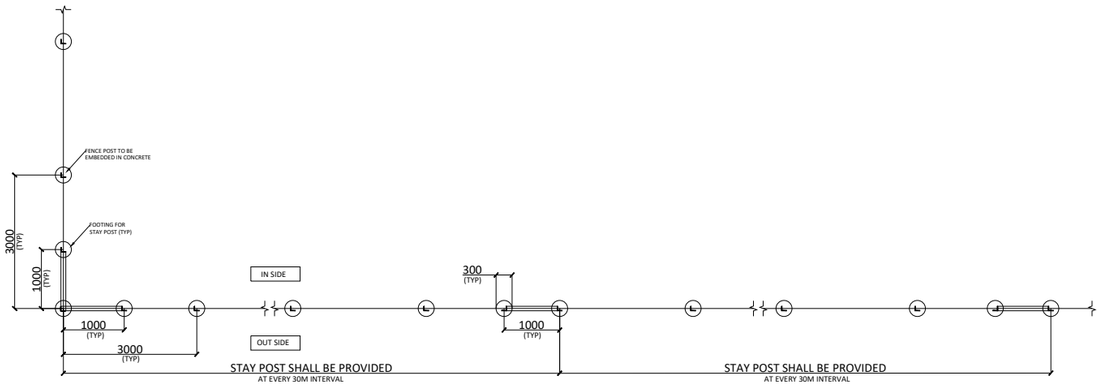
Initial Test Pile

Test piles which are not to be incorporated into the permanent works shall be broken down to 2m below ground level or as required, and the ground backfilled to the original level with approved material. For test piles which are to be incorporated into the permanent works, the pile head shall be made good or extended to the cut off level

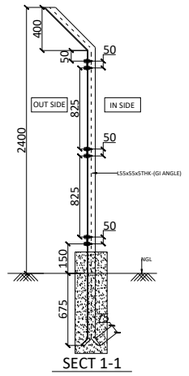
SUB-SECTION D

GENERAL ANNEXURE G

Tender Drawings



PLAN OF FOUNDATION



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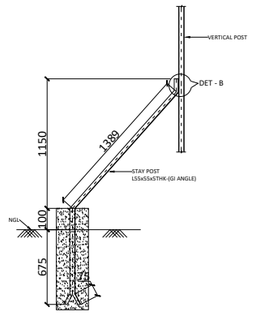


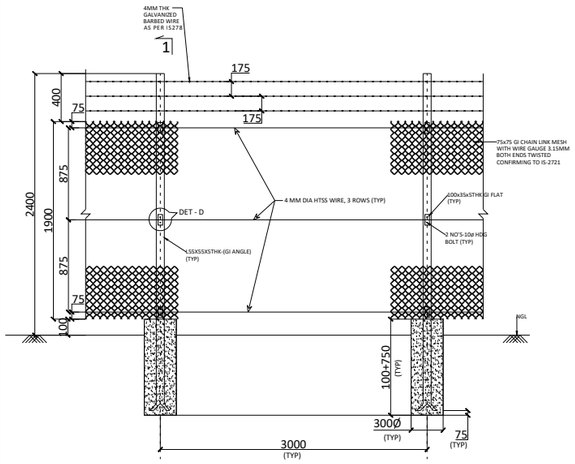
STAY POST DETAILS

LEGEND

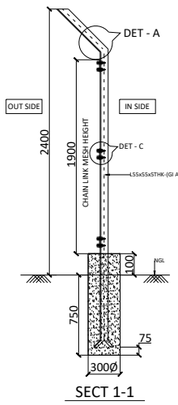
PCC	——	PLAIN CEMENT CONCRETE
NGL	——	NATURAL GROUND LEVEL
DET	——	DETAIL
TYP	——	TYPICAL
HDG	——	HOT DIP GALVANIZED
GI	——	GALVANIZED IRON
Eq	——	EQUAL
T&B	——	TOP & BOTTOM

