

SECTION - 5
TECHNICAL SPECIFICATION

Volume - II (TECHNICAL SPECIFICATION)**PART-A Civil Works****PART-B Mechanical Works****PART-C OPERATION & MAINTENANCE WORKS**

VOLUME - II	PART-A	TECHNICAL SPECIFICATIONS- CIVIL WORKS (GENERAL)
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A. INSTRUCTION AND CONDITIONS

All bidders are hereby informed that Volume-II, Part-A, Part-B, and Part-C, containing specifications for execution and maintenance of the work, are provided for guidance purposes only.

The Contractor shall be responsible for preparing and submitting its own design in accordance with the tender conditions and obtaining approval from the relevant authorities. Upon approval of the design, the Contractor shall submit a Quality Assurance Plan (QAP) covering workmanship, materials, and execution procedures to be followed during the implementation of the work.

The submitted QAP shall be reviewed and approved by the Engineer-in-Charge (EIC) before commencement of any execution activities. The specifications contained in Volume-II, Part-A, Part-B, and Part-C are general in nature and shall not be construed as exhaustive or limiting the Contractor's obligations for proper execution of the work.

Any changes, modifications, or additions to the QAP as directed by the EIC shall be binding on the Contractor. During execution, the Contractor shall ensure compliance with the minimum quality requirements and acceptance criteria stipulated in the approved QAP.

SECTION-A

TECHNICAL SPECIFICATIONS - CIVIL WORKS (GENERAL)

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SECTION A.1

PREAMBLE TO THE TECHNICAL SPECIFICATIONS

1.1 GENERAL

(1) These Technical Specifications form part of the Contract requirements for the execution of the Permanent Works and Temporary Works. "Permanent Works" shall mean the permanent works to be designed and executed under the Contract. "Temporary Works" shall mean all temporary works of any nature required for the design, construction, testing, commissioning, protection, and completion of the Works. The provisions contained herein shall form an integral part of all Technical and Contract Documents issued for the Works. Amendments and addenda to these Specifications may be issued during the bidding and execution stages and shall form part of the Contract Documents.

(2) These Specifications shall be read in conjunction with the Conditions of Contract, Drawings, Price Schedule, Employer's Requirements, and all other Contract Documents. The Contractor shall comply with all provisions contained therein and with the instructions issued by the Engineer-in-Charge (EIC).

(3) The intent of these Specifications, together with all other Tender and Contract Documents, is to provide the Contractor with guidance regarding the scope, performance requirements, functional requirements, quality standards, and minimum acceptance criteria for the Works. The specifications contained in Volume-II, Part-A, Part-B, and Part-C are general and indicative in nature and are provided for guidance purposes only. The Contractor shall be solely responsible for the complete design, engineering, detailing, procurement, construction methodology, execution, testing, commissioning, and performance of the Works in accordance with the Contract requirements.

(4) These Specifications establish the minimum standards of quality, performance, workmanship, materials, inspection, and testing required under the Contract. Minor deviations resulting from a manufacturer's standard production processes may be considered acceptable, provided that such deviations do not adversely affect the quality, safety, durability, functionality, or performance of the Works and are approved by the Engineer-in-Charge. All proposed deviations shall be clearly identified in writing and submitted for review and approval.

(5) The Contractor shall prepare and submit its own design, calculations, drawings, specifications, method statements, and other technical documents as required under the Contract. Such design and related documents shall obtain approval from the competent authorities wherever required and shall be submitted to the Engineer-in-Charge for review. Following approval of the design, the Contractor shall submit a Quality Assurance Program (QAP) covering workmanship, materials, inspection and testing procedures, acceptance

criteria, hold points, and execution methodology.

(6) No execution activity shall commence until the relevant QAP has been reviewed and approved by the Engineer-in-Charge. Any additions, modifications, or revisions required by the Engineer-in-Charge shall be incorporated by the Contractor and shall be binding upon the Contractor. During execution, the Contractor shall ensure compliance with the approved QAP and shall maintain, at a minimum, the quality standards and acceptance criteria specified therein.

(7) All work shall be executed in accordance with the Contractor's approved design, approved construction drawings, approved QAP, Contract requirements, applicable codes and standards, and instructions issued by the Engineer-in-Charge. Approval by the Engineer-in-Charge of any design, drawing, document, material, procedure, or QAP shall not relieve the Contractor of any responsibility or liability relating to the adequacy, safety, quality, performance, durability, or completeness of the Works.

(8) Notwithstanding anything contained in Volume-II, Part-A, Part-B, and Part-C, the Contractor shall remain fully responsible for the successful completion and performance of the Works. The specifications contained therein shall not limit the Contractor's obligations to provide all materials, equipment, services, and works necessary to meet the Contract requirements.

1.2 SUBMITTALS

(1) The Contractor shall submit to the Engineer-in-Charge all documents, drawings, calculations, reports, schedules, quality documents, method statements, inspection and test plans, material data sheets, and other submittals required under these Specifications and the Contract Documents. Such submissions shall be sufficiently detailed to enable proper review and understanding of the subject matter.

(2) The Engineer-in-Charge may, at any time, require additional information, clarification, revisions, or supplementary documentation in relation to any submitted document. The Contractor shall promptly comply with such requirements.

(3) The Contractor shall allow sufficient time for review, comments, and approval by the Engineer-in-Charge before commencing the related work activity. Any work carried out prior to obtaining the required approvals shall be at the Contractor's risk and responsibility.

(4) For all sections involving post-design activities, the timelines and requirements for submissions specified in Volume-II shall be deemed applicable from the date of approval of the relevant QAP unless otherwise directed by the Engineer-in-Charge.

1.3 STANDARDS AND CODES

1.3.1 General

(1) Indian Standards shall be adopted wherever applicable and are hereby incorporated into these Specifications. References to specific manufacturers or products are intended to establish minimum standards of quality and performance. Equivalent or superior products may be used subject to approval by the Engineer-in-Charge and compliance with applicable standards and codes.

(2) All standards, specifications, and codes referenced in the Contract Documents shall be the latest editions in force as of the Tender submission date unless otherwise specified.

(3) The Contractor shall maintain one complete set of all standards and codes adopted for the Works at Site for reference during the execution of the Works.

(4) In the event of any discrepancy between these Specifications and any applicable national or international code or standard, the more stringent requirement shall apply unless otherwise directed by the Engineer-in-Charge.

1.3.2 Indian Standards, Codes, Laws and Regulations

(1) Throughout the Contract period, all materials, equipment, design, services, workmanship, testing, and execution activities shall comply with the applicable Indian Standards, Codes, Acts, Rules, Regulations, and statutory requirements in force in India unless otherwise approved.

(2) The Contractor shall familiarize itself with all applicable laws, regulations, standards, and statutory requirements relevant to the Works and shall maintain copies of such documents at Site throughout the duration of the Contract.

1.3.3 International Standards and Codes

The following international standards and codes may be adopted subject to approval by the Engineer-in-Charge:

- a) International Organization for Standardization (ISO)
- b) United States Standards and Codes (ACI, ASTM, ANSI, USACE, USBR, AASHTO)
- c) British Standards (BS)

Provided that:

- i. The proposed standards are at least equivalent to or more stringent than the applicable Indian Standards; and
- ii. The Contractor submits complete details of the proposed standards and obtains approval from the Engineer-in-Charge before commencement of the related work.

1.4 SYSTEM OF UNITS

- (1) The International System of Units (SI) shall be used throughout the Contract for all technical, engineering, commercial, and contractual purposes.
- (2) The abbreviations used in the Contract Documents shall have the meanings assigned to them in the applicable schedules, drawings, and specifications.
- (3) The term "day" shall mean a calendar day unless otherwise specified.
- (4) Any reference to other systems of units shall be for information only and shall not supersede the SI system of units.

1.5 DEFINITION OF TIME AND KEY DATES

The periods of time, milestone dates, completion dates, and other key dates referred to in these Specifications shall have the meanings assigned to them in the Conditions of Contract and other relevant Contract Documents.

SECTION A.2

SITE INSTALLATIONS, SERVICES AND ENVIRONMENTAL OBLIGATIONS

2.1 SCOPE OF WORK

(1) The Contractor shall be fully responsible for providing all plant, equipment, materials, personnel, supervision, facilities, services, and Temporary Works necessary for the design, execution, testing, commissioning, protection, operation, maintenance, and completion of the Works under the Contract.

(2) The requirements contained in this Section are indicative and intended to establish the minimum functional, operational, safety, environmental, and quality requirements for Temporary Works and site facilities. The Contractor shall be solely responsible for the planning, design, engineering, furnishing, installation, operation, maintenance, modification, and removal of all Temporary Works, site installations, utilities, and Contractor's Equipment necessary for the execution of the Works, including but not limited to camps, offices, workshops, warehouses, storage and assembly areas, laboratories, batching and processing plants, vehicles, scaffolding, communication systems, water supply systems, power supply systems, access roads, environmental protection facilities, and all other temporary facilities required for successful completion of the Works.

(3) All Temporary Works, site installations, and services provided by the Contractor shall comply with the applicable Indian Acts, Rules, Regulations, Standards, Codes, statutory requirements, health and safety requirements, and environmental regulations in force. The Contractor shall also comply with all requirements relating to environmental protection, pollution control, mitigation of environmental impacts, occupational health and safety, and restoration of affected areas upon completion of the Works.

(4) The design, construction, installation, operation, maintenance, testing, monitoring, and removal of all Temporary Works and site services shall be subject to review, inspection, and audit by the Engineer-in-Charge. Such review; inspection, comments, or approval shall not relieve the Contractor of any responsibility for the adequacy, safety, quality, performance, or compliance of the Temporary Works and associated facilities.

(5) Unless otherwise specified in the Contract, all plants, equipment, camp facilities, Temporary Works, installations, utilities, materials, and services provided by the Contractor shall remain the property of the Contractor. Upon completion of the Contract, any sale, transfer, disposal, or retention of such assets within India shall be subject to applicable laws, taxes, duties, statutory approvals, and governmental permissions.

(6) The Contractor shall construct, operate, maintain, and subsequently remove, where required, all temporary roads, diversions, access routes, haul roads, working platforms, and other temporary infrastructure necessary for access to work areas, camps, storage facilities, plants, borrow areas, disposal areas, and all other locations associated with the execution of the Works. Such facilities shall be maintained in a safe and serviceable condition throughout the Contract period.

2.2 CONTRACTOR'S SITE OFFICES, STORES, WAREHOUSES AND MATERIALS YARDS

(1) The Contractor shall provide, equip, operate, maintain, and subsequently remove all offices, workshops, warehouses, storage facilities, fuel storage areas, explosive storage facilities, and other temporary facilities required for the execution of the Works. Such facilities shall be adequate for the Contractor's and subcontractors' operations and shall be maintained in a safe, secure, and serviceable condition throughout the Contract period.

(2) The facilities to be established by the Contractor may include, but shall not be limited to:

- a) Mechanical repair workshops;
- b) Electrical repair workshops;
- c) Fabrication workshops for metal, wood, and miscellaneous works;
- d) Main warehouse and spare parts stores;
- e) Bulk cement storage silos;
- f) Covered cement storage facilities;
- g) Spare parts and consumables storage facilities;
- h) Fuel, lubricant, and oil storage and dispensing facilities.

The Contractor shall determine the size, capacity, configuration, and number of such facilities based on its construction methodology, programme, and operational requirements.

(3) The Contractor shall maintain adequate stocks of construction materials, consumables, spare parts, and other essential supplies necessary for uninterrupted execution of the Works. Minimum inventory levels shall be determined by the Contractor considering procurement lead times, seasonal conditions, transportation constraints, and construction schedules. The Contractor shall take appropriate measures to ensure continuity of operations during adverse weather conditions, including monsoon periods.

2.3 CONCRETE AND MATERIALS PROCESSING PLANTS

(1) The Contractor shall procure, install, commission, operate, maintain, and remove all concrete batching plants, material processing plants, crushing plants, screening plants, storage facilities, and associated equipment necessary for execution of the Works. The capacity and configuration of such facilities shall be adequate to meet the peak construction requirements and approved construction programme.

(2) All processing plants, equipment, instrumentation, control systems, and measuring devices shall comply with the applicable standards, specifications, approved designs, and Quality Assurance Plan. The Contractor shall ensure proper maintenance, calibration, inspection, and operation of all equipment throughout the Contract period.

(3) Detailed designs, layout drawings, equipment specifications, manufacturer's data, operational

procedures, quality control procedures, and calibration arrangements shall be submitted to the Engineer-in-Charge for review prior to installation and commissioning.

(4) Concrete batching plants shall be fully automatic and equipped with computerized batching controls, automatic data recording, and batch printout facilities capable of generating permanent production records. Semi-automatic batching plants or batching plants without automated recording and printout facilities shall not be permitted unless specifically approved by the Engineer-in-Charge.

(5) Approval of any plant, equipment, layout, or operational arrangement by the Engineer-in-Charge shall not relieve the Contractor of responsibility for production capacity, material quality, safety, environmental compliance, reliability, or performance of the facilities.

2.4 MATERIALS TESTING LABORATORY

(1) The Contractor shall design, establish, equip, operate, maintain, and subsequently dismantle adequate site laboratories and quality control facilities necessary for sampling, inspection, testing, calibration, and quality assurance activities associated with the Works.

(2) The laboratory facilities shall be suitably located, environmentally controlled where required, and provided with adequate utilities, equipment, storage, safety provisions, and working space necessary to perform all specified tests and quality control activities.

(3) All laboratory equipment, instruments, and testing procedures shall comply with the applicable Indian Standards, approved international standards, Contract requirements, and the approved Quality Assurance Program (QAP). All equipment shall be properly calibrated through accredited agencies and maintained throughout the Contract period.

(4) The Contractor shall employ qualified and experienced personnel for laboratory operations, testing, quality control, and reporting activities.

(5) Any specialized testing that cannot be performed at the Site laboratory shall be carried out through approved laboratories at the Contractor's cost.

(6) Testing frequencies shall comply with the approved QAP, applicable standards, Contract requirements, and directions of the Engineer-in-Charge (EIC).

(7) The Contractor shall bear all costs associated with sampling, testing, calibration, third-party testing, laboratory establishment, operation, maintenance, and reporting.

2.5 SITE COMMUNICATION SYSTEMS

(1) The Contractor shall provide, install, operate, maintain, and upgrade, as necessary, communication systems required for efficient management, supervision, coordination, safety, security, and emergency response activities throughout the Site.

(2) The communication network shall adequately connect all work locations, offices, laboratories, workshops, plants, camps, storage facilities, and other operational areas associated with the Works.

(3) The Contractor shall maintain updated communication directories and emergency contact information and make such information available to the EIC.

2.6 SERVICE VEHICLES

(1) The Contractor shall provide, operate, maintain, and replace as necessary sufficient vehicles, transportation equipment, and support facilities required for management, supervision, inspection, testing, safety, security, operation, maintenance, and execution of the Works.

2.7 CAMPS FOR CONTRACTOR'S EMPLOYEES

(1) The Contractor shall construct, operate, maintain, and remove all camps, accommodation facilities, dining facilities, welfare facilities, recreational facilities, and associated infrastructure required for its personnel and subcontractors.

(2) All camp facilities shall comply with applicable labour laws, health and safety regulations, environmental regulations, and statutory requirements.

(3) The Contractor shall be responsible for acquisition of land, statutory approvals, surveys, site preparation, utility connections, operation, maintenance, security, sanitation, and restoration of camp areas upon completion of the Works.

(4) The Contractor shall maintain all camps in safe, hygienic, environmentally acceptable, and operational condition throughout the Contract period.

2.8 MEDICAL CARE FACILITIES

(1) The Contractor shall establish and maintain adequate medical, first-aid, emergency response, and occupational health facilities necessary for the workforce and in compliance with applicable laws and regulations.

(2) The Contractor shall provide emergency transportation, first-aid equipment, medicines, and facilities necessary to respond to workplace injuries, illnesses, and emergencies.

2.9 POWER SUPPLY AND ILLUMINATION

(1) The Contractor shall install, operate, maintain, and remove all temporary power generation, transmission, distribution, backup power, and illumination systems necessary for execution of the Works.

(2) The Contractor shall ensure continuous, reliable, and safe power supply sufficient to meet construction, camp, laboratory, security, safety, and emergency requirements.

(3) Adequate standby power systems shall be provided to ensure uninterrupted operation of critical facilities and services.

(4) The Contractor shall provide adequate illumination for all work areas, roads, plants, camps, offices, and safety-critical locations.

2.10 WATER SUPPLY

(1) The Contractor shall establish, operate, maintain, and monitor water supply systems necessary for construction activities, camps, offices, laboratories, and all associated facilities.

(2) Water used for construction and potable purposes shall comply with applicable standards and Contract requirements.

2.11 SANITATION AND SEWERAGE

- (1) The Contractor shall provide, operate, maintain, and remove all sanitation, drainage, sewerage, wastewater treatment, and disposal facilities necessary for the Site and camps.
- (2) All facilities shall comply with statutory requirements, environmental regulations, and approved environmental management plans.

2.12 SECURITY, INSPECTION AND FINAL CLEAN-UP

- (1) The Contractor shall provide and maintain adequate security arrangements, access control systems, fencing, lighting, identification systems, surveillance measures, and security personnel for protection of personnel, equipment, facilities, materials, and the Works.
- (2) The EIC shall have unrestricted access for inspection of all Temporary Works, facilities, records, testing activities, environmental measures, and site operations.
- (3) Upon completion of the Works, the Contractor shall dismantle and remove all Temporary Works and facilities, restore affected areas, dispose of waste materials, and leave the Site in a clean, safe, environmentally acceptable condition to the satisfaction of the EIC.

2.13 PAYMENT FOR SITE INSTALLATIONS, SERVICES AND ENVIRONMENTAL OBLIGATIONS

- (1) No separate payment shall be made for planning, installation, operation, maintenance, modification, replacement, monitoring, testing, environmental compliance, security, utilities, demobilization, restoration, or removal of Temporary Works, site installations, services, camps, laboratories, environmental protection measures, or any other facilities required under this Section.
- (2) All costs associated with the obligations described in this Section, including compliance with statutory requirements, environmental regulations, health and safety requirements, approved QAP, and directions of the Engineer-in-Charge, shall be deemed included in the Contract Price and no additional payment shall be admissible on any account.

SECTION A.3 SAFETY PRECAUTIONS

3.1 SAFETY STANDARDS AND STATUTORY COMPLIANCE

(1) The Contractor shall comply with all applicable Indian Acts, Rules, Regulations, Codes, Standards, Government Orders, statutory requirements, and industry best practices relating to occupational health, safety, welfare, fire protection, environmental protection, and construction activities.

(2) Where more than one standard is applicable, the more stringent requirement shall apply unless otherwise directed by the EIC.

(3) The Contractor shall maintain copies of all applicable safety regulations, codes, standards, emergency procedures, and safety records at Site throughout the Contract period.

3.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

General Requirements

(1) The Contractor shall provide, maintain, replace, and enforce the use of appropriate Personal Protective Equipment (PPE) for all personnel, subcontractors, visitors, consultants, inspectors, and representatives entering the Site.

(2) Minimum mandatory PPE shall include safety helmets, high-visibility clothing, safety footwear, and any additional protective equipment required for the specific work activity.

(3) Safety footwear with steel toe protection shall be mandatory in all construction and operational areas.

(4) Suitable eye protection, face protection, respiratory protection, hearing protection, hand protection, and protective clothing shall be provided where required by the nature of the work.

(5) Personnel exposed to chemical, biological, electrical, thermal, mechanical, or environmental hazards shall be provided with specialized PPE appropriate to the identified risks.

(6) Personnel working at height shall be provided with approved fall protection systems, including safety harnesses, lifelines, anchor points, guardrails, safety nets, and rescue arrangements.

(7) The Contractor shall provide training in the proper use, maintenance, storage, and replacement of PPE.

3.3 SITE ILLUMINATION, ELECTRICAL SAFETY AND EARTHING

3.3.1 General

(1) The Contractor shall provide adequate illumination for all work areas, access routes, roads, plants, workshops, storage areas, camps, emergency facilities, and temporary works during periods of darkness or reduced visibility.

(2) Lighting systems shall be installed, operated, and maintained to ensure safe working conditions and compliance with applicable standards.

3.3.2 Electrical Safety and Earthing

- (1) All temporary and permanent electrical installations used during construction shall be designed, installed, tested, operated, and maintained in accordance with applicable electrical safety standards and statutory requirements.
- (2) All equipment, installations, structures, generators, transformers, distribution systems, and metallic components exposed to electrical hazards or lightning shall be effectively earthed and periodically tested.
- (3) Electrical work shall only be performed by qualified and authorized personnel.
- (4) Appropriate lockout-tagout (LOTO) procedures shall be implemented for maintenance and isolation of electrical systems.
- (5) Electrical equipment used in wet, confined, or hazardous areas shall be specifically designed and approved for such conditions.
- (6) Portable electrical equipment, cables, and distribution systems shall be regularly inspected, tested, and maintained.

3.4 TRAFFIC MANAGEMENT AND PUBLIC SAFETY

- (1) The Contractor shall be responsible for the safety of all road users, pedestrians, workers, and members of the public affected by the Works.
- (2) The Contractor shall implement a Traffic Management covering traffic diversions, access arrangements, signage, barricading, lighting, speed control measures, emergency access routes, and public safety provisions.
- (3) All traffic control measures shall comply with applicable regulations, standards, and directions of the relevant authorities.
- (4) Suitable warning signs, barricades, lighting, flagmen, traffic marshals, and protective measures shall be provided and maintained wherever construction activities affect public access or traffic movement.
- (5) Temporary roads, bridges, crossings, pedestrian routes, and access arrangements affected by the Works shall be maintained in a safe condition throughout the Contract period.
- (6) The Contractor shall immediately repair any damage caused to public roads, access routes, utilities, structures, or public property resulting from its operations.

3.5 WATER POLLUTION PREVENTION AND ENVIRONMENTAL PROTECTION

- (1) The Contractor shall take all necessary measures to prevent contamination, pollution, or degradation of rivers, streams, watercourses, reservoirs, groundwater, and other water resources affected by the Works.
- (2) No untreated sewage, wastewater, slurry, fuel, oil, chemicals, hazardous substances, construction waste, or contaminated water shall be discharged into any natural water body, drainage channel, or open area.
- (3) The Contractor shall provide and maintain suitable treatment, containment, monitoring, collection, storage, transportation, and disposal systems for all waste streams generated by the Works.
- (4) Spill prevention and emergency response procedures shall be implemented for handling

fuels, lubricants, chemicals, and hazardous materials.

(5) The Contractor shall comply with all environmental permits, approvals, regulations, and requirements applicable to the Works and shall immediately rectify any environmental non-compliance identified by the EIC or statutory authorities.

3.6 PAYMENT

(1) No separate payment shall be made for preparation, implementation, monitoring, maintenance, revision, or compliance with safety, health, environmental protection, emergency response, training, traffic management, PPE, welfare facilities, statutory requirements, inspections, audits, reporting, or any other obligations described in this Section.

(2) All costs associated with compliance with the requirements of this Section shall be deemed to be included in the Contract Price.

(3) Any repair, replacement, rectification, compensation, penalty, claim, damage, loss, liability, or indemnity arising from the Contractor's failure to comply with safety, health, environmental, or statutory requirements shall be entirely at the Contractor's risk and expense

SECTION A.4

SURVEYING AND SETTING-OUT WORK

4.1 EXISTING SURVEY CONTROL POINTS

- (1) Existing survey control networks, reference benchmarks, triangulation stations, coordinates, levels, and other survey information, if provided by the Employer or Engineer-in-Charge (EIC), are furnished for guidance purposes only.
- (2) Prior to commencement of any design, engineering, surveying, or construction activities, the Contractor shall independently verify all survey control data, coordinates, levels, benchmarks, topographical information, and site conditions and satisfy itself regarding their accuracy, adequacy, and suitability for the Works.
- (3) Any discrepancy, inconsistency, omission, or error identified by the Contractor shall be promptly reported to the Engineer-in-Charge in writing. However, such notification shall not relieve the Contractor of its responsibility for establishing accurate survey controls and executing the Works in accordance with the Contract requirements.
- (4) The Contractor shall remain solely responsible for the accuracy and adequacy of all survey information used for design, engineering, setting-out, construction, measurement, monitoring, and completion of the Works.

4.2 CONTRACTOR'S OBLIGATIONS

4.2.1 General

- (1) The Contractor shall perform all surveys, calculations, setting-out, verification, monitoring, and measurement activities necessary for the design, construction, testing, commissioning, operation, and completion of the Works.
- (2) Within **21 days** from the date of issuance of the Notification of Award, the Contractor shall submit a comprehensive **Survey Management Plan** to the Engineer-in-Charge for review. The plan shall include survey methodology, control networks, equipment details, accuracy requirements, survey procedures, monitoring arrangements, personnel qualifications, record-keeping procedures, and quality control measures.
- (3) Before commencing any setting-out activities for major components of the Works, the Contractor shall submit details of the proposed survey methodology, benchmark establishment procedures, control networks, and verification processes.
- (4) Where the Contractor establishes additional survey control points, benchmarks, or reference stations, all costs, responsibilities, risks, maintenance, and verification obligations shall remain solely with the Contractor.
- (5) The Contractor shall carry out all topographical, hydrographical, utility, geotechnical interface, and construction surveys necessary to verify design assumptions, determine existing conditions, calculate quantities, establish work limits, and support execution of the Works.
- (6) Survey activities shall be performed only by suitably qualified and experienced survey personnel using calibrated and appropriate surveying instruments and software.
- (7) The Contractor shall maintain all survey records, calculations, field notes, electronic files,

coordinates, and survey reports in an organized and traceable manner and shall make them available for inspection by the Engineer-in-Charge upon request.

4.2.2 Benchmarks and Survey Control Stations

- (1)** Existing benchmarks, survey control points, triangulation stations, and baselines shall be verified by the Contractor and integrated into the Contractor's survey control system where appropriate.
- (2)** The Contractor shall establish, maintain, protect, monitor, and periodically verify permanent and temporary survey control points necessary for execution of the Works.
- (3)** Survey control points shall be located, protected, and documented in a manner that ensures long-term stability and reliability throughout the Contract period.
- (4)** Complete records of all survey control stations, benchmarks, coordinates, elevations, calculations, inspections, and verification activities shall be maintained by the Contractor.
- (5)** The Contractor shall protect all existing and newly established benchmarks, survey monuments, reference points, and control stations from disturbance, damage, removal, or destruction. Any damage shall be immediately reported to the Engineer-in-Charge and reinstated by the Contractor at its own cost.
- (6)** Permanent benchmarks shall be constructed using durable materials and installed in stable locations suitable for long-term use. Their details, coordinates, and elevations shall be properly documented.
- (7)** All newly established survey points shall be independently checked and verified through redundant observations and suitable survey controls before being used for construction purposes.

4.2.3 Survey Accuracy Requirements

- (1)** Surveying equipment, methodologies, and procedures shall be appropriate for the required accuracy and shall comply with applicable Indian Standards, Survey of India requirements, and approved international standards where applicable.
- (2)** Horizontal control surveys shall be performed using Total Stations, GNSS/GPS systems, electronic distance measurement equipment, laser scanning systems, or other approved technologies capable of achieving the required accuracy.
- (3)** Vertical control shall be established through differential levelling or other approved methods capable of meeting the specified accuracy requirements.
- (4)** Traverse networks and control surveys shall be designed, observed, adjusted, and verified to achieve the accuracy required for the Works and shall comply with applicable survey standards.
- (5)** All survey loops, traverses, benchmarks, and control networks shall be independently checked and closed within permissible tolerances.
- (6)** Survey instruments shall be calibrated and maintained throughout the Contract period, and calibration records shall be available for inspection.

4.2.4 Auxiliary Survey Works

(1) The Contractor shall perform all auxiliary works necessary to support surveying, setting-out, verification, monitoring, measurement, and construction activities, including but not limited to:

- a) Preparation of survey calculations, adjustment reports, coordinate schedules, and verification records;
- b) Recovery, exposure, relocation, protection, and reinstatement of survey control points and benchmarks;
- c) Establishment of additional benchmarks and control points where required;
- d) Removal of temporary obstructions affecting survey operations;
- e) Provision of lighting, access arrangements, and support facilities necessary for survey activities;
- f) Provision of labour, equipment, materials, vehicles, and resources necessary to perform survey work;
- g) Removal of water, vegetation, or other obstructions affecting survey accuracy;
- h) Additional topographical surveys required for design development, construction planning, quantity determination, and measurement purposes;
- i) Surveys required for instrumentation, monitoring systems, deformation monitoring, settlement observations, and structural behaviour assessments;
- j) Surveys required for as-built documentation and preparation of record drawings.

(2) All such activities shall be coordinated with the Engineer-in-Charge and other relevant stakeholders as required.

4.2.5 Protection of Property, Crops and Vegetation

(1) The Contractor shall take all reasonable measures to avoid unnecessary damage to crops, vegetation, trees, utilities, structures, and private property during surveying, setting-out, and related activities.

(2) The Contractor shall coordinate with relevant authorities, landowners, and designated representatives regarding valuation, protection, documentation, and management of affected crops, vegetation, and property.

(3) Where clearing limits or work boundaries are established, the Contractor shall clearly mark and maintain such limits using approved methods.

4.3 REVIEW OF CONTRACTOR'S SURVEY WORK BY THE ENGINEER-IN-CHARGE

4.3.1 Review and Verification

(1) The Engineer-in-Charge may review, inspect, witness, audit, or verify any aspect of the Contractor's survey activities, records, calculations, control points, setting-out operations, measurements, monitoring systems, and survey documentation.

(2) The Contractor shall provide reasonable assistance, access, equipment, information, survey records, calculations, and personnel required for such reviews.

(3) Where necessary for verification purposes, the Engineer-in-Charge may direct temporary suspension of affected activities until survey discrepancies are resolved.

(4) Any review, verification, comment, acceptance, approval, or inspection by the Engineer-in-

Charge shall not relieve the Contractor of responsibility for the accuracy, adequacy, completeness, or correctness of any survey work, setting-out, measurements, calculations, or construction activities.

4.4 PAYMENT FOR SURVEYING AND SETTING-OUT WORK

(1) No separate payment shall be made for surveys, investigations, verification of existing survey data, establishment and maintenance of survey control networks, setting-out, monitoring surveys, topographical surveys, hydrographical surveys, quantity surveys, deformation monitoring, as-built surveys, survey equipment, personnel, software, calibration, documentation, Survey Management Plans, Quality Assurance Programs, or any other activities required under this Section.

(2) All costs associated with surveying, setting-out, monitoring, verification, record preparation, quality control, design support, engineering support, and compliance with the requirements of this Section shall be deemed to be included in the Contract Price, and no additional payment shall be admissible on any account.

(3) Any rectification, reconstruction, delay, re-survey, redesign, rework, or corrective measures arising from inaccuracies or deficiencies in the Contractor's survey work shall be carried out entirely at the Contractor's cost and risk.

SECTION A.5

QUALITY ASSURANCE

5.1 QUALITY ASSURANCE IN EXECUTION OF WORKS

(1) The Contractor shall establish, implement, maintain, and continuously improve a comprehensive Quality Management System (QMS) for the design, procurement, manufacture, construction, installation, testing, commissioning, and completion of the Works. The Quality Management System shall ensure that all activities, materials, equipment, workmanship, and completed Works comply with the Contract requirements, approved design, approved Quality Assurance Plan (QAP), applicable standards, statutory requirements, and approved drawings.

(2) The Contractor shall submit, within **7 days** from the date of approval of final design, a comprehensive Quality Assurance Plan (QAP) covering all aspects of the Works, including but not limited to:

- a) Procurement and vendor list
- b) Material inspection and testing procedures;
- c) Method statements for construction activities;
- d) Inspection and Test Plans (ITPs);
- e) Hold points, witness points, and review points;
- f) Calibration procedures for equipment and instruments;
- g) Non-conformance reporting and corrective action procedures;
- h) Quality records management;
- i) Site laboratory operations and testing procedures;
- j) Procedures for monitoring, reporting, and continual improvement.

(3) No construction activity shall commence until the relevant QAP, Inspection and Test Plans, and Method Statements have been reviewed and approved by the Engineer-in-Charge (EIC).

(4) The Contractor shall deploy qualified personnel, suitable equipment, testing facilities, laboratories, procedures, and management systems necessary to achieve the quality requirements specified in the Contract.

(5) Where the Engineer-in-Charge determines that the resources, personnel, procedures, equipment, or quality control measures are inadequate, the Contractor shall promptly take corrective measures and provide additional resources at no additional cost to the Employer.

(6) Approval of the Contractor's QAP, procedures, personnel, materials, equipment, or inspection arrangements by the Engineer-in-Charge shall not relieve the Contractor of responsibility for quality, compliance, safety, performance, durability, or successful completion of the Works.

5.2 CONTROL OF PROGRESS OF THE WORK

(1) Progress monitoring, reporting, and control shall form an integral part of the Contractor's Quality Management System.

(2) The Contractor shall continuously monitor actual progress against the approved construction programme and shall maintain complete and up-to-date records of progress, resources,

production, testing, inspections, and quality activities.

(3) The Contractor shall submit progress reports at frequencies specified in the Contract or as directed by the Engineer-in-Charge. Such reports shall include, as applicable:

- a) Physical progress achieved;
- b) Planned versus actual progress;
- c) Resource deployment;
- d) Status of design submissions and approvals;
- e) Status of material procurement;
- f) Inspection and testing activities;
- g) Non-conformities and corrective actions;
- h) Critical issues affecting progress;

(4) The Contractor shall immediately notify the Engineer-in-Charge of any event, condition, delay, non-conformance, shortage, technical issue, or other circumstance that may adversely affect quality, cost, safety, performance, or completion of the Works.

(5) The Engineer-in-Charge may require additional reports, analyses, schedules, forecasts, or supporting information necessary for monitoring the progress and quality of the Works.

5.3 CONTRACTOR'S LABORATORIES

(1) The Contractor shall establish, equip, operate, maintain, and calibrate laboratories necessary for quality control, inspection, testing, verification, and monitoring of all materials, equipment, and works covered under the Contract.

(2) The laboratories shall be capable of performing all tests required under the Contract, approved QAP, applicable standards, and directions of the Engineer-in-Charge.

(3) Laboratory personnel shall possess appropriate qualifications, training, and experience and shall be subject to review by the Engineer-in-Charge.

(4) Complete records shall be maintained for all sampling, testing, calibration, inspections, results, non-conformities, and corrective actions.

(5) The Engineer-in-Charge shall have unrestricted access to laboratories, equipment, records, reports, samples, testing activities, and quality documentation at all times.

(6) All testing equipment, instruments, gauges, measuring devices, and monitoring systems shall be calibrated at regular intervals by NABL-accredited laboratories or other approved accredited agencies. Calibration certificates shall be maintained and made available for inspection.

(7) Where specialized testing facilities are not available at Site, testing shall be performed through approved independent laboratories at the Contractor's cost.

5.4 MATERIALS DELIVERED TO SITE

(1) The Contractor shall establish procedures for inspection, identification, traceability, handling, storage, preservation, testing, and acceptance of all materials delivered to Site.

(2) Complete records shall be maintained for all materials, including:

- a) Material test certificates;
- b) Delivery records;
- c) Batch identification records;

d) Calibration records where applicable;

e) Non-conformance and corrective action records.

(3) Materials shall not be incorporated into the Works unless they comply with the approved specifications, applicable standards, approved design requirements, and approved QAP.

(4) The Engineer-in-Charge may direct additional testing, verification, sampling, inspection, or independent third-party testing whenever deemed necessary.

5.5 PAYMENT

(1) No separate payment shall be made for preparation, implementation, maintenance, auditing, monitoring, updating, or compliance with the Quality Management System, Quality Assurance Program (QAP), Inspection and Test Plans (ITPs), laboratories, testing, calibration, inspections, quality personnel, quality records, reporting, corrective actions, audits, or any other quality-related activities required under this Section.

(2) All costs associated with quality assurance, quality control, testing, inspection, monitoring, calibration, documentation, audits, compliance, and implementation of the approved QAP shall be deemed to be included in the Contract Price.

(3) Any rework, replacement, rectification, additional testing, redesign, reconstruction, or corrective measures arising from quality deficiencies or non-conformance shall be carried out entirely at the Contractor's cost and risk.

Quality Assurance and Testing

A sample Quality Assurance Plan (QAP) and testing schedule is provided in the tender document for guidance and reference purposes only. The tests, frequencies and acceptance criteria indicated therein are indicative and shall not be construed as exhaustive. The Contractor shall prepare and submit a detailed Project Quality Assurance Plan based on the final approved design, construction methodology, applicable codes and specifications for approval by the Engineer-in-Charge.

Materials, components, equipment and works not specifically covered in the sample QAP shall also be subjected to appropriate inspection and testing requirements as per relevant IS Codes, IRC Specifications, MoRTH Specifications, GERI Manual, manufacturers' recommendations and directions of the Engineer-in-Charge.

The Contractor and the testing agency engaged by him shall mandatorily follow the latest applicable provisions of the GERI Manual attached with the tender document for sampling, testing procedures, testing frequency, quality control requirements and acceptance criteria wherever applicable. In case of any discrepancy, the more stringent requirement among the Contract Specifications, GERI Manual, relevant Codes and directions of the Engineer-in-Charge shall govern.

The final list of materials, testing requirements, test frequencies, inspection stages and acceptance criteria shall be finalized based on the approved detailed design and construction drawings. The Contractor shall carry out all such tests at GERI or other NABL approved laboratories, approved by the Engineer-in-Charge and shall maintain complete records for review and approval.

Nothing contained in the sample QAP shall relieve the Contractor of his responsibility for ensuring the quality, safety, durability and performance of the completed works under the EPC Contract.

Quality Assurance Plan

Sr. No.	Test Parameter	Test Frequency	Acceptance Criteria	Reference Document	Record	Test Inspection Acceptance			Remark
						Contractor	PMC	EIC/Client	
1. Water									
1.1	pH	Once at the time of source approval, or whenever there is a change in source or change in season.	Generally, not less than 6	IS:456-2000 (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	Test Results of Approved Laboratory	Perform	Checking and Approval	Review	
1.2	Sulphates (as SO ₃)		400 mg/l max.						
1.3	Chlorides (as CL)		2000 mg/l for plain concrete & 500 mg/l for RCC work max						
1.4	Organic Matter		200 mg/l max						
1.5	Inorganic Matter		3000 mg/l max.						
1.6	Acidity (0.02 N NaOH/100 ml)		5 ml max.						
1.7	Alkalinity (0.02 N H ₂ SO ₄ /100 ml)		25 ml max.						
1.8	Suspended matter		2000 mg/l max.						

2. Cement (OPC-53)

(a) Physical Tests

2.1	Setting Time	Upto 50 Tonne - 1 sample Upto 100 Tonne- 2 Sample Upto 200 Tonne- 3 Sample Upto 300 Tonne- 4 Sample Upto 500 Tonne- 5 Sample Upto 800 Tonne- 6 Sample Upto 1300 Tonne- 7 Sample Above 1300 Tonne - 8 Sample		As per IS: 12269:1987 (2013) (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	MTC & Test Results of Approved Laboratory	Perform	Checking and Approval	Review	
	Initial Setting time		Not less than 30 minutes						
	Final setting time		Not more than 600 minutes						
2.2	Compressive Strength								
	3 days		27 N/mm ²						
	7 days		37 N/mm ²						
	28 days		53 N/mm ²						
2.3	Fineness								
	(a) By sieving		Residue less than 10 percent						

	Blaine's method		Not less than 2250 cm ² /g for OPC						
2.4	Consistency		About 30 percent						
2.5	Soundness								
	(a) Le Chaterlier's method		Expansion not more than 10 mm						
	(b) Autoclave method		Expansion not more than 0.80 percent						
(b) Chemical Tests									
2.6	Ratio of % of lime to % of Silica, alumina & iron oxide	1 sample for every 10 physical samples or whenever there is a change in Brand	Between 0.80 and 1.02	As per IS: 12269:1987 (2013) (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	MTC & Test Results of Approved Laboratory	Perform	Checking and Approval	Review	
2.7	Ratio of % of alumina to % of iron oxide		Not less than 0.66						
2.8	Insoluble residue %		Not more than 2						
2.9	Magnesia %		Not more than 6						
2.10	SO ₃ %		Not more than 3.5						

2.11	Loss on ignition %		Not more than 4						
3. SAND									
3.1	Gradation (Fineness Modulus)	1 Sample for every 150 cum of concrete work done	2.8 to 3.2	As per IS:383-2016 (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	Field Test Register and Test Results of Approved Laboratory	Perform	Witness	Review & Random Witness	Gradation (Fineness Modulus (FM)), and silt content tests shall be performed at the field laboratory, and 1 out of every 10 samples shall be tested at an approved laboratory.
3.2	Silt Content		Not more than 3%						
3.3	Specific Gravity	Twice in a season or in case of change in source	-----			Perform	Checking and Approval	Review	
3.4	Water Absorption		-----						
3.5	Alkali Reactivity		As per Sc/Rc Curves of IS						
3.6	Petrography Examination		Deleterious constituents plus silt content not more than 5%						
4. COARSE AGGREGATE									

4.1	Gradation	1 Sample for every 150 cum of concrete work done	-----	As per IS:383-2016 (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	Test Results of Approved Laboratory	Perform	Witness	Review & Random Witness	Gradation tests shall be performed at the field laboratory, and 1 out of every 10 samples shall be tested at an approved laboratory.
4.2	Specific Gravity	Twice in a season or in case of change in source	2.5 to 3.0			Perform	Checking and Approval	Review	
4.3	Water Absorption		1 to 1.5%						
4.4	Crushing value(%)		Not more than 45%						
4.5	Impact value(%)		wearing surface 30% max. Overlaid surface 45% max.						
4.6	Flakiness & Elogation index (%)		30% maximum						
4.7	Abrasion Value		wearing surface 30% max. Overlaid surface 45% max.						
4.8	Soundness		Loss with Na2SO4 -12% max. Loss with MgSo4 -18% max						
4.9	Alkali reactivity		As per Sc/Rc Curves of IS						

4.10	Petrography		Deleterious constituents plus silt content not more than 5%						
5. CONCRETE									
5.1	Compressive Strength			IS-456:2000 (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	Field Test Register and Test Results of Approved Laboratory	Perform	Witness, Checking and Approval	Review & Random Witness	Testing of cube shall be performed at the field laboratory, and 2 out of every 10 samples for 28 days shall be tested at an approved laboratory.
	Quantity of concrete in work m3	No. of Samples							
	1-5	1							
	6-15	2	The minimum characteristic compressive strength shall be achieved in accordance with the specified grade of concrete as per IS: 456:2000						
	16-30	3							
	31-50	4							
	51 & above	One additional set of test specimen shall be taken for every 50 cum or part thereof.							