NOTES

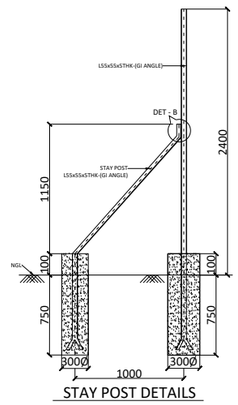
1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATION IN METERS.
2. ALL STRUCTURAL STEEL WORKS SHALL CONFORM TO IS:2062 GRADE-E250.
3. ALL DIMENSIONS TO BE CHECKED BEFORE FABRICATION OF STEEL WORK.
4. GALVANIZATION ON WIRES (INCLUDING CHAIN LINK FENCE) SHALL CONFORM TO IS:4826 (HEAVILY COATED WIRE).
5. GALVANIZATION THICKNESS SHALL BE MIN 85 MICRONS FOR ALL OTHER STEEL MEMBERS.
6. TOP OF FENCE SHALL FOLLOW THE NATURAL CONTOUR OF LAND.
7. BARBED WIRE SHALL BE OF MINIMUM 4MM DIA AND OF APPROVED MAKE. IT SHALL CONFORM TO IS:278.
8. THE BARBED WIRES SHALL BE INSERTED IN THE SLOTTED HOLE AND BINDED WITH BINDING WIRES.
9. TWO STAY POST SHALL BE PROVIDED AT EVERY CORNER COLUMN POST AND WHEREVER CHANGE IN ELEVATION/LEVEL.EVERY TENTH INTERMEDIATE POST SHALL BE PROVIDED WITH A STAY POST.
10. GRADE OF CONCRETE SHALL BE M20 (1:1.5:3) WITH 20MM NOMINAL SIZE GRADED AGGREGATES AS PER IS:456.
11. ALL REINFORCEMENT SHALL BE HIGH STRENGTH DEFORMED TMT BARS OF GRADE FE500D CONFORMING TO IS:1786
12. MIN CLEAR COVER TO REINFORCEMENT SHALL BE AS FOLLOWS: FOOTING = 50MM, COLUMN = 50MM & BEAM = 50MM.
13. HOLE DIAMETER SHALL BE 2MM LARGER THAN BOLT DIA.
14. A GRILL OF 20MM SQ. SOLID MS BAR WELDED TO IP1 AT SPACING OF 125MM C/C, WITH 20SQ HORZ.BARS OR 35MMX5MM THK FLAT WELDED TO VERTICAL SQ BARS AT SUITABLE INTERVALS (MIN. 3 NO OF THE BARS/FLATS) SHALL BE PROVIDED IN LIEU OF TOE WALL.
15. HEIGHT OF THE VERTICAL SQ SOLID MS BAR WILL VARY BASED ON ACTUAL NALLAH/DRAIN DEPTH.
16. POST ON EITHER SIDE OF NALA SHALL BE SUPPORTED WITH PEDESTAL & FOOTING ARRANGEMENT WITH A BEAM SPANNING ACROSS THE NALLAH/POND TO SUPPORT THE GRILLAGE AS SHOWN.
17. THE FOUNDATION OF THE STAY POSTS SHALL BE OF THE SAME SIZE AS THAT OF THE MAIN POSTS.
18. THE CHAIN LINK MESH FABRIC ALONG WITH HTSS WIRE SHALL BE FIXED AT THREE POINTS TO EACH VERTICAL POST USING 100x35x5 GI FLATS.
19. ALL WELDS SHALL BE 6MM THICK UNO.
20. THREE NOs. OF 4MM THICK GALVANIZED BARBED WIRES SHALL BE FIXED TO THE TOP ARM OF THE VERTICAL ANGLE POSTS.
21. SPACING BETWEEN BOTTOM OF FENCE AND GROUND LEVEL SHALL NOT BE MORE THAN 100MM.
22. EACH BOLTED CONNECTION SHALL BE PROVIDED WITH MIN 2 NOS. OF STANDARD GALVANIZED WASHERS.



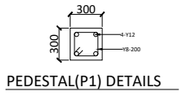
ELEVATION FOR BOUNDARY FENCING



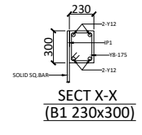
SECT 1-1



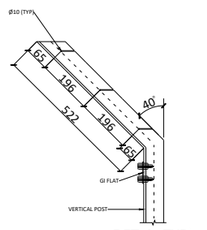
STAY POST DETAILS



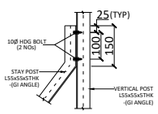
PEDESTAL(P1) DETAILS



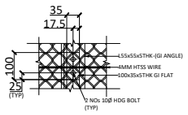
SECT X-X (B1 230x300)



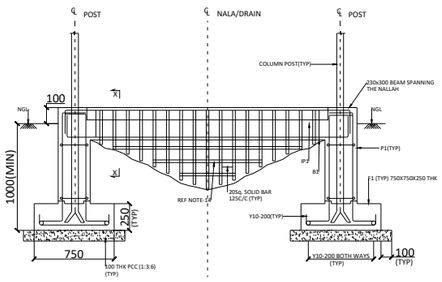
DET-A (TYP)



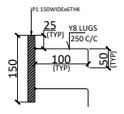
DET - B (TYP)



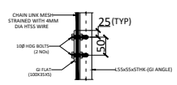
DET - D (TYP)



TYPICAL DETAILS AT NALLAH CROSSING/POND

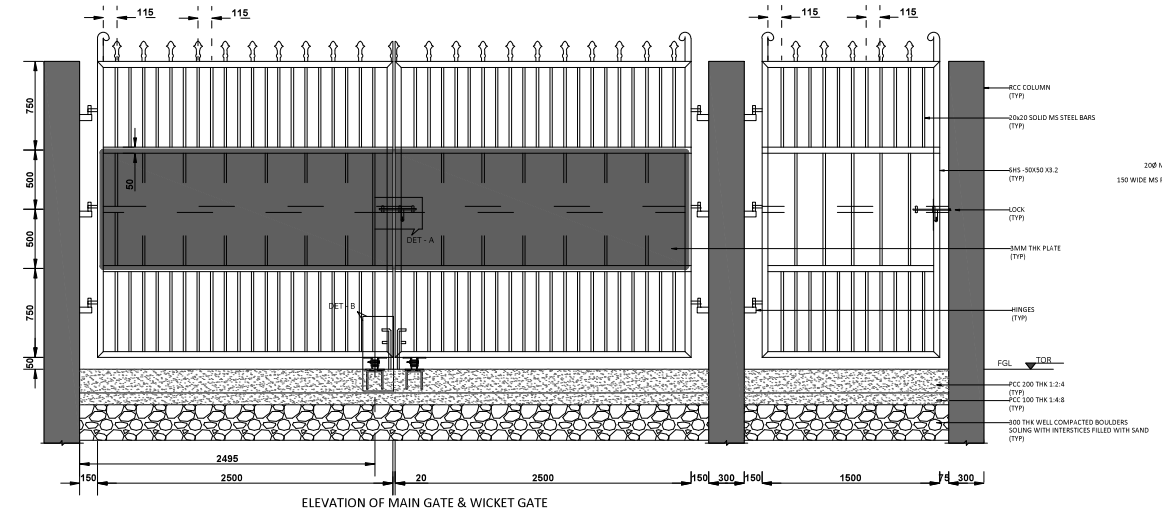


DETAILS OF IP-1

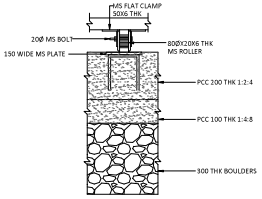


DET - C (TYP)

PROJECT CODE:					CHAIN LINK FENCE DRAWING	DRAWN	CHKD.	APPR.	SHEET
PROJECT:						DATE	DATE	DATE	REV.
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MM TOLERANCES						PART/DWG NUMBER-			SHEET SIZE A1
NO D.P.	ONE D.P.	TWO D.P.	ONE D.P.	SCALE NTS					



ELEVATION OF MAIN GATE & WICKET GATE



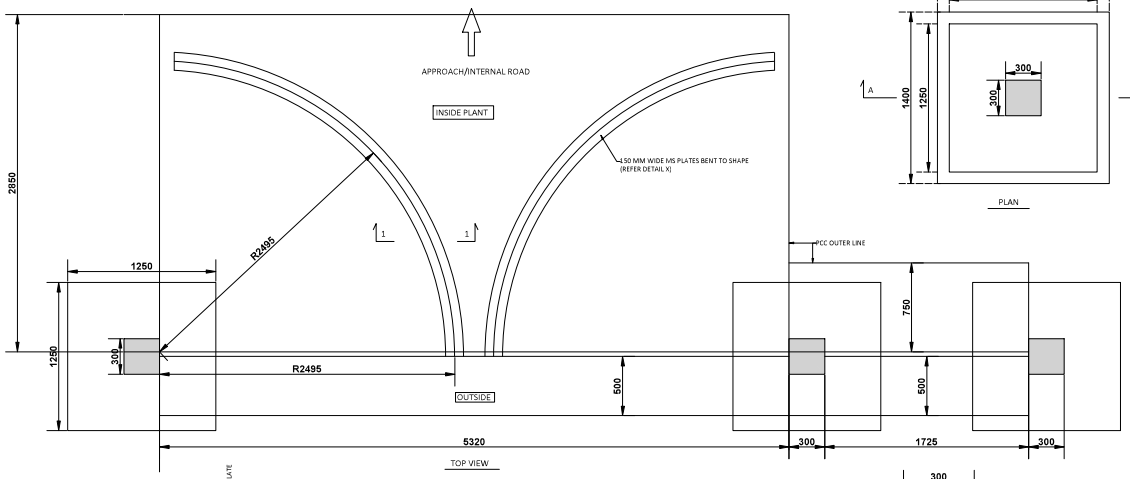
SECTION 1-1

LEGEND

FGL	—	FINISHED GROUND LEVEL
TYP	—	TYPICAL
THK	—	THICK
NB	—	NOMINAL BORE
TOR	—	TOP OF ROAD

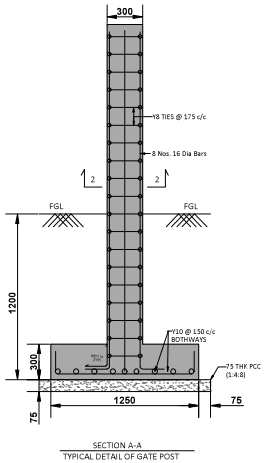
NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. DO NOT SCALE THE DRAWING. ONLY DIMENSIONS PROVIDED SHALL BE FOLLOWED.
3. CONCRETE SHALL BE OF M25 WITH 20MM NOMINAL SIZE GRADED AGGREGATES CONFORMING TO IS:456-2000.
4. REINFORCEMENT BARS SHALL BE OF HIGH YIELD STRENGTH TMT BARS OF GRADE FE500D CONFORMING TO IS:1786.
5. BENDING OF BARS SHALL CONFORM TO IS:2502.
6. LAP LENGTH/DEVELOPMENT LENGTH OF BARS SHALL BE 50xDIA OF BAR.
7. ANY DISCREPANCY IN THE DRAWING SHALL BE BROUGHT TO THE NOTICE OF ENGINEER IN CHARGE BEFORE EXECUTE OF WORK.
8. DRAWING SHALL BE READ IN CONJUNCTION WITH THE RELEVANT LAYOUT DRAWINGS.
9. CLEAR COVER TO MAIN REINFORCEMENT:
   a) FOOTING - 50 MM b) PEDESTAL - 40 MM c) COLUMN - 40 MM
10. HINGE, LOCKING ARRANGEMENT AND DROP RODS SHALL BE OF HEAVY DUTY TYPE.
11. ALL STRUCTURAL STEEL WORKS SHALL CONFORM TO IS:2062 GRADE-A & E-250.
12. WELD SIZE SHALL BE MIN 5 MM UNLESS NOTED OTHERWISE. ONLY SHOP WELDING SHALL BE PERMITTED.
13. GATE SHALL BE PROVIDED WITH THE PROJECT NAME PLATE (2.5 M X 1 M, 3 MM THICK MS PLATE) ON BOTH PANELS. DETAILS TO BE PROVIDED ON NAME PLATE SHALL BE SUBJECT TO APPROVAL FROM SECI.
14. ALL STRUCTURAL STEEL, GATE AND NAME PLATE SHALL BE PAINTED WITH 2 COATS OF EPOXY (TOTAL DFT 150 MICRONS) PAINT OF APPROVED MAKE AND SHADE OVER 2 COATS OF SUITABLE PRIMER.