	Note:- Each sample consists of three test specimens for testing at 28 days. In addition, one extra sample shall be cast for testing at 7 days.								
5.2	Slump Test	Daily for each Shift at Plant and Site	As per Mix Design						Working shifts shall be considered as 06:00–14:00, 14:00–22:00, and 22:00–06:00.
6. REINFORCEMENT (FE 550 D)									
A. MECHANICAL TEST									
6.1	Yield Strength	Lot below 100 tonnes under 10 mm - 1 sample from each 25 tonnes 10 mm to 16 mm - 1 sample from each 35 tonnes over 16 mm - 1 sample from each 45 tonnes <u>or whenever there is a change in Brand</u> Lot above 100 tonnes under 10 mm - 1 sample from	≥ 550 Mpa	IS-1786:2008 (Testing procedures shall be carried out as per the relevant IS Codes as mentioned in the GERI Manual or its latest revision).	MTC & Test Results of Approved Laboratory	Perform	Checking and Approval	Review	
6.2	Ultimate Tensile Strength		585 Mpa Min.						
6.3	Elongation %		≥ 14.5%						

(For office use only)

GUIDE LINES
FOR
QUALITY CONTROL AND QUALITY ASSURANCE
Vol. 1



Gujarat Engineering Research Institute
Narmada, Water Resources & Water Supply Department
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FOREWORD

It has been said that “entirely safe and substantial design may be entirely ruined by careless and shoddy execution. Careful attention to the details of the construction is, therefore, as important as the preliminary investigation and design. The consequences of being ignorant of, or ignoring the quality aspects may result into catastrophic failure of the structure.”

All civil engineering projects deal with a large variety of natural construction materials as well as factory made products. Before execution of any structure, properties of these materials are required to be determined. Selection of suitable materials and their use in building a safe and economical structure forms a very crucial process in the whole construction project. This process is known as quality control and quality assurance.

Determination of properties of natural as well as factory made products is done by laboratories as per standard test procedures laid down by the Bureau of Indian Standards. These standards also lay down frequency of testing and acceptance criteria. These criteria should be followed to meet with the assumptions made in design of the structure. This is the only way of providing guarantee for structural safety.

Quality control is obtained through testing of raw materials and end products. Inspection of workmanship and insistence on good performance by those who executes a project is also a part of quality control. But they collect samples subject them to various tests and receive results from laboratories. These results have to be interpreted and then they have to assure the owner of the structure (Government) and the people, about quality of the work as it is envisaged in the design. These guideline when used in consultation with various standards enlisted will provide with an effective tool to achieve quality control and provide quality assurance to the owner.

These guidelines should not be used as specifications of any particular work. A specific work has its own set of specifications. It should naturally and legally override the contents of this manual. As such, the constructing agency has to follow this guideline in conjunction with the standard specifications and use appropriate the information for filling up gaps in the requirements of inspection and quality control.

The manual is divided into two sections viz, (i) Earth work (i.e. Soils) & (ii) Materials

Part 1, “EARTHWORK” include construction sequence of planning, borrow area investigations, and embankment construction. The specific points to be inspected and looked into are mentioned. Frequency of testing, acceptance criteria, purpose of testing are also included to help constructing agency. "DO" and "DON'Ts" are also highlighted.

Part 2, "CONSTRUCTION MATERIALS" include guidelines for concrete making, brick and stone masonry, plaster, analysis of cement and concrete, quality control of brick/tiles for canal lining etc. It also includes field tests for common construction materials. Particulars of test with frequency, equipment, acceptance criteria, purpose of testing for different construction materials are given. List of related Indian Standards is also given.

These guidelines serve as a ready reckoner for the construction engineers. They are made considering work tender provisions in general, however if there are any aspects beyond such provisions leading to other implications, the guidelines may be adopted only after obtaining requisite approval from competent authority.

M. S. Patel
Secretary (WR)
Narmada, Water Resources & Water Supply Department

EARTH WORK

1.0 GENERAL

Earthwork is required for earth dam, road embankments, bridge approaches, canal embankments, C. O. T, filling behind retaining walls etc., different zones of embankments require soils with different properties. They therefore call for similar construction techniques and hence similar quality control. General activities carried out for earthwork are given below

- Stripping of borrow area and excavations to the required limiting depth or as per site conditions
- Laboratory testing of various materials available from excavation and / or borrow areas
- Suitability decision for specific application
- Determination of Natural Moisture Content (NMC) of borrow area material
- Determination of Proctor density values i.e. Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and degree of compaction
- Determination of moisture to be added to account for Natural Moisture Content (NMC), Optimum moisture Content (OMC) and construction needs
- Preparation of seat of embankment after removal of vegetation roots and other organic material by stripping to required depth
- Determination of type of soil and testing for its properties
- Field test for compaction of filter or necessary test for rubble/rock toe as the case may be
- Placing of uniform layers of specified thickness of soils for embankment
- Watering and compaction
- Checking Field Dry Density (FDD) and Field Moisture Content (FMC)
- Preparation of daily and monthly reports on results of compaction

2.0 BORROW AREA INVESTIGATIONS

Construction of embankment involves utilization of natural material, viz., Soils. Required soil is taken from borrow area and/or cuttings of excavations. This soil, before using in construction requires suitability testing for design of particular embankment. This needs borrow area investigations. The programme of borrow area investigation should be decided in consultation with Central Design Organisations & GERI.

Borrow area investigations consist of four major parts, Viz., collection of samples (Table-1), field tests and visual examination of soils (Table -2), laboratory testing for suitability of material at required frequency (Table -3). Table-1, shows brief details of sampling methods. Suitable method/methods as per site condition and soil type or for any other requirement may be adopted. Table - 2 shows simple field identification tests which are required to be performed on field. These tests can be performed as and when required. Table - 3 gives details of different soil tests, which can be performed as per requirements.

2.1 Laboratory Testing:

Soil samples collected from the borrow area are tested for different properties. The main physical and engineering properties are listed below.

1. Determination of water content (moisture content)
2. Specific gravity
3. Grain size analysis
4. Atterbergs limits (LL, PL, PI)
5. Density moisture relationship (light), Std. Proctor Density
6. Density moisture relationship (heavy), Modified Proctor Density
7. Shear strength properties
8. Density Index (Relative density) for granular soils
9. Permeability

In addition to these properties, determination of consolidation characteristics, swell pressure, swelling index etc. is required for certain soils. The list of relevant Indian Standards is given at

Table-4. Quantity of the soil sample required for various tests is given at Table -5.

3.0 EMBANKMENT CONSTRUCTION

Embankment construction can be defined as laterally unsupported fills built on the natural ground surface. Embankments are of two types Govt. circular M/S 1077-V-255-K2-1977 should be referred.

3.1 Homogeneous embankment: This consists of practically uniform quality of material. There is no designed plan of material distribution in the embankment in to zones.

3.2 Zoned embankment

From borrow area excavation

(i) General points to be observed before zoned embankment is constructed.

- Sources of material suitable for different zones should be properly demarcated
- Flow charts should be prepared showing borrow areas along with quantity of material available for different zones
- Excavated material available and suitable for embankment for different zones should be tested and stacked separately and carefully
- Advance planning is required so that whenever need arises excavated material is directly utilized in respective zone of embankment

Various tests carried out as per relevant IS for investigation, design as well as quality control are detailed in Table-4.

(ii) Preparation of embankment

- Strip off all trees, shrubs, jungle growth, roots, top soil containing small or large roots, organic matter etc
- Remove deep roots of trees at least up to one-meter depth below the ground surface
- Scarify the stripped surface to a depth of 100 mm to 200 mm

- Break the clods before spreading any material over surface
- Any ridges or mounds should be stepped so as to provide a close bond between new and old work

(iii) Laying

- All the acceptable material free from organic matter, is to be laid or placed in the embankment in 15 to 25 cm (loose) layers as per IS : 4701 or as specified
- The laying is to be done for full width of the embankment and is built up regularly in layers in accordance with the designed embankment section, with provision for dressing the shoulders or poulders
- All clods are broken at the borrow pits. Any remaining small clods are broken before compaction is commenced on the embankment section
- The surface is graded at all the times and crowned in center so that during rains, water is carried away rapidly to the edges and down the slope of the fill
- For the zoned embankments, the change over from one material to another is made and compacted with some allowance beyond the critical line of contact
- In case the whole length are not being taken up for lying at a stretch, the end edges of embankment are provided with steps is an overall slope of 1 in 5 to permit satisfactory contact with the length of embankment to be taken up

(iv) Compaction

- The dry density and the optimum moisture content at which the material in to be compacted is predetermined in the laboratory
- Compaction is achieved by using appropriate rollers necessary bed thickness of each layer

- Proper care is to be taken to see that required compaction is achieved around embedded instruments
 - While compacting back fill material along abutment contacts or adjacent to cut-off walls and rigid parts of any structure, care is to be taken to achieve intimate contact. Such surfaces are thoroughly cleared prior to placing the material. In general, clayey material as available is used at these locations to avoid seepage through the contact faces.
- (v) Moisture control
- Materials are conditioned to the desired moisture content at the site of excavation or embankment by surface inundation of the borrow pits prior to excavation by ponding or by sprinkling on embankment under construction.
- (vi) Field control
- It is necessary to establish a field laboratory to carry out requisite tests in field while compaction operations are in progress. The lab provides a continuous approximate of materials used and compaction attained. Following field tests are carried out.
- (1) Field moisture content test
 - (2) Density tests for both cohesive and non-cohesive material
 - (3) Optimum moisture content test
- Table-3, (Field Test) indicates the relevant IS and other relevant details for the testing.
- Penetrometer test provides a quick guide for field compaction control. Equipment like moisture and density gauge is deployed to indicate such appraisal quickly.
- A complete record is kept for all the tests made and compared carefully with the laid down standard. Any deficiencies are made good by suitably adjusting the moisture content and number of passes of the roller. The density determination tests are done

- (i) in area where degree of compaction is doubtful,
- (ii) in area where embankment operations are concentrated,
- (iii) for every 300 m³ of embankment where compaction is doubtful in isolated areas,
- (iv) for representative tests for every 4500 m³ of earth fill, and
- (v) for record tests at location of all embedded instruments

As general guidelines for field staff, specific "DO"s and "DON'Ts" are given in Table 6 for quality control. For rapid check, O. K. Card given in Table 7 is used. The list of records to be maintained and format of maintaining daily test report are given in Table 8 and 9 respectively.

(vii) Filter materials

Filter is required to prevent migration of soil particles with water as well as to allow the water to safely pass without building of excessive pore water pressure. Following aspects are taken care of to form a good filter.

- Layer of finer filter material is placed next to the earthwork in IP zone, as well as on the foundation, this followed progressively coarser layer of filter to form a graded filter
- The filter material is laid in layers of not exceeding 15 cm thickness or as specified.
- The gradation curve of filter is kept nearly parallel to that of the base material
- Filter material is clean, sound, well graded and free of debris, silt and clay
- The finer filter material consists of sand passing 2 mm sieve
- Laying of filter material is done side by side with casing and hearting materials
- It is saturated with water and properly rolled
- Mixing of filter material with adjoining soil is avoided
- No segregation is allowed
- Density are fulfilled as minimum of 70% RD or as specified

Following filter between casing and core material or between two consecutive casing materials if more than one casing material is used.

$$(a) \frac{D_{15(f)}}{D_{15(b)}} > 4 \text{ and } < 20$$

$$(b) \frac{D_{50(f)}}{D_{50(b)}} < 25$$

$$(c) \frac{D_{15(f)}}{D_{85(b)}} < 5$$

where (f) indicate filter material or the material on d/s side in the direction of seepage and (b) indicates base or u/s material.

As an alternative to graded filter, non-woven geofabrics can also be adopted. The minimum required properties including filter criteria of fabric are included in the chapter of “Sub Materials”.

TABLE -1
SAMPLING METHODS

Disturbed samples

- (a) From trial pits : From individual stratum by cutting a notch in the side
- (b) From bore holes
 - (i) Auger samples
 - (ii) Samples from S. P. T. spoons
 - (iii) Wash samples in case of granular soils or bailer samples

Undisturbed samples

- (a) From trial pits
 - i) Chunk sample
 - ii) Core cutter samples
- (b) From bore holes
 - i) Shelby tubes
 - ii) Piston tube samples

Note: When it is not possible to collect undisturbed samples in cohesionless soils, the following tests are conducted in addition to testing of disturbed samples, if required, to assess insitu status of the soil.

- (i) Dry density in place at accessible locations by sand or water replacement method
- (ii) Standard penetration tests in bore holes
- (iii) Dynamic cone penetration tests in bore holes
- (iv) Pressuremeter tests in bore hole
- (v) Plate load test

TABLE - 2
SIMPLE FIELD-TESTS FOR IDENTIFICATION OF SOILS

Sr. No.	Field test or visual examination	Procedure
(a)	Shaking or dilatancy test	<p>Take a small representative soil sample to form a pat of size of about 5 cm³ by addition of adequate quantity of water to nearly saturate it, mix thoroughly and place the soil pat in open palm of one hand and shake horizontally, striking vigorously against the other hand several times. Squeeze the pat between the fingers. The appearance and disappearance of the water with shaking and squeezing is referred to as reaction. This reaction is called quick if water appears and disappears rapidly; slow, if water appears and disappears slowly, and no reaction, if the water condition does not appear to change. Observe and report type of reaction as descriptive information.</p> <ul style="list-style-type: none"> • Fine clean sands react quickly & distinctly • Very fine-grained cohesionless soils like silt and rock flour react somewhat slowly than fine sands • Plastic clays do not react to this • Cohesionless soils when moist do not stain the hands when rubbed
(b)	Surface tests	<p>Cohesive soils are identified by rubbing a small ball or remoulded moist soil with a clean knife blade or fingernail. A small sample of the soil at above plastic limit is kneaded into a ball about 25 mm in diameter and rubbed with a clean knife blade or fingernail. If the knife blade leaves a shiny surface, the soil is highly plastic.</p>
(c)	Dry strength or crushing resistance	<p>Dry the prepared soil pat completely. Then measure its resistance to crushing and powdering between fingers. This resistance, called dry strength is a measure of the plasticity of soil and is influenced largely by the colloidal fraction content. The dry strength is designated as low, if the dry pat can be easily powdered; medium, if considerable finger pressure is required and high, if it cannot be powdered at all. Observe and record the dry strength as descriptive information.</p>
(d)	Toughness or Consistency near plastic limit	<p>Dry the pat used in the dilatancy test by working and moulding until it has the consistency of putty. The time required to dry the pat is the indication of plasticity. Roll the pat on a smooth surface or between the palms into a thread of about 3 mm in diameter. Fold and reroll the thread repeatedly to 3 mm in diameter so that its moisture content is gradually reduced until the 3 mm thread just crumbles. The moisture content at this time is called the plastic limit and the resistance to moulding at the plastic limits is called the toughness. After the thread crumbles, lump the pieces together and continue slight kneading action until the lump crumbles. If the lump can still be moulded slightly drier than the plastic limit and if high pressure is required to roll the thread between the palms of the hand, the soil is described as having high toughness. Medium toughness is indicated by a weak thread, it breaks easily and can not be lumped together when drier than the plastic limit. Highly organic clays have very weak and spongy feel at the plastic limit. Non-plastic soils can not be rolled into threads of 3 mm in diameter at any moisture content. Observe and record the toughness as descriptive information.</p>

TABLE - 3
LABORATORY TESTING OF SOILS

SR. NO.	TEST	FREQUENCY	EQUIPMENTS	ACCEPTANCE CRITERIA	PURPOSE OF TESTING
1	Grain size analysis IS : 2720-4-1985 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Coarse sieve (80mm, 63, 37.5, 25.0, 20.0, 10.0, 6.3, 4.75 mm) Fine sieves (2mm, 600 micron, 425, 212, 75 micron), balances oven, stirrer, hydrometer with jars	As specified	For classification of soil and there by getting indication of properties
2	Plasticity index IS : 2720-V-1985 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Uppal's cone penetrometer, sieves, oven, ground glass, spatula balance, containers	As specified Workable range for Hearting LL PL PI 35 20 15 to to to 50 30 30	Indicates properties of soils. Test not possible for nonplastic soils which are used for casing
3	Standard compaction IS : 2720-VII-1980 (1997 RA)	As per relevant specification provisions or 1 per 1000m ³	Standard compaction mould 1000m ³ with base, collar and rammer of 2.6 kg, soil extractor, balance 20 kg, oven, spatula	As per design	For determining the maximum density which can be attained on field at optimum moisture content, with standard energy in put
3 A	Heavy compaction IS : 2720 (Part-VIII)-1983 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Same as above except compaction mould is 1000cm ³ and 2250 cm ³ & rammer of 4.9 kg	As specified	Some as above but with heavy energy
4	Relative density IS : 2720-XIV-1983 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Relative density apparatus, vibrator, balance 50 kg, oven surcharge plates, Moulds with base plate	As specified	Similar as above but for coarse grained soils
5	Permeability IS : 2720-XVII-1986 (1997 RA)	As per relevant specification provisions or 1 per 1000m ³ or as required	Permeability apparatus, soil extractor, oven.	Workable range for hearting, less than 10 ⁻⁶ cm/sec. Casing more than 10 ⁻⁴ cm/sec or as specified	To decide drainage conditions under which the soil will behave in field, to anticipate probable, seepage and design drains

6	Direct shear (for soil up to 4.75 mm size) IS : 2720-XIII-1986 (1997 RA)	As per relevant specification provisions or 1 per 1000m ³ or as required	Direct shear apparatus, soil extractor, balance 5 kg. Shear moulds with grid plates, porous stone, loading pad, dial gauge, proving ring	As per design	To determine shear strength of soil in foundation or in an embankment To find out safe bearing capacity of soil
6 A	For soil containing gravel more than 4.75 mm size IS :2720-XXXIX-1979 (1997 RA)	As per relevant specification provision or 1 per 1000m ³ or as required	Direct shear apparatus - large size with all accessories, balance 20kg, dial gauge, proving ring etc.	As per design	To determine shear strength of soil in foundation or in an embankment
7	Triaxial compression (uu) IS : 2720 (Part XI)-1993 (1997 RA)	As per relevant provision	Triaxial shear apparatus, loading frame, Bishop por pressure apparatus, Constant pressure system, Soil extractor, Balance 5 kg, Membrane stretcher, Split mould, Proving ring, Dial gauge etc.	As specified	To determine shear strength of soils in unconsolidated undrained condition
7 A	Triaxial compression (cu) IS : 2720 (Part - XII)- 1981 (1997 RA)	As per relevant provision or 1/1000m ³	Triaxial shear apparatus, loading frame, Bishop por pressure apparatus, Constant pressure system, Soil extractor, Balance 5 kg, Membrane stretcher, Split mould, Proving ring, Dial gauge etc.	As specified	To determine shear strength of soils in foundation or in embankment in consolidated undrained condition To find out S. B. C. of soil
8	Consolidation IS : 2720-XV-1986 (1997 RA)	1 set of 3 samples per season per zone at end of season or as specified	Consolidation test apparatus. Stop watch, oven, extractor. balance	As per design	To determine settlement rate and magnitude & to assess whether soil is normally consolidated or preconsolidated To determine allowable bearing pressure
9	Unconfined compression IS : 2720-X-1973 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Compression device sample extractor, Dial gauge, Oven, Balance	As specified	To determine unconfined compressive strength of soil and shear parameter

10	Free swell index IS : 2720-(Part XL-1977 (1997 RA)	As per relevant specification provision	Sieve graduated glass cylinder 100cc capacity	As specified	To determine swelling index of soil
11	Swelling pressure of soils IS : 2720-(Part XLI-1977 (1997 RA)	As per relevant specification provision	Swell pressure apparatus or consolidometer, dial gauge, proving ring etc.	As specified	To determine swelling pressure of soil
12	Pin hole test ASTM : D-4647-1993	As per relevant specification provision	Pin hole test apparatus, graduated cylinder, compaction equipment, balance centering guide etc.	As specified	To know the dispersive characteristics of soil
FIELD TEST					
1	Field density and moisture IS : 2720-XXVII-1977 (1997 RA) 2720-XXIX-1975 (2001 RA) 2720-XXXIII-1971 (2001 RA)	1 per 300m ³ , minimum one in each zone per layer or as specified, 1 per 5000m ³ for Rock fill	Core cutter, sand replacement kit and water replacement kit	95 percent of MDD or 70 percent of RD Moisture OMC ± 2 percent or as specified Above 70 percent RD or as specified	To determine the placement density and to monitor compaction effort. It also indicates adequacy of moisture content
2	Moisture content IS :2720 (Part-2)-1973 (2001 RA)	1 per 300 m ³ or as specified	Balance & oven or rapid moisture meter	Depending upon OMC results	To determine degree of saturation, consistency rate of natural strata or a compacted soil