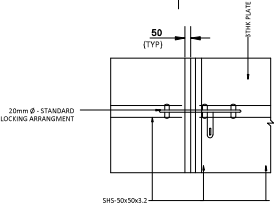


TOP VIEW

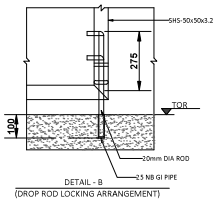
PLAN



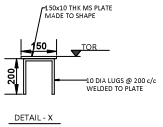
SECTION A-A
TYPICAL DETAIL OF GATE POST



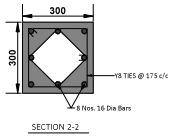
DETAIL - A
(LOCKING ARRANGMENT)



DETAIL - B
(DROP ROD LOCKING ARRANGEMENT)



DETAIL - X



SECTION 2-2

PROJECT CODE:					ENTRANCE GATE DRAWING	DRAWN	CHKD.	APPR.	SHEET
PROJECT:						DATE	DATE	DATE	REV.
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MM						PART/DWG NUMBER-			SHEET SIZE A1
TOLERANCES									
NO D.P.	ONE D.P.	TWO D.P.	ONE D.P.	SCALE NTS					

SUB-SECTION D

GENERAL ANNEXURE H

Functional Guarantee Test Procedure

TABLE OF CONTENTS

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SECTION - I

O&M TARGET GENERATION TEST

1 INTRODUCTION

To ensure proper functionality of the plant against operational acceptance milestone, and to ensure proper O&M during O&M Period, there shall be an O&M Target Generation Test for **THREE** months. The test shall be conducted at Site by the Contractor in presence of the Employer as described in this document. This test shall be binding on all the parties of the Contract. Any consecutive **three months** period after the successful commissioning of the plant, as mutually agreed by Owner and Contractor, shall be considered for conducting the O&M Target Generation Test (OTGT).

During O&M Target Generation Test, contractor shall be responsible for operation and maintenance of the plant so that the plant is running in the most optimum operation and generating in line with the designed parameters. The target generation for O&M shall be determined after the completion of O&M Target Generation test.

The Functional Guarantee for Solar Plant shall comprise of following:

(i) Visual/mechanical/Electrical checks

(ii) O&M Target Generation Test (OTGT)- Verification of Actual Generation against the Expected generation

The OTGT is intended to:

(i) Facilitate operational acceptance of the plant

(ii) Establish the target generation for the O&M period

This document lays down the procedures and requirements for conducting O&M Target Generation test including scope of the test, procedures for the test, reporting formats and process for determining test results in accordance with the Tender Specifications, applicable standards and industry best practices.

2 PRE OTGT

2.1 The EPC Contractor shall perform start-up tests after completion of Commissioning and Test Procedure as per General Annexure – I: Plant Documentation, Commissioning and Test Procedure and recording of punch points**.**

2.2 O&M Target Generation Test shall commence immediately after all issues arising from the functional/ start-up test have been rectified.

Note:

(a) All measurement(s) shall be carried out taking proper safety precaution.

(b) Also, it shall be ensured that to avoid any loose connection at the terminal points for which measurement procedure is conducted.

(c) Ensure proper functioning (e.g. Multimeters shall be calibrated) of all measuring instruments before conducting above measurement procedure.

(d) The accuracy class of the instrumentation shall be as per the relevant clause of SS-B: TS-Electrical.

(e) Pyranometers used for measurement of GHI shall be calibrated.

(f) The above test procedure shall be conducted in presence of site in-charge.

3 GENERAL REQUIREMENTS

3.1 The O&M target generation test shall commence within 60 days of the commissioning of plant facilities.

3.2 The OTGT shall be carried out for a period of 90 days at site by the contractor in presence of the employer/ employer's representative/ owner's engineer.

3.3 The dates of commencement of the OTGT shall be communicated to BOS Contractor and agreed upon by both parties i.e. Owner and EPC contractor. Any consecutive 90 days period (excluding interruptions that last entire day on account of grid outage or as per hindrance record maintained at site or weather conditions) for the purpose of conducting OTGT shall be mutually discussed and agreed between Owner and BOS contractor.

3.4 These tests shall be binding on both the parties to the contract for plant's operational acceptance as well as to determine O&M target generation.

3.5 The test shall consist of guaranteeing the target generation of the plant facilities, which is determined during the detailed engineering phase as per relevant clause, and based on the reading of the energy produced and delivered to the grid (ABT meter) and the global horizontal solar irradiation**.**

3.6 Any special equipment, instrumentation, tools, tackles, and manpower required for successful conduct of OTGT shall be arranged and provided by the Contractor at no additional cost to the Employer.

4 OTGT TEST REQUIREMENTS

4.1 Before the commencement of OTGT, the plant shall have completed pre-OTG tests as per **Clause 2** above and SCADA system and WMS shall be fully commissioned and functional.

4.2 Pyranometer Cleanness: The pyranometers shall be verified before the test commences and then visually inspected at regular intervals for cleanliness during the tests.

4.3 The Pyranometers and any other sensors used for the purpose of the PG Test shall have valid calibration certificates.

4.4 Bidder shall follow the benchmark O&M practices during the OTGT.

4.5 Average Reading of all the Pyranometers supplied shall be considered for Measurement of Global

Horizontal Solar Irradiation for the site. (Erratic / erroneous data from any of the pyranometers may be excluded for the purpose of GHI measurement at site)

5 GENERAL PROCEDURE FOR THE OTGT

5.1 **Data Collection:** The EPC Contractor shall provide the raw data as per **Annexure-1 (Format for Raw Data Submission)** to Owner. PV Power Plant test related parameters are collected in one-minute and 15 intervals for the 90 (Ninety) days reference period. The data shall consist of the following at a minimum:

- Irradiance at Horizontal Plane (GHI); (Source: SCADA, Temporal Resolution: 1 minute) (Average Reading of all the Pyranometers supplied under the scope of work will be considered)
- Other Met Data received from installed WMS; (Source: SCADA, Temporal Resolution: 1 minute)
- Energy generated at Plant (kWh) (Source: Plant TVM Meter from SCADA, Temporal Resolution: 1 minute)
- Energy exported into grid (kWh) (Source: Plant End ABT Meter, Temporal Resolution: 15 minute)
- Auxiliary Energy imported from grid (kWh) (Source: Plant End ABT Meter or separate meter for Auxiliary consumption, Temporal Resolution: 15 minute)
- PV Module Temperature recorded from the temperature Sensors (°C) (Source: SCADA, Temporal Resolution: 1 minute) (Average Reading of all the Temperature Sensors supplied under the scope of work will be considered)

5.2 **MEASUREMENT OF DAILY GENERATION**

- Plant generation measured at plant end ABT meter (**15-min time-block wise)**
- The same shall be recorded on daily basis from **0:00 am to 11:59 pm** as per the format provided at **Annexure-2: Sample for Daily Generation Report**
- This exercise shall be carried out & recorded for a period of 90 consecutive days for calculation of **OTF**.
- The filled-in format (Daily Generation Report) shall be signed by both the parties (EPC Contractor and Owner) and each party will keep one copy for record.

5.3 **RADIATION CORRECTION FACTOR (RCF):**

5.3.1 Adjustment due to Grid Outage: The measured global horizontal irradiance (kW/m^2) for the period of grid outage shall be excluded to estimate the cumulative measured global horizontal irradiation (GHI_m) (kWh/m^2) for the period of Target Generation Test. Under such situation, the radiation corresponding to the warm-up time of inverter as per data sheet shall also be adjusted to arrive at the cumulative global insolation for the OTGT period.

Note: The Contractor shall submit grid outage certification from competent authority of STU/CTU/DISCOM.

5.3.2 The Measured GHI (GHI_m) shall be calculated from the recorded irradiance values from the Pyranometer installed in horizontal plane at the site location (average in case of multiple pyranometers). This measured GHI (GHI_m) data shall be compared with the Reference GHI (GHI_{ref}) (mentioned in **SA-B: Project Specific Technical Details** of Tender Document) to estimate the **Radiation Correction Factor (RCF)** which is calculated as follows-

$$RCF = \frac{Measured\ GHI\ (GHI_m)}{Reference\ GHI\ (GHI_{ref})}$$

Note:

1. If the O&M Target Generation Test is performed over 90 days across four consecutive months, the Reference Target Generation should be determined on a pro-rata basis, based on the number of days in each month. The radiation data from the Plant Pyranometer shall be used for computation, except in case of any discrepancy (i.e. more than ± 10% variation from the Reference Irradiation, GHI_{ref}), in which case the radiation data from SolarGIS database for the said period will be used for computation.
2. RCF shall be rounded off to 3 decimal places

5.3.3 In case GHI data is not available from any of the Plant Pyranometers, the same shall be substituted by average of GHI measured for the same period in the past three (3) days or the test shall be extended for affected no. of days (**up to 15 days**) as decided by Owner.

5.3.4 All the plant Pyranometers shall be under CCTV coverage.

5.4 COMPUTATION OF UPDATED TARGET GENERATION (GT):

The **Reference Solar Target Generation (G_{TS_ref})** (P75 value) which is estimated during Detailed Engineering Phase as per **SA-B: Project Specific Technical Details** of Tender Document shall be radiation corrected to compute the **Updated Target Generation (G_T)** exclusive of BESS**.** The formula for calculation of Updated Target Generation (G_T) is mentioned below:

$$G_T = \left(RCF \times G_{TS_{ref}}\right)$$

- $E_{BESS,ref}$: Energy discharge by BESS as per detailed engineering
- RTE_{ref}: Round Trip efficiency of BESS as per detailed engineering

5.5 ESTIMATION OF ACTUAL GENERATION (G_a):

5.5.1 Metering point for Solar PV Plant shall be as per the Scope of Works of this Tender Document shall shall be c.

5.5.2 The Actual Generation (Ga) at the metering point shall be noted at regular intervals which shall be

calculated for OTGT period as follows –

$$G_a = \sum E_{export} - E_{aux}$$

Where,

- $\sum E_{export}$: Net Energy export recorded in the Solar Plant End metering point
- E_{aux}: Net Energy Import recorded (due to auxiliary consumption of Solar Plant)

5.6 COMPUTATION OF OTG TEST FACTOR (OTF):

This Actual Energy exported (G_a) at the Plant End ABT meter shall be compared with Updated Target Generation (G_T) of the test period to calculated the **OTG Test Factor (OTF)**. The **OTF** of the plant facility shall be calculated for the OTGT period as per following formula:

$$OTF = \frac{Actual\ Generation\ (G_a)}{Updated\ Target\ Generation\ (G_T)}$$

Note: OTF value calculated in above shall be used for calculation of Target Generation During O&M Period (GTn) (where n is the year of operation of the plant i.e., n- 1, 2,3, 4, etc.) as per relevant clause of **SS-F: O&M Agreement** of the tender document upon successful completion of OTGT test.