3	Field permeability IS : 5529-I-1985 (1995 RA)	1/3 m depth or as required	Field permeability apparatus like water storage drum, shovels, augers etc.	Workable range for hearting, less than 10^{-6} cm/sec. Casing more than 10^{-4} cm/sec or as specified	To determine the drainage condition of soil in situ.
4	Standard Penetration Test (SPT) IS : 2131-1981 (1997 RA)	1.5m to 2.0m depth in bore hole or as specified	Drilling equipment, Split spoon sampler, Drive weight assembly, screw jack etc.	As specified	To determine penetration resistance of sub soil in terms of standard penetration number (N).
5	Dynamic Cone Penetration Test (DCPT) IS : 4968-Part-I- 1997 (1992 RA) IS : 4968-Part-II- 1976 (1997 RA)	Continuous in bore hole up to specified depth	Standard cone, Driving head, Hoisting equipment hammer etc.	As specified	To determine penetration resistance of sub soil (Strata wise)
6	Load Test on soil IS : 1988-1982 (1888 RA)	As specified	Plate of different sizes, loading device, dial gauge, hydraulic jack, datum bar etc.	As specified	To determine load deformation characteristic of sub soil and to determine SBC and ABP values
7	Pressuremeter Test I S : 1892-1979 (1997-RA)	As specified	Pressuremeter assembly	As specified	To determine SBC and deformation characteristic of soil

TABLE - 4
LIST OF INDIAN STANDARDS – SOILS
UPDATED FROM CATALOGUE OF BUREAU OF INDIAN STANDARDS 1997

Sr. No.	IS: Code No.	Title	Sr. No.	IS: Code No.	Title
1	1498-1970	Classification and Identification of soils for general engineering purposes (First revision), (amendments 2) Reaffirmed-1997	11	2720 (Part 4) – 1985	Methods of test for soils: Part 4. Grain size analysis (Second revision), Reaffirmed 2001
2	1888-1982	Method of load test on soils (Second revision), Reaffirmed 1997	12	2720 (Part 5) – 1985	Methods of test for soils: Part 5. Determination of liquid and plastic limit (Second revision), Reaffirmed 2001
3	1892-1979	Code of practice for sub surface investigations for foundations (First revision), Reaffirmed 1997	13	2720 (Part 6) – 1972	Methods of test for soils: Part 6. Determination of shrinkage factors (First revision), Reaffirmed 2001
4	1904-1986	Code of practice for design and construction of foundation in soils, General requirements (Third revision), Reaffirmed 2000	14	2720 (Part 7) – 1980	Methods of test for soils: Part 7. Determination of water content-dry density relation using light compaction (Second revision), Reaffirmed 1997
5	2131-1981	Method of standard penetration test for soils (First revision), Reaffirmed 1997	15	2720 (Part 8) – 1983	Methods of test for soils: Part 8. Determination of water content-dry density relation using heavy compaction (Second revision), Reaffirmed 2001
6	2132-1986	Code of practice for thin walled tube sampling of soils (Second revision), Reaffirmed 1997	16	2720 (Part 9) – 1992	Methods of test for soils: Part 9. Determination of dry density – moisture content relation by constant weight of soil method (First revision), Reaffirmed 1997
7	2720 (Part 1) – 1983	Methods of test for soils: Part 1. Preparation of dry soil samples for various tests. (Second revision), Reaffirmed 1995	17	2720 (Part 10) – 1991	Methods of test for soils: Part 10. Determination of unconfined compressive strength (Second revision), Reaffirmed 2001
8	2720 (Part 2) – 1973	Methods of test for soils: Part 2. Determination of water content. (Second revision), Reaffirmed 2001	18	2720 (Part 11) – 1993	Methods of test for soils: Part 11. Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure (First revision), Reaffirmed 1997
9	2720 (Part 3/Sec.1) – 1980	Methods of test for soils: Part 3. Determination of specific gravity, Sec. I, Fine grained soils (First revision), Reaffirmed 1997			
10	2720 (Part 3/Sec.2) – 1980	Methods of test for soils: Part 3. Determination of specific gravity Sec.2, Fine medium and coarse grained soils (First revision), Reaffirmed 1997			

Sr. No.	IS: Code No.	Title
19	2720 (Part 12) 1981	– Methods of test for soils: Part 12. Determination of shear strength parameters of soil from consolidated undrained triaxial compression test with measurement of pore water pressure (First revision), Reaffirmed 1997
20	2720 (Part 13) 1986	– Methods of test for soils: Part 13. Direct shear test (Second revision), Reaffirmed 1997
21	2720 (Part 14) 1983	– Methods of test for soils: Part 14. Determination of density index (relative density) of cohesionless soils (First revision), Reaffirmed 2001
22	2720 (Part 15) 1986	– Methods of test for soils: Part 15. Determination of consolidation properties (First revision), Reaffirmed 1997
23	2720 (Part 16) 1987	– Methods of test for soils: Part 16. Laboratory determination of CBR (Second revision), Reaffirmed 1997
24	2720 (Part 17) 1986	– Methods of test for soils: Part 17. Laboratory determination of permeability (First revision), Reaffirmed 1997
25	2720 (Part 18) 1992	– Methods of test for soils: Part 18. Determination of field moisture equivalent (First revision), Reaffirmed 1997
26	2720 (Part 19) 1992	– Methods of test for soils: Part 19. Determination of centrifuge moisture equivalent (First revision), Reaffirmed 1997
27	2720 (Part 21) 1977	– Methods of test for soils: Part 21. Determination of total soluble solids (First revision), Reaffirmed 2001

Sr. No.	IS: Code No.	Title
28	2720 (Part 22) 1972	– Methods of test for soils: Part 22. Determination of organic matter (First revision), Reaffirmed 2001
29	2720 (Part 23) 1976	– Methods of test for soils: Part 23. Determination of calcium carbonate (First revision), Reaffirmed 2001
30	2720 (Part 27) 1977	– Methods of test for soils: Part 27. Determination of total soluble sulphates (First revision), Reaffirmed 2001
30 A	2720 (Part 29) 1975	- Methods of test for soils: Part-29: determination of dry density of soils in-place by the core-cutter method. (First Revision) Second Reprint Feb. '87. Reaffirmed 2001
31	2720 (Part 31) 1990	– Methods of test for soils: Part 31. Field determination of California Bearing Ratio (First revision), Reaffirmed 2001
32	2720 (Part 36) 1987	– Methods of test for soils: Part 36. Laboratory determination of permeability of granular soils (Constant head) (First revision), Reaffirmed 1997
33	2720 (Part 39/Sec.1) – 1977	Methods of test for soils: Part 39. Direct shear test for soils containing gravel, Sec.1, Laboratory test (Amendment 1) Reaffirmed 1997
34	2720 (Part 39/Sec.2) – 1979	Methods of test for soils: Part 39. Direct shear test for soils containing gravel. Sec.2 In-situ shear test Reaffirmed 1997
35	2720 (Part 40) 1977	– Methods of test for soils: Part 40. Determination of free swell index of soils. Reaffirmed 1997
36	2720 (Part 41) 1977	– Methods of test for soils: Part 41. Determination of swelling pressure of soils, Reaffirmed 1997

Sr. No.	IS: Code No.	Title	Sr. No.	IS: Code No.	Title
37	2809-1972	Glossary of terms and symbols relating to soil engineering (First revision), Reaffirmed 2001	45	6403-1981	Code of practice for determination of bearing capacity of shallow foundations (First revision) (Amendment 1), Reaffirmed 2000
38	2911 (Part 4) – 1985	Code of practice for design and construction of pile foundations. Part 4, Load test on piles (First revision)(Amendment-1), Reaffirmed 2000	46	6955-1973	Code of practice for subsurface exploration for earth and rock fill dams, Reaffirmed 1995
38 A	4332 (Part I) - 1967	Methods of test for stabilised soils Part-1 -Method of sampling & preparation of stabilised soils for testing (Second Reprint March '84) Reaffirmed 1995	47	8009 (Part 1) – 1976	Code of practice for calculation of settlement of foundations (Part 1) Shallow foundations subjected to symmetrical static vertical loads (Amendment 1), Reaffirmed 1998
39	4434-1978	Code of practice for In-situ vane shear test for soils (First revision), Reaffirmed 1997	48	8009 (Part 2) – 1980	Code of practice for calculation of settlement of foundations (Part 2) Deep foundations subjected to symmetrical static vertical loading (Amendment 1), Reaffirmed 2000
40	4701-1982	Code of practice for earthwork on canals. Reaffirmed 1999	48 A	8237 - 1985	Code of practice for protection of slope for reservoir embankment (1 st Revision), Reaffirmed 1997
41	4968 (Part 1) – 1976	Method for subsurface sounding for soils (Part 1) Dynamic method using 50 mm cone without bentonite slurry (First revision) (Amendment 1), Reaffirmed 1997	49	8763-1978	Guide for undisturbed sampling of sand and sandy soils, Reaffirmed 1997
42	4968 (Part 2) – 1976	Method for subsurface sounding for soils (Part 2) Dynamic method using cone and bentonite slurry (First revision) (Amendment 1), Reaffirmed 1997	50	9214-1979	Method for determination of modulus of sub grade reaction (K-value) of soils in the field (Amendment 1), Reaffirmed 1997
43	4968 (Part 3) – 1976	Method for subsurface sounding for soils (Part 3) Static cone penetration test (First revision), Reaffirmed 1997	51	9451-1985	Guidelines for lining of canals in expansive soils (First revision), Reaffirmed 1999
44	5529 (Part 1) – 1985	Code of practice for In-situ permeability test (Part 1) Test in overburden (First revision), Reaffirmed 1995	52	9640-1980	Split spoon sampler (amendment 2), Reaffirmed 1997
			53	10042-1981	Code of practice for site investigations for foundation in gravel boulder deposits, Reaffirmed 1997

TABLE - 5

QUANTITY OF SOIL SAMPLE REQUIRED FOR DIFFERENT TESTS

Sr No	Test	Quantity required for soils having maximum particle size of				
		4.75 mm	10 mm	20 mm	40 mm	80 mm
1	Grain size analysis	400 gm	1.5 kg	6.5 kg	25 kg	60 kg
2	Liquid limit	270 gm	-	-	-	-
3	Plastic limit	50 gm (Passing 425 micron)	-	-	-	-
4	Shear	3 kg	120 kg	120 kg	120 kg	120 kg
5	Consolidation	Undisturbed sample 75 mm dia	-	-	-	-
6	Permeability	5 kg	15 kg	30 kg	120 kg	120 kg
7	Proctor					
	(a) Light compaction	20 kg	20 kg	20 kg	-	-
	(b) Heavy compaction	20 kg	20 kg	20 kg	-	-
8	Relative density	12 kg	25 kg	50 kg	100 kg	120 kg
Total for all tests		65 kg	200 kg	250 kg	365 kg	420 kg

TABLE -6
EARTH WORK

DO'S	DON'TS
● Conduct density test at random intervals for specified quantum of earthwork	● Have square grid locations for density determinations
● Correction for oversize material should be effected in evaluation of placement density	● Careless rolling operation near a structure
● Always drive core-cutter to its full length	● Improper choice of roller for different types of soils
● Use standard equipment for density test based on thickness of layer and compacting material used.	● Over drive the core cutter
● Determine moisture content immediately after weighing the wet soil	● Deploy non standard equipment
● Insist on specified thickness of layer	● Delay moisture determination
● Provide extra width for slope dressing	● Allow thicker layers
● Allow next layer only after attaining specified density	● Work with tight widths and lengths
	● Allowing of next layer without attaining specified density

TABLE - 7

O. K. CARD FOR EARTH WORK

Name of work :
Reach & Location :

Name of Division :
Name of Sub-Division :

A BANK SEAT PREPARATION

Authorised sign.

- | | | |
|-----|--|--------|
| (1) | Whether the overburden, roots and foreign material are removed from the bank seat? | Yes/No |
| (2) | Whether the width of bank seat demarcated at site? | Yes/No |
| (3) | Whether bank seat has been moistened sufficiently and compaction done? | Yes/No |
| (4) | Whether the levels are recorded? | Yes/No |
| (5) | Whether density and FMC are taken for approval of seat? | Yes/No |
| (6) | Findings of test results
% compaction-----
% FMC----- | |

B BORROW AREA

- | | | |
|-----|---|--------|
| (1) | Name and Location----- | |
| (2) | Whether the required overburden roots and foreign materials are removed? | Yes/No |
| (3) | Whether the grid lines marked (3 m x 3 m or as specified) and levels taken? | Yes/No |
| (4) | Whether samples were collected for testing and test results are available? | Yes/No |
| (5) | Type of material----- | |
| (6) | Quantity of material expected to be available | |

C EMBANKMENT

- | | | |
|------|--|--------|
| (1) | Whether the seat for the embankment is approved? | Yes/No |
| (2) | Whether filter is required? | Yes/No |
| (3) | Are filter criteria fulfilled? Specify the details----- | |
| (4) | Whether proper compaction of filter is achieved?
----- % compaction | |
| (5) | Layer number/R. L.-----m | |
| (6) | Whether the embankment in different zones and different layers is raised in specified thickness? | Yes/No |
| (7) | Whether the required watering and compaction done? | Yes/No |
| (8) | Are density and moisture content test taken
% compaction-----
% FMC----- | Yes/No |
| (9) | Whether trip cards for dumpers, water tankers are maintained and available on site? | Yes/No |
| (10) | Remarks | |

Signature of Deputy Ex. Engineer

Signature of field staff

TABLE - 8
RECORDS TO BE MAINTAINED

- (1) Data of earth work as indicated in design note and drawing of embankment section
- (2) Record of properties of soils available from excavations and borrow areas
- (3) Confirmatory tests of soil being used for embankment (during construction)
- (4) Compaction test results of earth layer and base seat of embankment
- (5) Data for proctor test for each type of material used
- (6) Moisture control (before spreading NMC & comparison/difference of OMC)
- (7) Determination of FDD/FMC and comparison with design data
- (8) Layer wise R. L. location etc
- (9) Daily and Monthly progress report
- (10) Record for filter material used shall be maintained such as filter criteria, gradation, curve, compaction/watering etc
- (11) Records of machinery deployed/trips/output etc

TABLE - 9
DAILY REPORT ON TESTS TO BE CARRIED OUT FOR EARTH WORK

		Date:	Month :	Year :			
Name of work :		Chainage/Location :					
Agreement No. :							
Name of Agency :							
Name of Division :		Sub-Dn.:		Circle :			
Sr No	Item	No. of test required as per norms or as per tender provisions	Quantity of earth work m ³ /m ²	No. of tests carried out per Norms	Nos. of tests satisfying the acceptable criteria as per tender	Nos. of tests repeated and Nos. of test satisfactory after re-rolling and watering	Remarks
1	Embankment (a) FDD/FMC (b) Compaction (Proctor)						
2	Backfilling (a) FDD/FMC (b) Proctor test						
3	Lining (a) Sub grade (b) Compaction FDD/FMC						

Signature of Deputy Ex. Engineer

Signature of field officer

GUIDELINES FOR CONCRETE

1.0 Introduction:

Concrete, which externally appears to be crack-free, is sometimes found to be defective especially with layer lines and other discontinuities inside against requirement of monolithic nature of concrete when tested with non destructive methods. Hollows below reinforcement, inadequate cover, displacement of reinforcing bars and heavy corrosion to reinforcement were noticed after removal of cover in concrete of slab and beam. Surface defects like honeycombing shrinkage cracking, pourlines, entrapped air voids, unevenness of surface are very common. The cold joints occur in concrete because pouring rate is inadequate. The cold joints when left untreated, developed into plane of separation. This is the result of non-observance of standard/good practices to produce good concrete on field at the time of concreting. It is therefore necessary that good practices for manufacture of good concrete and necessary precautions are taken during concreting. Guidelines during inspection for preparatory work i.e. batching, mixing, conveying, placing, consolidating, finishing & curing are as follows.

2.0 Inspection for preparatory work:

Before concreting work begins, preliminary field inspection is essential to ensure better results.

2.1 Mixer : Check

- Revolution of drum per minute
- Cleanliness inside drum
- Number of mixing blades inside drum and the gap between drum & blades shall not be larger than 25mm
- Water tightness of drum
- Levelling of mixer on levelled ground
- Working of discharge of chute and hopper
- Working of water tank fitted with mixer, gauge mark
- Capacity of drum

2.2 Weight/Volume batching arrangement : Check

- Sensitivity of balances
- Measurement of boxes
- Adjustable arrangement in boxes
- Weight of boxes

2.3 Materials :

2.3.1 Cement : The requirements and the other details of various tests on cement are given in Table No. 3 & 4.

- Type of cement and source
- Freshness of cement (should not be older than three months)
- Weight of cement bags
- Storing condition, dry floor
- Cement account and adequate stock to complete concrete work

2.3.2 Sand: The requirements and the other details of various tests on sand are given in Table No. 11.

- Source and type
- Moisture content
- Gradation, fineness, silt content
- Adequate stock

2.3.3 Gravel/Metal: The requirements and the other details of various tests on gravel/metal are given in Table No. 10.

- Type and source
- Gradation
- Adequate stock

2.3.4 Water: The requirements and the other details of various tests on water are given in Table No. 21.

- Potable water
- Silt free
- Measuring arrangement

2.3.5 Admixture: The requirements and the other details of various tests on Admixture are given in Table No. 24.

- Type and Source
- Dosage
- Measuring arrangement

2.4 Foundation:

2.4.1 Rock Surface

- Check-lines & levels, obtain clearance of geologist
- Inspect with hammer for hollow sound
- Remove loose rock
- Clean with air and water jets under pressure
- Keep surface wet for 24 hrs before placement of concrete

- 2.4.2 Soil Surface:
 - Ensure adequate drainage or dewatering or caulking for leaks
 - Remove loose or soft patches
 - Moisten the surface to a depth of about 15 cm
 - Do tamping or rolling
 - Cover the surface with tar paper or closely woven burlap with proper lap and fastening
- 2.4.3 Concrete surface
 - Remove loose material
 - Existing concrete should be wet sand blasted & washed thoroughly
 - Completely dried immediately prior to placement
- 2.5 Computations
 - Work out batch weights of cement/sand and gravel/metal to suit the capacity of mixer, in proportion of design mix
 - Apply moisture/bulkage corrections to sand and gravel/metal
 - Check water meter / gauge
- 2.6 Quality control tests: The requirements and the other details of various tests on cement concrete are given in Table No. 17.
 - Mixer efficiency test, decide mixing time and batch weight of cement.
 - Slump test
 - Yield test
 - Air content test
 - Set of specimens for compressive strength and permeability
 - Records – Batch weight register, cement consumption register, F.M. register, gravel/metal register, weight/volume register, slump test register, air content register, yield test register, compression and permeability test register, work order book and progress book.
- 2.7 Form work:
 - Firmness of ground supporting props when it becomes wet.
 - Straightness of props
 - Adequate bracing
 - Nailing loose or tight, adequate penetration of nail in lower member
 - Leak proof

- Strong enough to resist movement of labourers and vibrations
- Cleanliness of form work
- Evenness of planks or plates, within tolerance limits as per IS 456:2000 as given below:
 - a) Deviation from dimensions of cross-section of columns and beams -6mm, + 12mm
 - b) Deviation from dimensions of footings:
 - i) Dimension in plan – 12 mm
 - ii) Eccentricity – 0.02 times the width of footing in direction of deviation but not more than 50 mm
 - iii) Thickness \pm 0.05 times the specified thickness
 - c) Check calculation for formwork of heavy structure
- 2.8 Reinforcement: The requirements and the other details of various tests on steel are given in Table No. 7 & 8.
 - Check size, spacing, location, numbers etc. as per schedule of reinforcement/design drawing
 - Ensure staggering of overlaps
 - Embedded fixtures and openings
 - Reinforcement free from grease, oil and rust
 - Check up welding joints, bent up bars, hooks and cold bending
 - Rack arrangement for movement of labourers to prevent disposition of reinforcement
- 3.0 **Batching:**

The aim of batching and fixing is to produce uniform concrete at required proportion. To attain this it is necessary that -

 - 3.1 Materials are maintained homogeneous and non-segregated prior to and during batching
 - 3.2 The equipment provided for batching will accurately batch the required amount of material
 - 3.3 The required proportions of materials are maintained from batch to batch
 - 3.4 All materials are introduced into the mixes in proper sequence
 - 3.5 Weigh batching:
 - a) Quantity of cement and aggregates should be determined by mass. Where bag is considered as batch weight, reasonable number of bags should be weighed periodically to check net mass

- b) Water should be measured by volume in calibrated tank or weighed
- 3.6 Blending of aggregates may be carried out as and when required
- 3.7 Gradation of coarse and fine aggregates should be done frequently
- 3.8 In case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching, provided periodic checks are made on mass/volume relationships of the materials
- 3.9 Moisture/bulkage corrections should be applied for moist materials.
- 4.0 Mixing:**
- 4.1 The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency.
- 4.2 If there is segregation after unloading from the mixer, the concrete should be remixed.
- 4.3 For guidance, the mixing time may be one and a half to two minutes.
- 4.4 In exceptional circumstances such as mechanical break down of mixer, work in remote areas or when the quantity is small, hand mixing may be permitted subject to adding 10 percent extra cement. When hand mixing is permitted, it shall be carried out on a watertight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency.
- 4.5 Workability shall be checked at frequent intervals.
- 4.6 The freshly mixed concrete should be finally placed in position within 30 minutes.
- 4.7 Freshly mixed concrete, should be tested for slump, mixer uniformity tests, yield test, unit weight, air content and compressive strength etc.
- 5.0 Conveyance/Transportation :**
- 5.1 Concrete shall be conveyed from mixer to final place of deposition as rapidly as practicable by methods which will prevent segregation or loss of slump and loss of materials including water.
- 5.2 Conveying method and equipment shall be approved by the engineer-in-charge not below the rank of Deputy Executive Engineer.