6 OTGT Pass/Fail Criterion:

6.1.1 For **successful O&M Target Generation Test, $OTF \geq 1$,** i.e., Actual Generation (G_a) at the Plant End ABT meter shall be greater than or equal to Updated Target Generation (G_T) for 90 days* of OTGT period.

Note: * 90 days excluding any interruption due to rainy/cloudy day or allowable interruptions as per this document.

6.1.2 During the OTGT, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of such breakdown, the test may be resumed once the complete system is rectified and working properly (max 15 days beyond 90 days for any reason identified in this document).

6.1.3 In case the Bidder fails to demonstrate the required performance (OTF ≥ 1), the BoS Contractor shall be allowed one additional opportunity to demonstrate compliance. Prior to the re-test, the BoS Contractor shall carry out root cause analysis and implement necessary corrective measures, including modification or addition of PV modules, replacement or augmentation of Balance of Plant equipment, and/or changes in O&M practices, as required to achieve the target generation.

6.1.4 The test shall be repeated for 90 days in case of any outage of following equipment (as applicable) for more than 7 days:

(i) Power Transformer/Inverter Duty Transformer

(ii) Power Conditioning Unit

(iii) HT Switchgear Panel

(iv) SCADA and data logger combined

(v) All the Horizontal Pyranometers

(vi) Other WMS sensors (if required)

6.1.5 In case the contractor fails to demonstrate the Successful OTGT even after the second chance, the Contractor shall be liable for Liquidated Damages for shortfall in generation over the Plant life as per relevant clause of this document.

7 LIQUIDATED DAMAGES FOR SHORTFALL IN GENERATION DURING OTGT

7.1 **FOR SHORTFALL IN OTGT (OTF<1)**: Liquidated damages (LD) of amount equal to the NPV of the estimated shortfall in cash flow resulting over the period of 25 years due to shortfall in actual generation against target generation, calculated at a tariff of **Rs. 3.56 per unit (kWh) and discount rate of 8.34%** shall be levied.

7.2 In case the above LD amount is more than the amount against 'Operational Acceptance Milestone' in line with the defined payment terms, then the total plant will be accepted on "as-is basis" & no payments will be made to the contractor pertaining to 'Operational Acceptance Milestone'. OTF value calculated during OTGT shall be accepted for calculation of Target Generation during O&M period (G_{Tn}) as per relevant clause of SS-F: O&M Agreement of the tender document. However, any other earlier pending/running payments as may be applicable, will be paid to the contractor as usual.

7.3 Cumulative value of the liquidated damages shall be limited to 'operation acceptance' milestone in line with the defined payment terms.

8 ILLUSTRATION

Sample OTF Calculation and calculations of shortfall/excess in energy generation during O&M **Target Generation** Test for **200MW plant with 100 MWh BESS** is given below-

8.1 **OTGT Period** – 12th March, 2025 to 9th June, 2025 (90 Days)

8.1.1 Sample Target Generation for 88MW plant for the site for different months are mentioned in the table below:

Month	March	April	May	June	Total
Reference GHI of the month as per tender clause) (a)	206.7	214.2	225.2	164.9	811.00 kWh/m2
Reference Target Generation for 200MW Plant as per approved PVSyst Report during detailed Engineering (GTref) (b) (*)	46,410.00	44,440.00	44,660.00	33,260.00	1,68,770.00 MWh
No of test days in a Month (c)	20	30	31	9	90.00
No of Days in a Month (d)	31	30	31	30	
Reference GHI for OTG Test Period (GHIref) (e)=(c)x(a)/(d)	133.4	214.2	225.2	49.5	622.2 kWh/m2
Reference Target Generation for OTG Test Period (GTref) (f)=(c)x(b)/(d)	29,941.94	44,440.00	44,660.00	9,978.00	1,29,019.94 MWh
Measured GHI at Site (GHIm) (g)	130.0	220.0	230.0	50.0	630.0 kWh/m2

**Note: ***Generation assumed above for illustration purpose only and shall be finalized during Detailed Engineering (as per approved DBR).

Cumulative Reference Solar Insolation for OTGT Period, i.e. 90 days (A)=∑(e)	622.22 kWh/m2
Cumulative Reference Target Generation for OTGT Period (B)=∑(f)	1,29,019.94 MWh
Cumulative Measured GHI at Site (C) =∑(g)	630.00 kWh/m2
Radiation Correction Factor (RCF) for OTGT Period (D)=(C)/(A)	1.012
Updated Target Generation (GT) for OTGT period (E)=(B)x(D)	130568.17 MWh

Case (1) OTF>=1:

If Actual Generation at site during OTGT Period (Ga) = 1,31,000.00 MWh;

Then O&M Test factor (OTF)=(Ga)/(E) = 1.003

Here, OTF>=1; O&M Target Generation test is successfully completed.

OTF= 1.003 (rounded off to 3 decimal places) **shall be accepted for O&M Period Generation Guarantee.**

Case (2) OTF<1:

If Actual Generation at site during OTGT Period (Ga') = 1,25,000.00 MWh;

Then O&M Test factor (OTF)=(Ga')/(E) = 0.957

Here, OTF<1; Therefore, Liquidated Damage may be applicable as below-

Liquidated Damage Calculations-

Shortfall in Generation during OTGT Period (i.e., 90 days) (H)=(E)-(Ga') = 5,568.17 MWh

Shortfall in Generation for Entire Year (i.e., 365 in case of non-leap year) (I)=(H)x365/90 = 22,582.04 MWh

Ceiling Tariff (J) = 3.51 Rs/kWh

Estimated Revenue Loss in a year due to Shortfall in generation (K)=(I)x(J) = ₹ 792.63 Lakhs

NPV of the estimated shortfall in cash flow resulting over the period of 25 years (at 8.34% discount rate) (L) = ₹ 8,221.08 Lakhs

Let us assume - Payment against Successful completion of Milestone against Operational Acceptance (M) is ₹ 2,400.00 Lakhs

LD applicable as per Clause 7 = ₹ 2,400.00 Lakhs

OTF= 0.957 (rounded off to 3 decimal places) **shall be accepted for O&M Period Generation Guarantee.**

Case (3) OTF<1:

If Actual Generation at site during OTGT Period (Ga') = 1,30,000.00 MWh;

Then O&M Test factor (OTF)=(Ga')/(E) = 0.996

Here, OTF<1; Therefore, Liquidated Damage may be applicable as below-

Liquidated Damage Calculations-

Shortfall in Generation during OTGT Period (i.e., 90 days) (H)=(E)-(Ga') = 568.17 MWh

Shortfall in Generation for Entire Year (i.e., 365 in case of non-leap year) (I)=(H)x365/90 = 2,304.26 MWh

Ceiling Tariff (J) = 3.51 Rs/kWh

Estimated Revenue Loss in a year due to Shortfall in generation (K)=(I)x(J) = ₹ 80.88 Lakhs

NPV of the estimated shortfall in cash flow resulting over the period of 25 years (at 8.34% discount rate) (L) = ₹ 838.88 Lakhs

Let us assume - Payment against Successful completion of Milestone against Operational Acceptance (M) is **₹ 2,400.00 Lakhs.**

LD applicable as per Clause 7 = ₹ 838.88 Lakhs

OTF= 0.996 (rounded off to 3 decimal places) **shall be accepted for O&M Period Generation Guarantee.**

Annexure -1 (Format for Raw Data Submission)

Temporal Resolution: 1 Minute

Date & Time dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	GHI (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source: TVM)

Temporal Resolution: 15 Minute (Every 15th Min record from the 1 Min Data)

Date & Time Dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (° C)	Ambient Temp. (° C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	GHI (kWh/m²)	Humidity (%)	Wind Direction(°)	Generation (kWh) (Source: TVM)	Remarks

SUB-SECTION D

GENERAL ANNEXURE I

Quality Assurance & Inspection of Civil Works

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1 Introduction

1.1 This part of the specification covers the sampling, testing and quality assurance requirement (including construction tolerances and acceptance criteria) for all civil and structural works covered in this specification.

1.2 This part of the technical specification shall be read in conjunction with other parts of the technical specifications, general technical requirements & erection conditions of the contract which covers common QA requirements. Wherever IS code or standards have been referred they shall be the latest revisions.

1.3 The rate for respective items of work or price shall include the cost for all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirement including construction tolerances and acceptance criteria and as specified in subsequent clauses of this part of the technical specifications.

1.4 The QA and QC activities in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / contract documents shall be carried out at no extra cost.

1.5 The contractor shall prepare detailed construction and erection methodology scheme which shall be compatible to the requirements of the desired progress of work execution, quality measures, prior approvals from statutory authorities etc. if any and the same shall be got approved from the Engineer.

1.6 If required, work methodology may be revised/ reviewed at every stage of execution of work at site, to suit the site conditions, work progress commensurate with project schedule by the contractor at no extra cost to the Engineer

2 QA and QC Manpower

2.1 The contractor shall nominate one overall QA coordinator for the contract detailing the name, designation, contact details and address at the time of post bid discussions.

2.2 All correspondence related to Quality Assurance shall be addressed by the contractor's QA coordinator to the Engineer.

2.3 Employer/ Consultant shall address all correspondence related to Quality issues to the contractor's QA coordinator. The contractor's QA coordinator shall be responsible for co-ordination of Quality activities between various divisions of the contractor and their sub-vendors on one hand & with Engineer on the other hand.

2.4 The contractor shall appoint a dedicated, experienced and competent QA & QC in-charge at site, preferably directly reporting to the Project Manager, supported as necessary by experienced personnel, to ensure the effective implementation of the approved QAP.

2.5 The contractor shall finalize and submit a deployment schedule of QA & QC personnel along with their details to Engineer for approval/ acceptance and further shall ensure their availability well before the start of the concern activity.

3 Laboratory and Field Testing

3.1 The contractor shall make necessary provisions to provide all facilities required for QA & QC activities by setting up a field laboratory for QA and QC activities in line with the indicative field QA & QC laboratory set-up.

3.2 The Laboratory building shall be constructed and installed with adequate facilities to meet the requirement of envisaged test setup. Temperature and humidity controls shall be available wherever necessary during testing of samples.

3.3 The quality plan shall identify the testing equipment/ instrument, which the contractor shall deploy and equip the field quality laboratory for meeting the field quality plan requirements.

3.4 The contractor shall furnish a comprehensive list of testing equipment/ instrument required to meet the planned/scheduled tests for the execution of works for Engineer's acceptance/ approval.