- 5.3 Newly mixed concrete is susceptible to segregation if dropped through height. The unrestrained dropping of concrete on apex of a pile also results in coarser particles segregating and concentrating at the toe of the slope. Unrestrained dropping, chuting and horizontal flow of concrete should not be permitted.
- 5.4 Minimum handling and persistent precautions should be observed to prevent segregation and to see that concrete remains a cohesive mass.
- 5.5 During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by heat loss in cold weather may also be adopted.
- 6.0 Placement:**
- 6.1 When slabs and beams & the supporting walls & columns are cast monolithically the concrete in the top 60 or 90 cm of walls & columns should be of the lowest slump that can be vibrated adequately & should be fully consolidated at the surface
- After placing the fillet, beam and slab concrete, the vibrator should penetrate & revibrate the concrete in the tops of walls and columns
 - Concrete should be continued without avoidable interruptions until the placement is completed or until satisfactory construction joints can be made.
- 6.2 Concrete should be deposited in horizontal layers. Each layer should be compacted thoroughly before succeeding layer is placed. In reinforced concrete work, it is good practice to place concrete in layers 0.25m thick. However, thickness shall be decided in view of size and shape of section, consistency of concrete, spacing of reinforcement, method of concrete placement, method of compaction and necessity of depositing concrete of next layer before hardening of previous layer which takes place within 30 minutes.
- 6.3 Concrete shall be deposited continuously in order to avoid appearance of slightest layer line on the finished structure. No construction joint should be allowed to form unless directed by the designer.
- 6.4 Placement of concrete shall be carried out at such a rate that lower layer concrete which is being integrated with fresh concrete is always plastic. Normally this will be achieved if next layer is placed within 30 minutes. If this is not done, cold joints will

develop which must be avoided. The cold joints are interfaced which remain as discontinuities and cause separation when subjected to tensile stresses.

6.5 Placing of concrete in supported elements shall not be started until the concrete previously placed in columns or wall is no longer plastic and has been in place at least for two hours.

6.6 The concrete should be worked thoroughly into all positions around reinforcement, embedded fixtures and into corners of form work. Only slurry, if allowed to pass below reinforcement gives a firm finish but leaves voids near reinforcement and hence causes loss of bond and corrosion.

7.0 Consolidation:

7.1 Concrete shall be consolidated by vibration, spading, rodding or forking so that concrete is thoroughly worked around the reinforcement, around embedded items and into concrete of forms, eliminating all air or stone pockets which cause honeycombing, pitting or planes of weakness

7.2 Internal vibrators shall have a minimum frequency of 8000 vibrations per minute with sufficient amplitude to consolidate concrete effectively.

7.3 Vibrators shall be inserted vertically and withdrawn gradually at points approximately 0.4 to 0.5m apart. At each insertion, the duration shall be 5 to 15 seconds which is sufficient to consolidate the concrete but to disallow segregation and increase in surface laitance.

7.4 Where the concrete is to have coat finish, a full layer of mortar shall be brought against the form by vibration process.

7.5 Vibrations shall be operated by competent workman.

7.6 A spare vibrator shall be kept on site of work during all concrete placing operations.

7.7 Whenever vibration has to be applied externally the design of form work and the disposition of vibrators should receive special consideration to avoid surface blemishes.

7.8 The use of suitable mechanical vibrators complying with IS:2505-1968, IS:2506-1968, IS:4656-1968 is recommended.

7.9 Over vibration or vibration of very wet mixes is harmful and should be avoided. Under vibration is also harmful. Complete consolidation can be judged by evidence of levelled appearance of concrete at exposed surface, embedment of surface aggregate,

expulsion of entrapped air, formation of cement skin and appearance of cement slurry at surface.

8.0 Finishing:

The quality of concrete surface is judged by condition and appearance of the finished surface. The exposed surfaces are subjected to more or less severe conditions of wetting or drying, temperature changes, mechanical wear etc.

8.1 Concrete proportions and consistency and methods of compaction should be such that sufficient mortar is available at the surface for finishing purposes.

8.2 Floats shall be used to remove high and low spots and to produce a true plane surface. High and low areas should be corrected at once.

8.3 Over sanded or too wet or over consolidated mix is likely to be covered with bleed water. They may be corrected for better finishing. Such water shall be allowed to drain or absorb or scrap.

8.4 Any water which comes to surface during darning or floating operations should be allowed to evaporate before surface is floated with hand floats or trowelling. If the amount of water of laitance is excessive it should be scooped off before surface is again floated.

8.5 Sprinkling of dry cement or a dry mortar should not be permitted.

8.6 All finishing operations should be controlled so as to prevent bringing an excess of paste to the surface.

8.7 Trowelling should be delayed as long as possible. Final floating is used to remove remaining minor irregularities. The concrete is ready for floating when any sheeny water has disappeared and when a man stopping on surface will leave an imprint of about 5mm.

8.8 The proper time of trowelling varies with cement, weather and other conditions. It is ready when surface just reaches the stage that it can no longer be dented with finger.

8.9 If surface is trowelled too soon, a layer of laitance is found, if too late, the partly hardened concrete is too hard to be trowelled effectively.

8.10 During trowelling the steel trowel should be tilted at a slight angle and heavy pressure should be exerted to compact the paste and form a dense hard surface.

9.0 Stripping Period:

Removal of form depends upon grade of concrete, type of member, weather conditions, winds, strength attained, type of cement etc. Early removal of form is desirable for finishing and is usually desirable from points of view of airing.

9.1 Forms shall not be struck until the concrete reaches a strength at twice the stress to which the concrete may be subjected at the time of removal of formwork.

9.2 Wherever possible, the formwork shall be left longer as it would assist the airing.

9.3 In normal circumstances and where ordinary portland cement is used, forms may generally be removed after expiry of the following periods as per IS: 456-2000

a. Walls, columns and vertical faces of all structural members
16 to 24 hours

b. Slabs (props left under)
3 days

c. Beam soffits (props left under) 7 days

d. Removal of props under slabs:
1. Spanning upto 4.5 m 7 days
2. Spanning over 4.5 m 14 days

e. Removal of props under beams and arches:
1. Spanning upto 6 m
14 days
2. Spanning over 6 m
21 days

f. Modify stripping time suitably for other cements

9.4 The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam as the case may be, together with any live load likely to occur during further construction.

10.0 Curing:

Curing is defined as maintenance of humidity and temperature of freshly placed concrete during definite period following finishing to assure satisfactory hydration of cementitious material and proper hardening of the concrete. The curing period depends upon type of cement, weather condition, wind speed, stripping time, sections of concrete, methods of curing, etc. Improper curing results in formation of surface / shrinkage cracks, loss of strength, increase in permeability, spoilage of surface finishing, decreases durability

and quality of concrete is affected. Moist curing, membrane curing are normally used. Former is predominantly used.

10.1 Exposed surface of concrete shall be kept continuously in damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least seven days.

10.2 The curing period should be increased by one week for pozzolonic cement for best results.

10.3 The freshly laid concrete shall be protected from direct exposure to sun and high winds.

10.4 The curing in hot weather conditions i.e. temperature above 40°C needs special attention to disallow rapid evaporation and prevent plastic shrinkage cracking.

10.5 Membrane curing: Approved curing compounds may be used in lieu of moist curing. Such compounds shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. The requirements and other details are given in Table No.22

11.0 Concreting under special conditions:

a) Underwater concreting: Do not place concrete in running water, use rich mixes, use tremie or direct pumping, ensure continuous placement.

b) Hot weather concreting: Dampen the subgrade and forms, place concrete at the lowest practicable temperature, start curing early, use cold water or ice as a part of mixing water.

c) Cold weather concreting: Prevent concrete from freezing, concrete should be placed at temperature not lower than 5°C, maintain curing condition which fosters normal strength development without excessive heat, keep surface at a temperature that may not cause early freezing or seriously prolong hardening.

12. Records and reports:

Check registers of cement consumption, fineness modulus, aggregate quality and quantity, weight/volume batching, tests for fresh concrete and for specimens for compressive strength and permeability, examine critically work order book, review test results and review design mix, ensure monthly summary reports giving compliance of instructions recorded in work order book.

Points to remember while laying masonry

- a) **Brick work:** The requirements and the other details of various tests on bricks are given in Table No. 12 & 13.
- 1) Ensure thorough soaking of bricks in clean water for 24 hrs. before use
 - 2) See the workmanship for bond, thickness of joint, finishing of joint etc.
 - 3) Courses should be truly horizontal and joints truly vertical
 - 4) Restrict use of brickbats to a minimum
 - 5) English bond preferable
 - 6) Thickness of joint should be uniform and not more than 13 mm
 - 7) Specified cement mortar should be placed within 30 minutes after addition of water
 - 8) Bricks on edge should not be used unless specified
 - 9) Disallow vertical joint filling by spreading mortar
 - 10) Masonry may be raised up to 90 cm in a day. Raising with all connected brickwork be carried out at one level
 - 11) The buttress, counter forts should be built simultaneously, maintaining proper bond with main wall and not added afterwards
 - 12) Fixtures of frame should be embedded while raising masonry
 - 13) The joints should be raked to a depth of 13 to 19 mm when mortar is green. If plaster or pointing is not to be done, the joints should be struck flush
 - 14) Curing should be done for at least seven days or as laid down in specifications
 - 15) Old or dry surface should be thoroughly cleared and wetted, joints raked before starting
- b) **Stone work:** The requirements and the other details of various tests on stone are given in Table No. 9.
- Additional points for stone masonry are as under
- 1) Rubble should be as per specifications
 - 2) Stone should be laid on their natural bed
 - 3) Through stones should be used at regular intervals in staggered manner
 - 4) Quoins should be used for openings. The width should be at least 1.5 times the depth of course and its length should be twice its depth
 - 5) Wet the stones before use

- 6) Spalls shall be used wherever necessary to avoid thick mortar beds for joints and shall not exceed 10 %
- 7) The use of wooden mallet must be carried out to hammer down stone in to position and solidly bedded in the mortar
- 8) Iron templates shall be used to compact the mortar in joints
- 9) Every stone shall be carefully fitted to the bed and adjacent stone so as to form neat and close joints. No joints shall be thicker than 35mm.
- 10) All exposed surfaces shall be kept moist at least for 21 days.
- 11) Permeability tests shall be carried out as provided in specifications.

c) **Plaster work:**

- The details are covered in IS: 1661 – 1972
- Thickness of single coat shall be between 10 to 15mm
- Thickness of two coat plaster shall not exceed 20mm (Backing coat 10 to 12mm, finishing coat 8 to 10 mm)
- Plastering work to be suspended during frosty weather. It shall also be suspended in extreme dry condition
- The walls shall be damped evenly before application of plaster.
- Drying shrinkage of first coat or backing material should be complete before application of subsequent coat

14 **Storage of cement:**

1. Check for age of cement – Retesting to be done if cement is older than three months
2. To be stored on raised platform
3. Shall be stocked properly away from walls, facilitate for physical verification
4. Maintenance of cement register and it shall be checked by senior officers
5. Leak-proof ceiling

15 **Analysis of cement & concrete** When large work of cement mortar or cement concrete is to be done, analysis of cement testing is important. For analysis, first arrive at the limit of variability i.e. standard deviation or co-efficient of variation. On the basis of the target average strength of cement samples and the statistical parameters of variability, the test results should be compared with suitable control charts. These charts are very convenient device to keep track on the monitoring of

activity. Very useful guidelines on control charts for concrete are given in ACI 214-1977. Recommended Practice for evaluation of strength test results of concrete, Indian Standards IS:397 (Part 1 to 3) also cover control charts for general and special application in industrial application. Different charts for cement and concrete are (1) Master chart (2) Moving average strength chart (3) Within-test moving average range chart (4) Between test moving average range chart. The control charts can also incorporate certain reference lines as limits. As a general concept, four limits can be defined viz. Lower as well as upper warning and action limits.

Cement Concrete Lining

Points to be observed for proper exercise of the functions

- Sub grade approval i.e. degree of compaction & moisture content
- Testing of construction materials i.e. fine aggregate, coarse aggregate, cement, water, Air entraining agent, PVC strips & curing compound
- Checking of paver's Jack level, girder's alignment, roller movement
- Test for concrete
- Placement of concrete & arrangement of conveyor belt etc.
- Proper insertion of crack inducing joints in transverse and longitudinal directions, if specified
- To ensure specified thickness of cement concrete lining
- Testing of hardened concrete
- Cores to be taken to check positioning of PVC insertion in C.C. lining
- To undertake screening of green concrete for examining consistency of concrete (occasionally)
- Proper curing arrangements

Quality control of Brick / tiles lining

- Sub grade approval i.e. degree of compaction & moisture content
- Testing of construction materials i.e. Brick / Tiles, Sand, cement and water
- To ensure the correct batch weight as per the mix design of mortar and to check the mortar consistency
- Proper arrangement for soaking of brick / tiles
- Curing arrangement
- Mixing of mortar – consistency
- Casting of cubes for compression strength at 28 days
- Maintaining records for consumption of mortar & cement, curing period, joint testing etc.

TABLE - 1**Recommended Values Of Slump For Different Conditions Of Placing
(To enable concrete to be fully compacted)**

Placing Conditions	Degree of Workability	Slump (mm)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	See 7.1.1 of IS: 456-2000
Mass concrete ; Lightly reinforced sections in slabs, beams, walls, columns ; Floors ; Hand placed pavements ; Canal lining ; Strip footings	Low	25 - 75
Heavily reinforced sections in slabs, beams, walls, columns ; Slipform work; Pumped concrete	Medium	50 - 100
Trench fill; In-situ piling	High	100 - 150
Tremie concrete	Very high	See 7.1. 2 of IS: 456-2000

NOTE :- For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete are not required to be used (see also 13.3 of IS: 456-2000).

TABLE - 2
Field-Tests For Common Materials Of Construction

Sr. No.	Material	Field test	Procedure
1	Cement	Initial setting time	Take three parts of cement and one part of water. Mix it thoroughly to get a plastic cement paste and fill it up in an empty cigarette tin, observe penetration of an uncut butt of a pencil, Note time since addition of water when resistance to penetration is felt. Normally it should not be less than 30 minutes.
2	Lime	Visual	Colour : dirty white, white, pure white State of aggregation : Lumpy, powdery, soft and hard Class C lime : White or pure white colour-hard Quick lime : Lumpy but porous
		Acid test	Take a tea spoon full of powdered lime and add 10 ml of 50 percent HCl by volume in a test tube, stir with glass rod. Effervescence indicates unburnt lime Residue after 24 hours indicates inert material, comparison with original volume of lime indicates its proportion Classification : Class A : Good thick gel at top and inert material at bottom Class B : Medium thick gel which does not flow when turned Class C : No gel is formed
		Ball test	Take lime, add enough water, prepare egg size ball, allow to set for six hours and then place in water Classification : Class A : No expansion Class B : Little expansion and numerous cracks on surface Class C : Expansion and disintegration within few minutes
		Impurities test	Take known weight of lime from kiln, add water, wash it on 250 micron sieve, determine residue weight Classification : Good – less than 10 per cent residue. Fair – 10 to 20 percent, Poor – above 20 percent
		Blotting paper test	Prepare thick cream like consistency and leave over night-then spread like butter on a blotting paper with knife-Compare it with behaviour and performance of standard lime of good quality and judge
3.	Pozzolana	Workability test	Prepare mortar, apply on rough surface and observe area covered
		Visual	Clay pozzolana Colour : well burnt indicated by red copper colour Fineness : feels finer than cement between fingers
4	Sand	Silt content	Take 300-400 cm ³ of sand in a measuring jar, add water to submerge the sand under 3.5 cm depth of water after removal of air– close the mouth of jar with rubber cork or palm of hand, shake or turn the jar up side down two-three times and allow sand to settle. Silt will settle on sand top. Read

depth of silt and compute percentage, of depth of sand which has settled below the silt.

Coarseness of sand – gradation can be judged by comparison with bottle specimens, missing fractions indicate gap gradation

Physically deleterious material like coal, clay-balls, mica, lime kankar can be picked out, percentage occurrence can be judged

5	Metal / gravel	Visual	Identify rock types, judge shape and size-rounded, sub-rounded, flaky, cubical, angular-also percentage of undersize and oversize fractions. Basalt-dolerite, granite, quartzite, hard limestone, siliceous sandstone serve well as road metal. Shales absorb water and give earthy smell, phyllite and mica schists are flaky and show shining surface. Avoid both.
6	Water	Visual	Examine in glass beaker or test tube for suspended sediment. Use potable water. If brackish or saline use only after testing, check pH with indicator paper.
7	Bricks	Visual	Red copper colour indicates well burnt bricks, check shape, size, frog, weight, presence of nodules, cracks, corners, Metallic sound when struck with each other or by hammer, no damage when allowed to fall free from about five feet on either header or stretcher face.
8	Stones	Visual	Metallic sound when struck with hammer. Iron nail streak indicates softness; observe joints, cracks, cavities, veins, weathered skin and re-entrant angles, check weight, look for fresh fracture when broken with hammer, rocks like basalt, granite, quartzite, dolerite, compact sandstone and limestone serve well as rubble. Shales, phyllites and mica schists are not good.
9	Steel bar	Bending	Shales absorbs water and give earthy smell Free from rust, grease, oil; mild steel can be bent to 'U' shape with mendrel of 2 d with indicating cracks. Check diameter and weight per unit length
10	Tiles	(a) Visual (b) Strength	Check dimensions, colour, expose tiles to sunlight for few days and observe for loss of colour Saturate the tile with water, support it at the edges, ask one adult to stand in the centre, should not break as wet transverse strength is about 80 kg.
11	Flush door	Adhesion	Cut 150 mm square four specimens from all corners, immerse in boiling water for four hours; examine delamination which should not exceed 50 mm in length and 3 mm in depth

Sampling

Any material shall be collected as per relevant Indian Standard of materials & shall be sent to laboratory for testing. Frequency of sample requirement are given in the manual. The material shall be reduced to required size as under

1. Coning and quartering:

The material shall be mixed and then scooped into a cone shaped pile. Care shall be taken to drop each scoopful over the same spot. After cone is formed it shall be flattened. Then it is divided into quarters by two lines intersecting at right angles at the centre of cone. The bulk of sample is reduced by rejecting either set of two diagonally opposite quarters. The process is continued till the sample is reduced to required size.

2. Stacks of bricks and tiles:

The stacks shall be divided into sections of approximately equal dimensions. Required samples shall be drawn from each section in a random number.