3.5 The contractor shall mobilize the requisite laboratory equipment and QA & QC manpower at least 15 days prior to the planned test activity as per the schedule of tests.

3.6 In case contractor desires to hire the services of any established laboratory nearby for any field tests then he shall ensure that the subject laboratory is well equipped with all requisite testing facilities and qualified QA & QC staff and this shall not affect in anyway the work progress.

3.7 All equipment and instruments in the laboratory/ field shall be calibrated before the commencement of tests and then at regular intervals, as per the manufacturer's recommendation and as directed by the Engineer. The calibration certificates shall specify the fitness of the equipment and instruments within the limit of tolerance for use. Contractor shall arrange for calibration of equipment and instruments by an NABL / NPL accredited agency and the calibration report shall be submitted to Engineer.

3.8 The tests which cannot be carried out in the field laboratory shall be done at a laboratory of repute. This includes selected IITs, NCB, CSMRS, reputed government / autonomous laboratories / organizations, NITs and other reputed testing laboratories. The test samples for such test shall be jointly selected and sealed by the engineer and thereafter these shall be sent to the concerned laboratory through the covering letter signed by Engineer. Test report along with the recommendations shall be obtained from the laboratories without delay and submitted to Engineer.

3.9 Based on the schedule of work agreed with the Engineer and the approved FQP, the

contractor shall prepare a schedule of tests and submit them to the Engineer and organize to carry out the tests as scheduled/agreed.

4 Sampling and Testing of Construction Materials

4.1 The method of sampling for testing of construction materials and work / job samples shall be as per the relevant BIS / standards / codes and in line with the requirements of the technical specifications / quality plans.

4.2 All samples shall be jointly drawn, signed and sealed wherever required, by the contractor and the engineer or his authorized representative.

4.3 The contractor shall carry out testing in accordance with the relevant IS standards/ codes and in line with the requirements of the technical specifications / quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

4.4 All testing shall be done in the presence of Engineer or his authorized representative in a NABL accredited / Govt. Laboratory acceptable to Engineer.

4.5 The test samples shall be jointly selected and sealed and signed by the Site-in-charge and thereafter these shall be sent to the concerned laboratory.

4.6 The test report along with the recommendations shall be obtained from the laboratory without delay and submitted to Engineer.

5 Purchase and Service

5.1 All structural steel shall be procured only from main steel producers In case of non-availability of some of the sections with main steel producers, the contractor may propose to procure the sections from the re-rollers of the main steel producers, the name of such re-rollers will have to be cleared by the Engineer for which details such as BIS approval, main steel producer's approval, past experience for production of sections of specified material, details of machines, plant, testing facilities etc.

5.2 Confirmation that the process control and manufacturing of steel sections by re-rollers shall be same as that of main steel producers, that billets for re-rolling will only be sourced from main steel producers shall be furnished with regard to re-roller.

5.3 For Module Mounting Structures (MMS), sources of steel other than those specified under this clause may also be used subject to the condition that they otherwise meet the requirements of the Technical Specifications / Bid documents. Even after clearance of re-rollers, induction of billets with identified and correlated Mill test certificates (MTC) in the process of re-rolling, sampling of steel, quality checks thereof and stamping of final product for further identification and correlation with MTC prior to dispatch shall be the responsibility of the contractor and these shall be performed in presence of the

authorized representative of the main Contractor.

5.4 Reinforcement steel shall be procured only from main steel producers and Mill test certificates (MTC) shall be obtained and submitted to the Engineer for correlation.

6 Field Quality Plan

6.1 Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans to Employer for approval, which shall detail out for all the works, equipment, services, quality practices and procedures etc. in line with the requirement of the technical specifications to be followed by the contractor at site.

6.2 This FQP shall cover all the items / activities covered in the contract / schedule of items required, right from material procurement to completion of the work at site.

6.3 An Indicative Field & Manufacturing Quality Plan for civil, structural and MMS works is enclosed with this specification for reference as Annexure-F.

7 General QA Requirements

7.1 The contractor shall ensure that the works, BOIs and services under the scope of Contract, whether manufactured or performed within contractor's works or at his subcontractor's premises or at the project site or at any other place of work, are in accordance with Technical specification, applicable standards / codes, approved drawings / data sheets / quality plans and BOQ. All the works, BOIs and services shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

Equipment	**UOM**	**Approx. Qty.**
Cube moulds for cement testing	nos.	4
Sieve shaker	nos.	1
Sieve for sand, coarse and fine aggregate	set	1
Sieve for coarse aggregate	set	1
Slump testing equipment	nos.	6
Oven	nos.	2
Physical balance	nos.	1
Thermometer	nos.	4
Burret	nos.	2
Measuring cylinder	nos.	9
Measuring flask	nos.	3
Compression testing machine	set	1
Cube mould for concrete	nos.	10

Mechanical weighing machine	nos.	1 (100kg capacity)
Drum type concrete mixer (for trial mixes)	nos.	1
Proctor testing equipment	set	1

7.2 Notes

- The equipment listed above is indicative and minimum required. Additional equipment, if any, required for successful completion of work shall be provided /arranged by the contractor.
- All test reports/ inspection reports shall be submitted in soft copy also and shall be available at site for easy access to the Engineer.

Based on the schedule (L2/L3 Network), Quality control & Quality Assurance Work plan shall be finalized by the contractor and the same shall be submitted to Engineer for acceptance/approval.