TABLE - 3
CEMENT OF VARIOUS TYPES & GRADES
IS 4031- (part 1 to 15) - 1988 to 1996, 4032-1986

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Sample : 15 kg.
					Purpose of testing
1.	Consistency IS:4031-(Part-4)-1988	Upto 50 T. - 1 50-100 T. -2 100 - 200 T -3 each sample or as required	Vicat apparatus with plunger 10 mm dia. (G type), Triple beam balance	About 30 percent	Determines mixing water requirements for subsequent tests and minimum water requirement for hydration of cement.
2.	Setting time IS:4031-(Part-5)-1988				
	(a) Initial setting time	Each sample or as required	Vicat apparatus with needle 1 mm sq. (c-Type)	Not less than 30 minutes	Placement compaction is to be completed within initial time.
	(b) Final setting time		Vicat apparatus with annular attachment (F-type)	Not more than 600 minutes	Final setting time limit indicates hardening and gain in strength.
3.	Fineness				
	(a) By sieving IS:4031-(Part-I)-1988	Each Sample or as required	90 micron IS sieve and balance	Residue less then 10 percent	More volume retained on sieve indicates cement having undergone moisture attack or inadequate grinding.
	Specific surface by Blain air permeability IS:4031-(Part-2)-1988	Each sample or as required	Blain air permeability apparatus with accessories	Not less than 2250 cm ² /g for OPC (33,43,& 53 grade) & SRC. Not less than 3000 cm ² /g for PPC	Less volume indicates cement having undergone moisture attack or inadequate grinding.
4.	Soundness IS:4031-(Part-4)-1988				
	(a) Le Chatelier's method	Each sample or as required	Le Chatelier's apparatus with accessories	Expansion not more than 10 mm	More expansion indicates likely excessive and harmful chemical reactions.
	(b) Autoclave method	1 in 10 samples	Autoclave, length comparator, 25 x 25 x 250 mm mould and other accessories.	Expansion not more than 0.80 percent.	-do-
5.	Compressive strength IS:4031-(Part-6)-1988	Each sample or as required sample	Cube mould (7.07 cm) 50 cm ² face area, baby vibrator, compression testing machine, curing tank etc.	As per Table-4	Higher strength indicates acceptability
6.	Chemical Analysis IS:4032-1986	1 in 10 sample	Muffle furnace, oven, platinum crucible, chemical balance etc.	As per Table-4	

TABLE - 4
VARIOUS TYPES OF CEMENT

Sr. No.	Particulars of Tests	Acceptance criteria					Purpose of testing
		33-G	43-G	53-G	PPC	SRC	
1.	Compressive strength (Min.) <u>N/mm²</u>						
	3 days	16	23	27	16	10	
	7 days	22	33	37	22	16	
	28 days	33	43	53	33	33	
2.	Chemical analysis						
	(a) Ratio of % of lime to % of Silica, alumina & iron oxide	Between 0.66 and 1.02	Between 0.66 and 1.02	Between 0.80 and 1.02	–	Between 0.66 and 1.02	
	(b) Ratio of % of alumina to % of iron oxide	Not less than 0.66	Not less than 0.66	Not less than 0.66	–	--	
	(c) Insoluble residue %	Not more than 4	Not more than 2	Not more than 2	$\frac{X+4(100-X)}{X}$	Not more than 4	X is the % of declared pozzolana
	(d) Magnesia %	Not more than 6	Not more than 6	Not more than 6	Not more than 6	Not more than 6	Higher MgO indicates harmful expansion at a later age
	(e) SO ₃ %	Not more than 2.5 & 3 when C ₃ A % is 5 or less & > 5 respectively	Not more than 2.5 & 3 when C ₃ A% is 5 or less & > 5 respectively	Not more than 2.5 & 3 when C ₃ A% is 5 or less & > 5 respectively	Not more than 3	Not more than 2.5	Higher SO ₃ indicates less durability
	(f) Loss on ignition %	Not more than 5	Not more than 5	Not more than 4	Not more than 5	Not more than 5	It indicates the freshness of cement
	(g) C ₃ A%	--	--	--	--	Maximum 5.0	
	(h) C ₄ AF+2C ₃ A%	--	--	--	--	Maximum 25.00	

TABLE - 5
Pozzolana (Calcined clay, flyash)
IS:1344 – 1981, IS:3812-1981, IS:1727-1967

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria			Sample – 15 kg. Purpose of testing
1.	Lime reactivity IS:1727-1967	1/100 t	Flow table, mixing apparatus, humidity cabinet, 5 t loading frame	Not less than 40 kg/cm ²			Less lime reactivity indicates inadequate content of reactive silica to combine with free lime
2.	Fineness by specific surface area by Blain's method IS:1727-1967	1/5 Samples	Blains permeability apparatus	For calcined clay not less than 2250 cm ² /g For flyash not less than 3200 cm ² /g			Higher the fineness greater the strength, lesser bleeding and better workability
3.	Compressive strength IS:1727-1967	1/100 t	Vibrating machine 40 t compression testing machine	At 28 days minimum 80 percent of the strength of plain cement mortar cube. At 90 days it shall not be less than that of 28 days strength			Higher strength is acceptable
4.	Chemical analysis IS:1727-1967	1/5 Sample	Muffle furnace, Platinum crucible, Balance	Constituent	Unburnt Clay (Soil)	Flyash	Silica constituent has to be the major one. MgO causes expansion and disintegration
				SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	Not less than 70 %	Not less than 70%	
				SiO ₂ (min)	40 %	35 %	
				Na ₂ O+K ₂ O(max.)	3 %	1.5 %	
				Water Soluble alkali (max.)	1 %	-	
				Loss on ignition(max.)	10 %	12 %	
				CaO (max.)	10 %	-	
				MgO (max.)	3 %	5 %	
				So ₃ (max.)	3 %	2.75 %	

TABLE - 6
Building lime
IS: 712-1989, 6932 (Part 1 to 11) – 1973

Sr. No.	Particular of Test	Frequency	Equipment	Acceptance Criteria	Sample – 10 kg packed tin Purpose of testing
1.	Workability IS:6932-(Part-8)- 1973	1/100 T 2/300 T Each sample	Flow table with moulds, Oven, Triple beam balance	Bumps more than 12 for flow from 11 to 19 cm for C and D types	Determines water requirement for subsequent tests
2.	Fineness IS:6932-(Part-4)- 1973	-do-	Sieves 2.36 mm, 850 micron, 300 micron	No residue on 2.36 mm. 5 percent residue on 850 micron for A and B Class No residue on 850 micron for C class. 10 percent residue on 300 micron for A and B class 5 percent residue on 300 micron for C class	Higher residue indicates inadequate calcination and slaking
3	Setting time IS:6932-(Part-2)- 1984	-d0-	Vicat needle apparatus	For Class A Initial – Not less than 2 hours Final – Not more than 48 hours	Placement and compaction is to be completed within initial limit, final limit indicates hardening
4	Compressive strength IS:6932-(Part-7)- 1973	-do-	Pug mill, 5 cm cube three moulds, 5 ton loading frame	A class 17.5, 28 kg/cm ² at 14 and 28 days B Class 12.5, 17.5 kg/cm ² at 14 and 28 days	Hardening is measured in terms of compressive strength which further indicates class of lime
5	Transverse strength IS:6932-(Part-7)- 1973	1 in 5 samples	2.5X2.5X10 cm moulds Transverse strength tool, 5 ton loading frame	A class 10.5 kg/cm ² at 28 days B Class 7.0 kg/cm ² at 28 days	Hardening is measured in terms of transverse strength and indicates type of lime
6	Soundness IS:6932-(Part-9)- 1973	1 in 5 samples	Le Chaterlier apparatus	Maximum expansion 10 mm	Excessive expansion indicates higher content of MgO

Sr. No.	Particular of Test	Frequency	Equipment	Acceptance Criteria	Purpose of testing
7	Chemical analysis IS:6932-(Part-1)-1973	Each sample	Muffle furnace, Oven, Platinum crucible, Chemical balance, Water bath	Analysis percentage <u>Class</u> A B C D E CaO+MgO min 60 70 85 85 25 MgO...max 5 5 5 5 5 SiO ₂ +R ₂ O ₂ min 25 15 - - Cementation 0.6 0.3 - - Value to min. to 0.6 As per IRC-51-1992	Excessive content of MgO causes expansion. Relative percentage of CaO and SiO ₂ indicate class of lime
8	Lime content for lime stabilised soil/moorum IS:1514-1959 or 712-1984	a) Before 1 consignme nt mixing subject to minimum of 1 test per 5 T lime b) After 1/250 m ² mixing		Lime as CaO not less than 50 percent and 60 percent for lime soil and lime flyash stabilisation respectively No result shall be less than 75 percent of specified lime content Average of 10 samples should not be less than specified lime content	Larger variation indicates inadequate mixing

TABLE - 7
Steel

**IS: 432 (Part 1 & 2) – 1982, IS: 1785 (Part 1 & 2) – 1983, IS: 1608-1993,
IS: 1599-1985, IS: 1786-1985, IS:1716-1985**

Sample: 60 cm long

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Tensile, Yield, Elongation IS: 1608-1995	1 per 40 t	Universal testing machine, Vernier calliper, centre-Punch, Hammer	As per table 8	The measure of its strength and elasticity
2.	Bend IS: 1599-1985	1 per 20 t	Universal testing machine	Round bars, above 25mm dia, should be able to bend without fracture with sides parallel and internal diameter not greater than three times the thickness of the test piece.	It is an indication of carbon content in steel so as to ensure its use in any bent form.
3.	Rebend (in the case of deformed bars only) IS: 1786-1985	1 per 20 t	For Fe 415 & 500 Universal testing machine, mendrels of suitable dia. (5D for bars upto 10mm dia & 7D for bars over 10mm) of 135° and 157½° angle	The bar should withstand without fracture on the bent portion	To evaluate effect of deformation
4.	Reverse bend for ductility (in the case of wires only) IS: 1716-1985	Sample: Number of coils 3 in 25 – 4 - 65 5 - 180 7 - 300 10 over 300	Vice with Jaws of radius 10.0, 12.5, 15.0, 20.0 and 25.0 mm	The wire should withstand without showing any sign of fracture. Permissible defective number in coils tested. 0 in 3 to 4, 1-5 to 7 and 2-10	Measure of its ductility

TABLE - 8
VARIOUS TYPES OF STEEL

Sr. No.	Material	Nominal thickness diameter (mm)	Ultimate Tensile strength Min. (N/mm ²)	Yield stress Min. (N/mm ²)	Elongation , Percent Min. Gauge length $5.60 S_0$
1.	Mild steel and medium Tensile steel Bars and Hard-Drawn Steel wire for concrete reinforcement IS: 432(Part I) – 1982 (Third Revision) Mild steel and medium tensile steel bars IS:432(Part-2)-1982, Hard drawn steel wire	<u>Mild steel gr.I</u> 0 – 20	410	250	23
		20 – 50	410	240	23
		<u>Mild steel gr.II</u> 0 – 20	370	225	23
		20 – 50	370	215	23
		<u>Medium Ten. Steel</u> 0 – 16	540	350	23
		16 – 32	540	340	20
		32 – 50	510	330	20
		All sizes	570	480	7.5
2.	High strength deformed steel bars and wires for concrete Reinforcement IS: 1786-1985 (Third Revision)	All sizes	<u>Grade Fe 415</u> 485	415 *	14.5
			<u>Grade Fe 500</u> 545	500 *	12.0
			<u>Grade Fe 550</u> 585	550 *	8.0
3.	Plain Hard-Drawn steel wire for prestressed concrete IS: 1785 (Part I) – 1983 Cold Drawn Stress – Relieved Wire (Second Revision)	2.50	2010	85 Percent of the minimum specified tensile strength	2.5
		3.00	1865		2.5
		4.00	1715		3.0
		5.00	1570		4.0
		7.00	1470		4.0
		8.00	1375		4.0
4.	Plain Hard-Drawn Steel Wire for prestressed concrete IS: 1785 (Part II) – 1983 As – Drawn Wire (Ist Revision)	3.00	1765	75 Percent of the minimum specified tensile strength	
		4.00	1715		
		5.00	1570		

} Gauge length 200 mm

Sr. No.	Material	Nominal thickness diameter (mm)	Ultimate Tensile strength min. (N/mm ²)	Yield stress min. (N/mm ²)			Elongation , Percent Min. Gauge length 5.60 S _o
				< 20mm	20-40 mm	>40mm	
5.	Steel for General structural purposes – specification IS: 2062 – 1992 (Fourth Revision)	Gr. A Fe 410 WA (All sizes)	410	250	240	230	23
		Gr. B. Fe 410 WB (All sizesa)	410	250	240	230	23
	Steel plates, strips, sections, flats, Bars etc.	Gr. C. Fe 410 WC (All sizes)	410	250	240	230	23

*Indicates proof stress at 0.2 percent of the original gauge length

TABLE - 9
Building Stone
IS:1597(Part 1 & 2)-1992 IS:1121 (Part - 1 to 4)-1974, IS:1122-1974,
IS:1124-1974, IS:1125-1974

Sample-2 Rubble 25x25x25 cm

Sr. No.	Particular s of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Specific gravity (apparent) & water absorption IS:1124-1974	1/week	Mortar & pestle, 150micron sieve, sp.gr.bottle, balance, cylinder	Absorption: Not more than 5% for rubble masonry. Not more than 2.5% for sand stone flooring	Lesser the water absorption higher the durability, lesser the weathering. For dams higher porosity causes more leakage Higher the specific gravity more is the durability & economy
2	Specific gravity (true) IS:1122-1974	1/week	Mortar & pestle, 150micron sieve, sp.gr.bottle, balance, cylinder	As per relevant specifications	
3	Porosity IS:1124-1974	1/week	Mortar & pestle, 150micron sieve, sp.gr.bottle, balance, cylinder	As per relevant specifications	
4	Compressive strength IS:1121(Part –I)-1974	Building /bridges 2 sets of tests per working season	Rock cutting machine 200 t compression testing machine	Workable range: Granite-1000kg/cm ² Basalt-400kg/cm ² Sand stone-300kg/cm ²	Indicates load carrying capacity & integrity
5	Transverse strength for flooring IS:1121(Part-2)1974 IS:3622-1977-	1/800Nos.	5t loading frame, transverse block	Sand stone-70 kg/cm ²	Ensures least breakage
6	Shear strength IS:1121(Part-4)1974	2 sets of tests per working season	Shear tool	Workable range: Granite-140-500kg/cm ² Basalt-200-600kg/cm ² Sandstone-80-400kg/cm ²	Ensures integrity against vertical sustained load.
7	Weathering IS:1125-1976	2 sets of tests per working season	Balance, gypsum powder	As per design	Measure of durability & strength

TABLE - 10
Coarse Aggregate (Metal, gravel etc.)
IS: 2386-1963 (Part 1 to 8), IS: 383-1970

Sample : 100 kg.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Gradation : IS:2386(Part-1)-1963	1/150 m ³ for concrete or as per specification	Set of coarse sieves 80mm to 4.75mm, balance	As per relevant specifications' provision	Gradation governs the bulk density and void content.
2.	Sp.gravity & water absorption IS:2386(Part-3)-1963	2/season	Wire basket, two pan balance, oven	As per relevant specifications' provision Sp.gravity generally 2.5 to 3.0 and water absorption 1 to 1.5%	Higher the specific gravity the higher the density and greater the durability.
3	Flakiness & elongation indices IS:2386-(Part-1)-1963	As per specification	Balance, length gauge, thickness gauge, sieves	As per design	Flaky material needs more sand, water & cement for same strength.
4	Impact value IS:2386(Part-4)-1963	2/season	Impact testing machine, triple beam balance, sieves	As per IS: 383-1970 Concrete-wearing-surface-30% max. Overlaid surface 45%max.	Lower impact value gives better performance in facing successive moving loads
5	Abrasion value IS:2386(Part-4)1963	2/season	Los angel's abrasion machine, balance, sieves	As per IS:383-1970 Concrete- Wearing surface-30%max. Over laid surface-45%max.	Higher abrasion value indicates more wear & tear & higher cost of repairs & maintenance
6	Soundness IS:2386(Part-5)1963	2/Season	Sieves, oven	As per-IS:383-1970 Concrete- Loss with Na ₂ SO ₄ -12%max. Loss with MgSO ₄ -18%max.	Higher loss indicates less ability of the stones to withstand effect of freezing & thawing
7	Alkali reactivity IS:2386-(Part-7)1963	2/Season	Reactivity container, water bath, balance	As per Sc/Rc curve of IS or relevant specifications provisions	Deleterious aggregate cause disintegration of concrete
8	Petrographic examination IS:2386(Part-8)-1963	2/Season	Microscope, hammer, balance	Relevant specifications provision or deleterious constituents not more than 5% including silt content	Deleterious material beyond 5% leads to chemical reactions, cracking of concrete etc.

TABLE - 11
Fine aggregate(Sand)
IS:2386-1963(Part - I to 8), IS:383-1970

Sample 20 kg

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Gradation Fineness modulus IS: 2386-(Part-1)1963	1/150m ³ or as per requirements of the relevant specification	Fine sieve set of 4.75,2.36,1.18mm & 600,300.150,75 micron, balance	As per relevant and specification provision and looking to the purpose of the use For concrete IS:383-1970 Masonry mortar IS:2116 –1980 Plaster IS:1542-1992	Poor gradation & lower F.M.give low strength, demand more water for mixing
2	Specific gravity & water absorption IS: 2386-(Part-3)1963	2/Season	Pycnometer, oven, two pan balance	As per relevant specifications & design	Lower specific gravity & higher water absorption decrease durability & density & increase shrinkage
3	Silt content IS: 2386-(Part-1)1963	1/150m ³	75 micron sieve, balance, oven	Not more than 3% or the relevant specifications' provision	Higher silt content reduces strength, increases water requirement & inhiibits bond
4	Alkali reactivity IS: 2386-(Part-1)1963	2/Season	Reactivity container, water bath, balance	As per Sc/Rc curves of IS or Relevant specifications provisions	Amorphous silica,glass,mica content lead to chemical disintegration
5	Petrographic examination IS: 2386-(Part –8)1963	2/season	Microscope, balance	Relevant specifications' provision or deleterious constituents plus silt content not more than 5%	Deleterious material beyond 5% affects durability

TABLE - 12
Building Bricks
IS : 1077 - 1992, IS : 3495 (Part 1 to 4) - 1992.

Sample : 20 bricks.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria			Purpose of testing
1.	Dimension and tolerance IS:1077-1992	50 bricks from 50,000 (20 bricks)	Steel tape	For 19 x 9 x 9 cm (for 20 bricks)	Length 3720 to 3880 Width 1760 to 1840 Height 1760 to 1840		Uniform bricks need minimum thickness of joint and hence less mortar. Bond improves.
2.	Water absorption IS : 3495 (Part-2) 1992	5 bricks	Oven, two pan balance, water tank.	Not more than 20 percent or as specified in relevant specifications.			More absorption means inadequate burning and less durability. Excess absorption leads to dampness, leaching of salt.
3.	Compressive strength IS: 3495-(Part -1)-1992	5 bricks	Compression testing machine	Not less than 3.5 N/mm ² or as specified in relevant specifications.			Strong and durable masonry is ensured. More load can be laid on the wall. High strength bricks are ideal for hollow brick masonry.
4.	Efflorescence IS : 3495-(Part-3)-1992	5 bricks	Glass dish or porcelain or stoneware dish	Classified as Nil - No deposition of salt on Bricks. Slight - Deposit of salt covering 10 % of exposed brick area. Moderate- Thin deposit of salt covering upto 50 % of the exposed brick area.			Excess efflorescence causes disintegration and defacement.
5.	Chemical analysis of soil for suitability of preparing bricks. IS : 2117 - 1991	Each soil sample (5 bag)	Chemical balance furnace, water bath.	CaO+MgO Water soluble Salts	Not more than 1% for alluvial and not more than 15 % for other than alluvial. maximum 1 %		Initial indication of suitability of soil for bricks.

TABLE - 13
Acid Resistant Bricks
IS: 4860 – 1968

Sample – 24 Bricks

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Dimensions and tolerances 230 X 114 X 64mm IS:4860-1968	50 Bricks from 1000 & sub sample of 24	Tape	Permissible tolerances shall be as follows Tolerances Length ± 3.5 mm Width ± 2.0 mm Height ± 1.0 mm	Acceptable bricks mean economy, less joints and more durability
2.	Water absorption IS:4860-1968	5 Bricks	Oven, Balance	Class I – Not more than 2 % Class II – Not more than 4 %	Indicates integrity of bricks and masonry or lining
3.	Compressive strength IS:4860-1968	5 Bricks	200 t Compression testing machine	Class I – Not less than 700 kg/cm ² Class II – Not less than 500 kg/cm ²	Strength and durability are ensured
4.	Flexural strength IS:4860-1968	5 Bricks	40 t Universal testing machine of loading frame	Class I – Not less than 100 kg/cm ² Class II – Not less than 70 kg/cm ²	Strength and durability are ensured
5.	Resistance to acid IS:4860-1968	1 Brick	Chemical balance	Class I – Not more than 1.5 % Class II – Not more than 4.0 %	Indicates capacity to withstand corrosive action and hence durability

TABLE - 14
Cement Concrete Flooring Tiles
IS: 1237 - 1980

Sample - 18 Nos

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Water absorption	6/2000 tiles	Balance, Oven, Water Tank	Not more than 10 percent.	Ensures dryness of flooring and durability.
2.	Transverse strength	6/2000 tiles	5 T loading frame, transverse apparatus	Shall not be less than 30 kg / cm ²	Capacity to withstand load if support is lost
3.	Abrasion	6/2000 tiles	Tile abrasion machine, stone cutting machine.	Average wear shall not exceed 3.5 mm - wear on any individual specimen shall not exceed 4.0 mm	Lower the abrasion value, higher the durability and lower the maintenance.
4.	Size	-do-	Steel tape	The size of cement concrete flooring tiles shall be as follows. <div style="display: flex; justify-content: space-around;"> <div>Length mm</div> <div>Breadth mm</div> <div>Thickness mm</div> </div> <div style="display: flex; justify-content: space-around;"> <div>200</div> <div>200</div> <div>20</div> </div> <div style="display: flex; justify-content: space-around;"> <div>250</div> <div>250</div> <div>22</div> </div> <div style="display: flex; justify-content: space-around;"> <div>300</div> <div>300</div> <div>25</div> </div>	
5.	Tolerances	-do-	Steel foot rule	Length or Breadth Thickness	± 1 mm + 5 mm

TABLE - 15
Low Density Polythelene Film (LDPE)
IS:2505-1989

Sample : 10 m²

Sr. No.	Particulars of Tests	Frequency		Equipments	Acceptance criteria	Purpose of testing
1	Tolerance on thickness	Lot size	No.of samples	Micrometer or thickness gauge meter	Up to & including 40μ - $\pm 25\%$ Above 40μ $\pm 20\%$	Uniformity, assurance of performance, economy
		1	1			
		2-15	2			
		2-16	3			
		41-65	5			
2	Tensile strength	-do-		Tensile testing machine	Tensile strength MN/m ² (min) a)length wise 11.77 b)cross wise 8.33	The measure of tensile strength
3	Elongation	-do-		Tensile testing machine	Elongation %(min) a) length wise 200 b)crosswise 400	The measure of film elasticity, durability
4	Impact test	-do-		Impact tester	Impact failure load shall not be less than 1.20N for 100μ LDPE film	To examine resistance to impact

TABLE - 16
Flush Door
IS: 2191 (Part – I) – 1983, IS: 2202 (Part – I) – 1991

Sample : 2 Nos.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Dimension and tolerances	Lot Sample size 26-50 51-100 101-150 From above 2 samples to be selected	Steel taper, vernier caliper	Height + 3mm Width + 3 mm Thickness \pm 1.2 mm Thickness variation not more than 0.8 mm Permissible limit for defective upto 50-0 number, 300-1,	Trueness of shape and form defined edges ensure tight fitting
2.	End immersion	-Above-	Curing tank, Steel foot rule	No delemination	To check the quality of glue resin used in the flush door, so as to ensure durability
3.	Adhesion	-Above-	Water heater, Vernier caliper	No delemination in the plywood 3 pieces out of 4 should not have single delemination measured continuously more than 50mm in length and 3mm in depth	To know the strength of adhesion in flush door and hence durability

Note : In case of solid core type flush door when physical tests are not satisfied, two additional shutters for each unsatisfactory shutter are tested for particular test and all shutters ought to satisfy the requirement of test.

TABLE - 17
Cement Concrete
IS: 456-2000, IS:516-1959, IS: 1199-1959

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria		Purpose of testing
1.	Mixer efficiency IS:4634-1968	At start of job and occasionally for each batching plant/mixer - Requirement of work	Container, Mixer, weighing balance etc.	Maximum unit weight variation within batch 0.8 percent from average. Maximum average variability 0.6% for 3, 0.5% for 6, 0.4% for 9, 0.3% for 10 batches		Ensures intimate homogeneous mixing and uniform dispersal of cement paste
2.	Workability IS: 1199-1959	Daily for each shift at plant and site	Slump cone, Tamping rod, steel tape	It should be as per "Hand book on concrete mixes" based on Indian Standards		Ensures proper placement and minimum voids
3.	Yield & Unit weight IS: 1199 – 1959	Occasionally or as directed by Engineer in charge	0.03 m ³ container, Weighing balance, Tamping rod	± 2% from design or as specified in the specification		Useful for determining and controlling cement level
4.	Air content IS: 1199-1959	-do-	Air entrainmeter with accessories	± 1% from design or as specified in the specification		Higher air content causes reduction in strength
5.	Compressive strength IS: 516-1959	As per IS and as specified in the relevant specification Quantity of concrete in work m ³	200 t compression testing machine, 15 cm cube mould, Vibrating machine	Grade designation	Specified characteristic compressive strength at 28 days, N/mm ² (kg/cm ²) Approx	To evaluate the quality of concrete, its acceptability. If not acceptable measures to improve are tried.
		1-5	1	M 10	10 (100)	
		6-15	2	M 15	15 (150)	
		16-30	3	M 20	20 (200)	
		31-50	4	M 25	25 (250)	
		51 & above	4 plus one additional sample for each additional 50 m ³ or part thereof	M 30 M 35 M 40 Upto M80 in increment of 5	30 (300) 35 (350) 40 (400) Upto 80 (800) in increment of 5 (50)	

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
Note : (1) At least one sample is taken from each shift (2) Each sample consists of three test specimens for testing at 28 days. Additional cubes are required for various purposes such as to strength of concrete at 7 days or at the time of striking the form work, or to duration of curing, or the size testing error.				<p>(A) The concrete shall be deemed to comply with the strength requirements when both the following condition are met :</p> <p>a) The mean strength determined from any group of four consecutive test results compiles with the appropriate limits in col 2 of Table below</p> <p>b) Any individual test result complies with the appropriate limits in col 3 of Table below</p> <p>(B) If the concrete is deemed not to comply pursuant to (B), the structural adequacy of the parts affected shall be investigated (see clause 17 of IS:456-2000) and any consequential action as needed shall be taken</p> <p>Note :</p> <p>1. The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results as early as possible, when a mix is used for the first time.</p> <p>2. Concrete of each grade shall be assessed separately</p>	

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria			Purpose of testing
				Specified Grade	Mean of Group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2	
				(1)	(2)	(3)	
				M 15	$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 3 \text{ N/mm}^2$ whichever is greater	$\geq f_{ck} - 3$ N/mm^2	
				M 20 or above	$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 4 \text{ N/mm}^2$ whichever is greater	$\geq f_{ck} - 4$ N/mm^2	
				NOTE: In the absence of established value of standard deviation, the values given in Table 8 of IS:456-2000 may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.			

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
(B)	Ordinary and controlled concrete for road bridge	3 cubes/60 m ³ each for 7 and 28 days age, Further that every day for first six days and once in three days there after.	200 tonne compression testing machine	Average compressive strength of each day should not be less than specified strength subject to that 20 percent cubes per day (i.e. 1 per 5 may fall below specified strength upto its 85 percent).	
(C)	Concrete pavements roads and runways IRC-SP-11-1981 IRC-15-1981	3 cubes/beams for each age of 7 and 28 days for every 30m ³ .	200 tonne compression testing machine	Lower control limit calculated for a tolerance level of 1 in 15 test results, shall not be lower than the specified minimum strength. The lower control limit is given by the mean-value of the set of tests minus 1.6 times the standard deviation.	
2	Hardened concrete				
	(A) Concrete pavement/Bridge. IRC-Sp.-11-1981 IRC:15-1981;Test if failure in test 1	2 cores/30m ³	Core drilling machine	The crushing strength of cores shall not be less than 0.8 times the corresponding crushing strength of cubes	To evaluate the quality of concrete, its acceptability. If not acceptable measures to improve can be tried.
	(B) Dams	3 cores/1500m ³	Do	As in 1(A) + 1(B)	

Note: For tests 1 and 2, if individual results vary by more than ± 15 percent from average strength, reject those only (maximum rejection 1 in 3 or 2 in 5 cubes), and rework the average.

TABLE - 18
R.C.C. Precast Concrete Pipes
IS:458-1988 & IS:3597-1985

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Sample-4Nos
					Purpose of testing
1	Dimension test IS:458-1988	As per table 15 of IS:458 or as specified in the relevant specification	Steel tape	Tolerance as specified in IS:458 or as per the relevant specification	Uniformity, economy, performance
2	Hydraulic test IS:3597-1985	As per table 15 of IS:458 or as specified in the relevant specification	Hydrostatic testing machine & pump	No leakage sign should be seen when the specimen is filled with water & pressure of 0.7.kg/cm ² is applied & maintained for the specified time	To know the leakage at certain pressure. To ensure water tightness
3	Three edge bearing test IS:3597-1985	As per table 15 of IS:458 or as specified in the relevant specification	Testing machine with accessories, Pressure applying device, crack measuring gauge	No crack should develop up to the load to produce 0.25 mm crack as specified in IS:458 or the relevant specifications	Structural safety against bridging on subgrade
4	Absorption test IS:3597-1985	-	Oven, Balance	a) Absorption in the first 10 minutes shall not exceed 2.5 percent of the dry mass b) Total absorption at the end of 24 hrs. shall not exceed 6.5 percent of the dry mass	To know the porosity of the pipe material

Note: 1) The concrete for non-pressure pipes shall have a minimum cement content of 360 kg/m³ & minimum comp. Strength of 20 N/mm² at 28 days.
For pressure pipes minimum cement content 450 kg/m³ and minimum comp. strength of 20 N/mm²
2) Reinforcement used for the manufacture of RCC pipes shall be as per relevant specifications of steel

TABLE - 19
Masonry Mortar
IS : 2250 - 1981

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Consistency (Workability) IS:2250-1981	Each working day	Standard cone apparatus, flow table	As specified in the relevant specification	Ensures proper placement and minimum voids.
2.	Compressive strength IS:8605:1977	3 Cubes / 100 m ³ or / day whichever is more for each age	Compression testing machine, 5 x 5x5 cm cube mould, mixing bowl.	1 in 5 samples may fall below specified strength upto 80 percent.	Governs strength and durability.
3.	Permeability IS: 3085-1965	1 / week	Permeability apparatus	As specified in the relevant specification	Ensures water tightness
4.	Water retentivity IS:2250-1981	When mortar is to be used with masonry unit which has got high suction characteristics.	Water retentivity apparatus, straight edge, mixing bowl, flow table.	Flow after suction in the test shall not be less than 10 percent of the flow before suction.	To know the ability of mortars to retain water against suction and evaporation.
5.	Air content	1/50 m ³	Air entrainmeter	± 1 per cent from design	Higher air content causes reduced strength.
6.	Yield & Unit weight	1/50m ³	0.03m ³ containers	± 2 per cent from design cement level unit volume of mortar or as specified in relevant specification	Useful for determining and controlling cement level.
7.	In situ permeability	As per specification	Drilling machine, insitu permeability apparatus with pressure gauge and packers.	As per design	Ensures water tightness.

33TABLE - 20
Sealing Compound
IS:13143-1991, 5256-1968

					Sample – 3 kg.
Sr. No.	Particular of Test	Frequency	Equipment	Acceptance Criteria	Purpose of testing
1	Softening Point IS:1205-1978	As per specification	Ring and Ball apparatus, Bath & Stirrer	It shall not be less than 85° C	For determination of softening point of sealing compound
2.	Penetration at 25 °C 100 g 5%, 1/10 IS:1203-1978		Penetrometer with accessories	Minimum – 15, Maximum – 30	To determine the grade of sealing compound
3.	Flash Point IS:1209-1978		Pensky-Martens closed Tester	Minimum 200 °C	To determine the flash point & fire point of sealing compound
4.	Pour Point IS:1834-1984			Maximum 170 ° C	To ensure viscosity & workabiulity
5.	Increase in softening point after heating to 20 ° C above the maximum pour point for 3 hrs. IS:1205-1978		Ring & Ball apparatus, Bath & Stirrer	Maximum 5 ° C	To determine increase in softening point of sealing compound
6	Extensibility at 0°C IS:1834-1984			Minimum 6 mm	Determination of capacity to extend
7	Water content IS:1211-1978		Dean & Stane Assembly, Heater	Maximum 0.5 percent by weight	To determine water content of sealing compound

TABLE - 21
Water (For concrete & Mortar)
IS : 456 - 2000

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Sample 1 liter Purpose of testing
1.	Chemical Analysis.	Once for approval of source	Muffle furnace, water bath Oven, PH meter & Platinum Crucible.		Chemical suitability & stability
	pH			Generally not less than 6	pH lower than 6 is acidic, leads to corrosion, loosens bond. pH more than 8 causes excessive leaching.
	Chlorides (mg / l) IS : 3025 (part-32) - 1988			2000 mg/l for plain concrete & 500 mg/l for RCC work max.	Higher chlorides cause corrosion.
	Organic matter (mg/l) IS : 3025 (part - 18) -1984			200 mg/l max.	Excess organic matter may adversely affect the hardness of concrete, may stain the concrete.
	Inorganic matter (mg/l) IS : 3025 (part-18)-1984			3000 mg/l max.	Excess inorganic matter causes efflorescence.
	Sulphate (mg/l) IS : 3025 (part-24) -1986			400 mg/l max.	Excess sulphate attacks calcium carbonate to form calcium aluminosulphate which is weak, expands and disintegrates concrete.
	Suspended matter IS : 3025 (part - 17) - 1984			2000 mg/l max.	
	Neutralization of alkalinity IS : 3025 (part-23) - 986			25 ml with 0.02 N H ₂ SO ₄ max.	
	Neutralization of acidity IS : 3025 (part-22) - 1986			5 ml with 0.02 N NaOH max.	

Note: In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified in 5.4.1.2 & 5.4.1.3 of IS : 456 - 2000.

TABLE - 22
Curing compound
ASTM C-156-1989 C-309-1989, D-1309-1988, D-1644-1988, E-1347-1990

Sample: 1 litre

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Water retention test ASTM C-156-1989	1lit.per 1000 lit. or as specified in the relevant specification	Mould, sprayer, balance, humidity chamber etc.	Water loss after 72 hrs.-not more than 0.55 kg/cm ²	To find out the ability to reduce moisture loss during the early hardening period
2	Reflectance test ASTM E-1347-1990	-do-	Tristimulus colorimeter	Shall exhibit a daylight reflectance not less than 60 %	To find out reflectance value of white pigment based curing compound
3	Drying time test ASTM C-309-1989	-do-	Mould, sprayer, humidity chamber	a) Dry to touch not more than 4 hrs. b) After 12 hrs. the compound shall not be tracky or track off the specimen	To know the drying time requirement
4	Long term settling ASTM D 1309-1988	-do-		Rating between 4 to 10	
5	Non volatile content ASTM D-1644-1988	-do-	Pipette, Oven, Balance, Desicator	-	To find out non volatile content of curing compound

TABLE - 23
PVC Water stops
IS: 8543-(Part 4)-1984 IS: 12200-1987, ASTM D 638-1991, D 412-1992, D 2240-1991,
Sample: 1.5m long – 3 pieces

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Tensile Strength IS: 8543-(Part 4 / Sec.1) - 1984	Per lot of 45m or as per specified in specification	Tensile strength testing machine with accessories	Shall not be less than 116 kg/cm ²	To measure its strength
2.	Ultimate elongation IS: 8543-(Part 4 / Sec.1)- 1984	-do-	-do-	Shall not be less than 300 percent	To measure its elasticity
3.	Tear resistance	-do-		Shall not be less than 49 kg/cm ²	To disallow tearing
4.	Stiffness in flexure	-do-		Shall not be less than 24.60kg/cm ²	
5.	Accelerated Extraction i) tensile strength	-do-	Tensile strength testing machine with accessories	Shall not be less than 105 kg/cm ²	To measure strength
	ii) Ultimate elongation	-do-	-do-	Shall not be less than 250 percent	To measure its elasticity, Durability
6.	Effect of alkali at 7 days a) Change in weight % b) Hardness change	-do- -do-		± 0.10 percent max. ± 5.0 point	To measure strength
7.	Effect of alkali after 28 days a) Weight increase b) Weight decrease c) Change in dimension			0.40 percent max. 0.3 percent max. ± 1 percent	
8.	Durometer Hardness			± 1 percent shore "D"	

TABLE - 24
Admixture for Concrete
IS: 9103-1979

Sr.No.	Particulars of test		Frequency	Equipment	Acceptance criteria			Air entrain Admixture	Sample : 1 Litre Purpose of Testing
					Accelerating Admixture	Retarding Admixture	Water reducing Admixture		
1.	Water content of control sample		1/1000 lit.	Oven with Thermometer	-	-	95	-	To evaluate % of water
2.	Setting time allowable deviation from control sample in hrs.			Vicat Apparatus with initial & final needle	-3 max. -1 min.	+3 max. +1 min.	± 1 max.	-	To know the suitability in concrete/ mortar in setting time
	Initial				-2 max. -1 min.	+3 max.	± 1 max.	-	
	Final							-	
3.	Compressive Strength Allowable from control mix (%)	Days 3 7 28		C.T.M machine	125 min. 100 min. 100 min.	90 min. 90 min. 90 min.	110 min. 110 min. 110 min.	90 min. 90 min. 90 min.	To know the suitability in concrete/mortar in strength
4.	Flexural strength Allowable from control mix (%)	Days 3 7 28		Flexural Testing machine	110 min. 100 min. 90 min.	90 min. 90 min. 90 min.	100 min. 100 min. 100 min.	90 min. 90 min. 90 min.	To know the suitability in concrete/mortar in strength
5.	Length change percent increase from control sample								To know the shrinkage in mortar / concrete
	28 Days			Length change comperater	0.010 max.	0.010 max.	0.010 max.	0.010 max.	
	6 Months				0.010 max.	0.010 max.	0.010 max.	0.010 max.	
	1 Year				0.010 max.	0.010 max.	0.010 max.	0.010 max.	

Sr.No.	Particulars of test	Frequency	Equipment	Accelerating Admixture	Acceptance criteria		Air entrain Admixture	Purpose of Testing
					Retarding Admixture	Water reducing Admixture		
6.	Bleeding percent increase over control sample		Pipette, Temping Bar, Cylinder	5 max.	5 max.	5 max.	2 max.	To determine relative quantity of mixing water that will bleed from a sample.

O.K. CARD FOR CEMENT CONCRETE MIX (AT BATCHING PLANT)

Location of plant :

Grade of concrete : M-

Date :

Proportion as per mix design.

Location of placing concrete :

- | | | |
|-----|--|-----------------|
| 1. | Coarse aggregate : Natural or crushed | ----- |
| 2. | Whether gradation, Size and quality of coarse aggregates are as per specifications and mix design ?
Give % oversize and under size. | Yes/No
----- |
| 3. | Is the coarse aggregate free from excessive silt ? Specify actual % of silt | ----- |
| 4. | F. M. of Sand | ----- |
| 5. | Is the sand free from excessive silt ? Specify actual % of silt | Yes/No
----- |
| 6. | Type and brand of cement : PPC/OPC | ----- |
| | A.E.A. | |
| | Water | ----- |
| 7. | a. Start of pour | ----- |
| | b. End of pour | ----- |
| 8. | a. Total m ³ . batched | ----- |
| | b. Total m ³ . placed | ----- |
| | c. Total m ³ . wasted | ----- |
| 9. | Ambient temperature at Start : at Finish :... | ----- |
| 10. | Mixing time specified | ----- |
| 11. | W/C ratio | ----- |
| 12. | Slump specified | ----- |
| 13. | a. Slump at batchmix plant | ----- |
| | at placement site | ----- |
| | b. Air content | ----- |

Sign. of Contractor

Sign. of AE/AAE

Deputy Exe. Engineer

DEE/AE/AAE

Quality Control Sub. Dn.

Name of Division :

Sign. of Inspecting Officer.

Name of Sub-Division :

Name of Dn. :
Name of Sub Dn. :

O.K.CARD FOR CONCRETING AT THE STRUCTURE UNDER CONSTRUCTION :

Name of Work :
Name of Structure :
Location :
Details of component :
Date of Start : Time :
Date of Completion : Time :
Type of Con. :
Proportion :
as per mix desing
Embient Temp. :
Enbient Temp. :

A. SURFACE PREPARATION :

1. Whether the cleaning of foundation is done as specified? Yes/No
2. Dewatering arrangement whether adequate? Yes/No
3. Whether foundation mapping is done? Yes/No
4. Whether the surface to receive the concrete is prepared as specified? Yes/No

B. REINFORCEMENT :

5. Whether placing of reinforcement is as per design and drawings? Yes/No
6. Whether cleaning and checking of reinforcement is done? Yes/No
7. Whether checking of reinforcement done for adequacy of cover maintaining spacing uniformity and rigidity. Yes/No

C. FORMWORK AND WATER STOPS AND STEEL ITEMS :

8. Whether the erection of form work, placement of water stop and joints are as per the requirement. Yes/No
9. Whether geometry of form work and adequacy of supporting system is checked. Yes/No
10. Whether form work joints are properly sealed Yes/No
11. Whether the Oiling of forms is done adequately. Yes/No
12. Whether the concrete mixes, their location and sequence of placement satisfactory. Yes/No
13. Whether the transporting units, placement units and vibrators are sufficient and adequate. Yes/No
14. Whether Curing arrangements are adequate ? Yes/No
15. Slump =
16. No. of cubes cast

Signature of Contractor

Sign. of A.E./AAE

Deputy Ex. Engr.

D.E.E./ A.E./A.A.E.

Sign. of inspecting Officer

Name of Dn. :

Name of Sub Dn. :

O.K. CARD FOR C.C. LINING

Location:

Chainage from to

Distance from Centre line :

Date :

1. Whether sub grade is Okay from geometric angle?
2. whether sub grade is prewetted sufficiently before placing the concrete?
3. Density and moisture content of sub grade
4. Date and time of approval of sub grade
5. Date and time of starting C.C. Lining.
6. Whether Paver machine is Okay and its alignments set?
7. Whether the levels of rails are checked?
8. Whether placing arrangement of concrete is proper (i.e. sufficiency of lining equipments and transit mixers)
9. Workability of concrete at placement/B.M. Plant
10. Whether No. of labourers, masons etc. are adequate ?
11. Are curing arrangements adequate and satisfactory?
- 12.A Whether PVC strips to be inserted is checked W.R.T. quality and quantity
- B Whether PVC strip insertion is made?
- C Whether proper cutting of joints has been done ?
13. Whether log book of paver machine is maintained ?
- 14.A Whether curing compound to be used is tested ?
- B Specify results with coverage.
15. No. of cube cast
16. Date and time of completion of lining
17. Remarks :

Yes/No

Yes/No

Yes/No

Yes/No

Yes/No

slump M.M. _____

Yes/No

Yes/No

Yes/No

Yes/No

Sign. of Contractor

Sign. of AE/AAE

Deputy Exe. Engineer

D.E.E./A.E./A.A.E.
Quality Control Sub-Dn.

Sign. of Inspecting Officer

Name of Division :
 Name of sub-Division :
 Name of canal :

O.K. CARD FOR SUB GRADE OF C.C. LINING

Location: Chainage From to

Distance from Central Line : Date :

- | | | |
|-----|--|--------|
| 1. | Whether proud has been removed before commencement of C.C. lining as per specifications? | Yes/No |
| 2. | Whether final levels after proud removal are within the tolerance limits? | Yes/No |
| 3. | Over excavation, if any, may be specifically indicated. | |
| 4. | Whether final levels have been recorded | Yes/No |
| 5. | Whether mapping of rock/soil is done | Yes/No |
| 6. | Whether filling in over excavation is carried out? | Yes/No |
| 7. | Whether sub grade has been properly watered compacted as per design? | Yes/No |
| 8. | Depth of moisture in the sub grade after watering. | |
| 9. | Whether designed under drainage arrangements are provided? (e. g. P.R.V., longitudinal & cross drains) | Yes/No |
| 10. | Whether necessary approval of sub grade is taken? | Yes/No |
| | Result of test, % compaction & % of FMC | |
| 11. | Instruction of inspecting officer if any. | |

Sign. of Contractor

Sign. of AE/AEE

Deputy Exec. Engineer

D.E.E./A.E./A.A.E.

Quality Control Sub-Dn. No.

Sign. of Inspecting Officer.

Name of Dn. :
 Name of sub-Division :

O.K. CARD FOR SUB GRADE OF BRICK LINING

LOCATION	CHAINAGE Date :-	from	to
(A) SUB-GRADE			
1 Whether proud has been removed just before placing the leveling course 10 mm thick in C.M. 1:6 (or as specified)		Yes/No	
2. Whether Template at an interval of 3m to 5m are prepared showing the layers of cement mortar and final profile of cross-section with brick lining ?		Yes/No	
3. Whether the levels after proud removal are within the tolerance limit ?		Yes/No	
4. In case of over excavation, whether earth filling is carried out Yes/No Watered and Compacted ?			
5. Whether Sub-Grade has been properly watered upto the required depth ?		Yes/No	
6. Whether necessary tests for approval of sub-grade are taken? Results of tests		Yes/No	
	% age of compaction	-	
	% age of FMC	-	
7. Whether sub grade is okay from geometrical angle and necessary templates are provided ?			
8. Remarks			
Sign. of Contractor	Sign. of A.E/A.A.E	Deputy Executive Engineer Sub-Dn	
D.E.E/A.E./A.A.E. Quality Control Sub-Dn		Sign. of Inspecting Officer	

Name of Division :
 Name of sub-Division :
 Name of canal :

O.K. CARD FOR BRICK LINING

LOCATION	Chainage Date :-	from	to
(A) SUB GRADE AND CONSTRUCTION MATERIAL.			
1. Whether subgrade is approved ?			Yes/No
2. Whether sub grade is okay from Geometrical angle and necessary Templates are Provided.			Yes/No
3. Date and time of approval of sub-grade	-		
4. Whether Bricks to be used are tested and test results are available?			Yes/No
5. Whether proper arrangement has been made for soaking of bricks before use ?			Yes/No
6. Whether over burnt/under brick/pilla bricks/Rejected bricks stacked seperately?			Yes/No
7. Whether sand to be used is of the approved quality and free from deleterious materials, well screened and of requisite F.M ?			Yes/No
8. Whether cement to be used is fres h, not older than 90 days? Brand of cement, Grade, and Batch No.			Yes/No
9. Whether cement Account Book and consumption register maintained upto date and kept available on site?			Yes/No
10. Whether Mixer Machine & Weigh batcher have been tested? Corrected batch weight is provided considering the free moisture in sand?			Yes/No
11. Board indicating proportion of cement mortar is displayed.			Yes/No
12. Whether proper handling arrangement for mortar is done and impervious platform is provided for motar ? Whether mortar tank is being used.			Yes/No
13. Total time taken for the use of particular batch of cement mortar (not more than 30 minutes.)		-	
14. Whether the W/C ratio for the required consistancy is maintained properly.			Yes/No

15.	Proper arrangement for measurement of water is provided?	Yes/No
(B)	MORTAR LAYERS	
16.	Whether wooden L patties for uniformity in thickness of mortar are used in plaster layer?	Yes/No
17.	Whether strings and threads are kept on site to be used extensively for ensuring thickness and geometry of plaster? Whether wooden templates are used for curved portion ?	Yes/No
18.	Date and time of starting levelling course i.e. 1 st layer of 10mm thick or as specified in cm 1:6 or as specified.	-
19.	Whether adequate arrangement for curing is done ? (e.g.covered with wet gunny bags etc.)	Yes/No
20.	Whether 1 st layer is moistened, cleaned and scrubbed with broom	Yes/No
	before the 2 nd layer of plaster ?	
21	Date and Time of starting the 2 nd layer i.e. impervious layer of specified thickness in C.M. 1:3 proportion/or as specified.	
22	Whether the 2 nd plaster layer is scrubbed as per requirement with wire brush ?	Yes/No
23	Whether the 2 nd plaster layer is cured ?	Yes/No
24	Are curing arrangements adequate ?	Yes/No
	(C) BRICK LINING	
25	Date and time of starting the brick lining	
26	Whether the bricks are soaked sufficiently	Yes/No
27	Whether proper care for putting the bed plaster and filling of frog/joints with mortar taken ? Squeezing out of mortar between the joint space checked ?	Yes/No
28	Whether the masonry is broomed with wire brushes at the end of day ?	Yes/No
29	Whether the joints have been checked with joint tester and log book is maintained for joint testing ?	Yes/No
30	Whether adequate curing arrangement for curing in bed like water ponds and slopes to be covered with mats soaked in water, or hose pipe for sprinkling of water on slopes or perforated pipes on top of lining or pucca gutter on top of lining is provided ?	Yes/No
	Specify curing register maintained or not	

Sign. Of contractor

Sign. Of AE/AAE

Deputy Ex. Engineer

D.E.E/A.E./A.A.E.
Quality Control Sub-Dn

Sign. of Inspecting Officer

LIST OF INDIAN STANDARDS

Sr.No.	Standard No.	TITLE			
1.00	CEMENT :				
1.1	IS : 269:1989	Specification for 33 grade ordinary portland cement (Fourth) Revision)	1.6.13	IS:4031 (Part-13):1988	-do-Determination of measurement of water retentivity of masonry cement. (First revision)
1.2	IS : 455:1989	Portland blast furnace slag cement. (Fourth revision) Amed-3.	1.6.14	4031 (Part-14) : 1989	-do- Determination of False test.
1.3	IS : 1489: 1991	Specification for Portland Pozzolona Cement (Third revision) Flyash based.	1.6.15	IS:4031 (Part-15):1991	-d0- Determination of fineness by wet sieving.
1.4	IS : 3466:1988	Specification for masonry cement (Second revision)	1.7	IS:4032:1986	Methods of chemical analysis for hydraulic cement (First revision)
1.5	IS : 3535:1986	Methods of Sampling hydraulic cement (First revision)	1.8	IS:4905:1968	Methods for random sampling Amed – 1, Reaff – 1991.
1.6	IS : 4031(part-I)-1988	Methods of physical tests for hydraulic cement - Determination of fineness by dry sieving. (First revision)	1.10	IS:6909:1990	Specification for super sulphated cement Amed –2.
1.6.2	(Part-2) : 1998	--do – Determination of fineness by specific surface by blaine air permeability (First revision)	1.11	IS:8041:1990	Rapid hardning cement.
1.6.3	(Part-3) : 1988	-- do --Determination of soundness (First revision)	1.12	IS:8042:1989	White Portland cement.
1.6.4	(Part-4) : 1988	-- do -- Determination of consistency of sand and cement paste (First revision)	1.13	IS:8112:1989	43 Grade Ordinary Portland Cement Specification Amed – 3.
1.6.5	(Part-5) : 1988	-do-Determination of initial and final setting time (First revision)	1.14	IS:12269 – 1987	Specification for 53 grade ordinary Portland cement. Amed-3.
1.6.6	(Part-6) : 1988	-- do --Determination of comp. strength of hydraulic cement other than masonry cement (First revision)	1.15	IS:12330-1988	Specification for sulphate resisting Portland cement Amed-3.
1.6.7	(Part-7) : 1988	-- do -- Determination of Comp. strength of masonry cement (First revision)	2.00	POZZOLANA :	
1.6.8	(Part-8) : 1988	-- do -- Determination of transverse and Comp. stren. of plastic mortar using prism (First revision)	2.1	IS : 1344 : 1981	Specification for calcined clay pozzolana Second revision)Amed–1.
1.6.9	(Part-9) : 1988	-- do -- Determination of heat of hydryation. (First revision)	2.2	IS : 1727 : 1967	Method of test for Pozzolanic materials (First revision) Amed-1, Reaff – 1990.
1.6.10	(Part-10) : 1988	-- do -- Determination of drying shrinkage (First revision)	2.3	IS : 3812 : 1981	Specification for fly ash for use as pozzolana and admixture (First revision) Reaff-1992.
1.6.11	(Part-11) : 1988	-- do -- Determination of density (First revision)	2.4	IS:6491:1981	Method of Sampling of Flyash.
1.6.12	(Part-12) : 1988	-- do -- Determination of air content of hydraulic cement mortar. (First revision)	2.5	IS : 10153 :1982	Guidelines for utilisation and disposal for Flyash.
			3.00	BUILDING LIME :	
			3.1	IS:712:1984	Specification for building limes.(Third revision)Amed (Reaff-1995)
			3.2	IS:1128:1974	Specification for limestone. (Slab & tiles) (First revision) Reaff-1993.
			3.3	IS : 1624 : 1986	Method of field testing of building lime (First revision) Amed-1, Reaff – 1993.
			3.4	IS : 3115 :1992	Lime based blocks. (Second revision)
			3.5	IS : 4095 : 1983	Lime pozzolana mixture. (First revision) Amed – 2, reaff – 1989.

3.6	IS : 6508 : 1988	Glossary of terms relating to building lime (first revision) Reaff-1993.	4.4	IS:1599:1985	2, Reaff-1995.
3.7	IS : 6932 : 1973	Methods of test for building limes.			Method for bend test (supersiding IS:1962-1974. IS:3260-1960 and IS:4598:1965) Reaff-1991.
3.7.1	IS : 6932(Part – I):1973	Determination of insoluble Residue, loss on ignition, butyric and aluminium oxide calcium oxide and magnesium oxide Reaff-1995.	4.5	IS:1608:1995.	Method for tensile testing of steel product (Second revision)
3.7.2	IS : 6932(Part – 2):1973	-- do --Determination of Carbon dioxide content Reaff – 1990.	4.6	IS:1785(Part-I):1983	Specification for plain hard drawn steel wire for pre-stressed conc. to part-I cold drawn stress relieved wire (Second revision) Amed-1, Reaff-1995.
3.7.3	IS : 6932(Part-3) : 1973	-- do --Determination of Residue on Slaking of quick lime. Reaff-1995.	4.7	IS:1785(Part-II):1983	Specification for plain hard drawn steel wire for pre stressed concrete Part-2 a cold drawn wire (First revision) Amed-1, Reaff-1995.
3.7.4	IS : 6932(Part-4) : 1973	-- do --Determination of fineness of Hydraulic lime. Reaff-1995.	4.8	IS:1786:1985	Specification for high strength deformed steel bars and wires for concrete reinforcement (Third revision) Amed-1, Reaff-1990.
3.7.5	IS : 6932(Part-5):1973	-- do --Determination of unhydrated oxide. Reaff-1995.	4.9	IS:1977:1966	Low tensile structural steel (Third revision)
3.7.6	IS:6932(Part-6):1973	-- do --Determination of volume-yield of quick lime Reaff-1995.	4.10	IS:2062:1992	Steel for general structural purposes (Fourth revision) Amed-1.
3.7.7	IS:6932(Part-7):1973	-- do --Determination of compressive and transverse strength. Reaff-1995.	4.11	IS:2090:1983	High tensile steel bars for concrete reinforcement. (Third revision, Reaffirmed – 1990.
3.7.8	IS:6932:(Part-8):1973.	-- do -- Determination of workability Reaff-1995.	4.12	IS:8500:1991	Structural steel medium & high strength qualities(first revision Amed-2.
3.7.9	IS:6932(Part-9):1973	-- do --Determination of soundness. Reaff – 1995.	4.13	IS:6003-1983	Indented wire for prestressed concrete (first revision)
3.7.10	IS:6932 (Part-10):1973:.	-do-Determination of poping and pitting of hydrated lime.Reaff-1995.	4.14	IS:6006-1983	Specification for uncoated stress relived strend for prestressed concrete (first revision)
3.7.11	IS:6932 (Part-11):1984:.	-- do -- Determination of setting time of hydrated lime. Reaff-1990.	4.15	IS:13620-1993	Fusion bonded epoxy coated reinforcing bars (amend - 1)
4.00	STRUCTURAL STEEL:		5.0	BUILDING STONE :	
4.1	IS:432(Part-I):1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part-I Mild steel. (Third revision Reaff. 1995)	5.1.1	IS:1121(Part-I):1974	Method of test for determination of
4.2	IS:432(Part-II):1982	Specification for mild steel and Medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part-2 hard drawn steel wire (Third revision) Reaff-1995.			
4.3	IS:1566:1982	Hard drawn steel wire fabric for concrete reinforcement (Secomd revision) Amed-			

5.1.2	IS:1121(Part-2):1974	strength properties of natured building stones. Compressive strength (First revision) Amed-1, Reaff-1993. -do- Transverse strength. (First revision) Reaff-1993.	6.4..2	IS:2386(Part-2):1963.	-- do --Estimation of deleterious material and organic impurities. Amed-1, Reaff-1990.
5.1.3	IS:1121(Part-3):1974	-do Tensile strength (First revision) Reaff-1993.	6.4..3	IS:2386(Part-3):1963.	-do- Specific gravity density voids, absorption and bulking. Reaff-1990.
5.1.4	IS:1121(Part-4):1974	-do Shear strength (First revision) Reaff-1993.	6.4..4	IS:2386(Part-4):1963.	-- do --Mechanical properties. Amed-5, Reaff-1990.
5.2	IS:1122:1974	Method of test for determination of true specific gravity of natural building stones (First revision) Reaff-1993.	6.4..5	IS:2386(Part-5):1963.	-- do --Soundness, Reaff-1990.
5.3	IS:1123:1975	Identification of Petrographic examination of natural building stone. First revision Reaff. 1990.	6.4..6	IS:2386(Part-6):1963.	-- do -- : Measuring mortar making properties of fine aggregate. Amed – 2, Reaff-1990.
5.4	IS:1124:1974	Method of test for determination of water absorption apparent sp. gr. and porosity of natural building stone(First revision) Reaff-1990.	6.4..7	IS:2386(Part-7):1963	-- do --Alkali aggregate reactivity, Reaff-1990.
5.5	IS:1125:1974	Method of test for determination of weathering of natural building stone(First revision) Reaff-1990.	6.5	IS:2430:1969	Method for sampling of aggregate for concrete.
5.6	IS:1126:1974	Method of test for determination of durability of natural building stone (First revision) Amed-1, Reaff-1990.	6.6	IS:5640:1970	Method of test for determining aggregate impact value of soft coarse aggregates. Amed-1. Reaff – 1990.
6.00	AGGREGATE :		7.00	BRICKS :	
6.1	IS:383:1970	Specification for coarse and fine aggregate material (Second revision) Reaff-1990.	7.1	IS:654:1992	Specification for clay roofing roofing tiles mangalore pattern (Third revision)
6.2	IS:1542:1992	Sand for plasters (Second revision)	7.2	IS:1077:1992	Specification for common burnt clay building bricks (Fifth revision)
6.3	IS:2116:1980	Sand for masonry mortars (First revision) Reaff-1992	7.3	IS:2117:1991	Guide for manufacture of hand made burnt clay building bricks (Third revision)
6.4.1	IS:2386(Part-I):1963.	Method of test for aggregate for concrete, Particle size and Shape,	7.4	IS:2248:1992	Glossary of terms relating to structural clay products for building (First revision)

7.5	IS:3495:1992(Part-I to 4) -1992	Method of test for burnt clay building bricks Part-1 to 4 (Third revision)	10.1.2	IS:1708(Part-2):1986	-do- Determine of specific gravity (Second revision)
7.6	IS:4860:1968	Specification for acid resistant bricks Reaff-1991.	10.1.3	IS:1708(Part-3):1986.	-do- Determination of volumetric Shrinkage.(Second revision)
7.7	IS:5454:1978	Method of sampling of clay building bricks (First revision) Reaff-1995.	10.1.4	IS:1708(Part-4):1986.	-do- Determination of radial and tangential shrinkage and fibre saturation point. (Second revision)
7.8	IS:6165:1992	Dimensions for special shapes of clay bricks (First revision)	10.1.5	IS:1708(Part-5):1986.	-do- Determination of static bending strength under two points loading. (Second revision)
8.00	TILES :		10.1.6	IS:1108(Part-6):1986.	-do- Determination of static bending strength under 2 point loading. (Second revision)
8.1	IS:1237:1980	Specification for cement flooring tiles (First revision) Reaff-1990.	10.1.7	IS:1708(Part-7):1986.	-do- Determination of impact bending strength (Second revision)
8.2	IS:1464:1992	Clay ridge and ceiling tiles specification (Second revision)	10.1.8	IS:1708(Part-8):1986.	-do- Determination of compressive strength parallel to grain (Second revision)
8.3	IS:2690(Part-1&2):1992	Burnt clay flat terracing tiles (Second revision)	10.1.9	IS:1708(Part-9):1986.	-do- Comp. strength perpendicular to grain. (Second revision)
8.4	IS:4457:1982	Specification for ceramic unglazed vitreous acid resisting tile (First revision) Reaff-1990.	10.1.10	IS:1708(Part-10):1986.	-do- Determination of hardness under static identification (Second revision)
9.00	LDPE FILM:		10.1.11	IS:1708(Part-11):1982	-do- Determination of sheer strength parallel to grain (Second revision)
9.1	IS:2508:1984	Low density polythelene films (Second revision) Amed-1, Reaff-1990.	10.1.12	IS:1708(Part-12):1986	-do- Determination of tensile strength parallel top grains. (Second revision)
10.00	TIMBER :		10.1.13	IS:1708(Part-13):1986.	-do- Determination of tensile strength perpendicular to grain (Second revision)
10.1.1	IS:1708(Part-1):1986	Method of testing of small clear specimen of timber Determination of moisture content. (Second revision) Reaff -1991.	10.1.14	IS:1708(Part-14):1986.	-do- Determination of clear age strength parallel to grain. (Second revision)

10.1.15	IS:1708(Part-15):1986.	-do- Determination of Nail screw holding power (Second revision)	12.3	IS:458:1988	Concrete pipes. (Third revision) Amed-2.
			12.4	IS:516:1959	Method test for strength of concrete. Amed-2, Reaff -1991.
10.1.16	IS:1708(Part-16):1986.	-do- Determination of brittleness by Izod impact (Second revision)	12.5	IS:1199:1959	Methods of sampling and analysis of concrete. Reaff - 1991.
10.1.17	IS:1708(Part-17):1986.	-do- Determination of brittleness of carphy impact. (Second revision)			
10.1.18	IS:1708(Part-18):1986.	-do- Determination of torsional strength (Second revision)	12.6	IS:1791:1985	General requirements for batch type concrete mixtures (Second revision.)
			12.7	IS:1834:1984	Hot applied sealing compounds for joints in concrete(First rev.)
10.2	IS:2202(Part-1):1991.	Specification for flush door shutters solid core type) (Fifth revision(Amed – 3.	12.8	1838(Part1.2)1983/1984	Preformed fillers for expansion tests in concrete pavement and structures (non extruding & resitient type)
10.3	IS:2408;1963	Methods of static tests of timber in structural sizes. Amedment-1, Reaff1990.	12.9.1	IS:2185(Part-1):1979.	Specification for concrete for masonry units part-1. Hollow and solid concrete (Second revision) Amed-1, Reaff-1992.
10.4	IS:4970:1973	Key for identification of commercial timber (First revision)	12.9.2	IS:2185(Part-2):1983	Specification for concrete masonry units, Part-2 Hollow and solid light weight concrete blocks (first revision) Reaff-1995.
11.00	ADMIXTURE :		12.9.3	IS:2185(Part-3):1984	Specification for concrete masonry units part-3, Autoclave cellular aerated concrete blocks (First revision) Reaff-1990.
11.1	IS:2645:1975	Specification for integral cement water proofing compound. (First revision) Amed-1, Reaff-1992.	12.10	IS:3085:1965	Methods of tests for permeability of cement mortar and concrete. Reaff-1990.
11.2	IS:9103:1979	Specification for Admixture for concrete (first revision) Reaff-1990.	12.11	IS:3597:1985	Method of testing for concrete pipes. (first revision) Reaff 1990.
12.00	CONCRETE :		12.12	IS:3860:1966	Precast cement concrete slabs for canal linings.
12.1	IS:456:2000	Code of practice for plain and reinforced concrete (Third revision) Amed-2, Reaff.1991.	12.13	IS:3873;1978	Code of practice for laying insitu cement concrete lining on canals (First revision.)
12.2	IS:457:1957	code of practice for general construction of plain and reinforced concrete for dams and other massive structure. Reaff-1991.	12.14	IS:4926;1976	Ready mixed concrete (First revision.)

12.15	IS:4969:1968	Method of test for determining flexural strength of precast cement concrete slabs for canal lining.	16.1	ASTM-C-309-1989	Specificatin for liquid membrane forming compounds for curing concrete.
12.16	IS:9012;1978.	Recommended practice for shotcreting (Reaff - 1987)	16.2	C-156-1989	Test method for water retention by concrete curing material
12.17	IS:10262:1982	Recommanded guideline for concrete mix design. Reaff-1989.	16.3	D- 869 –1985	Method for evaluating degree of settling of paint.
13.00	MASONARY MORTAR :		16.4	D-1309-1988	Test method for settling properties of traffic paint.
13.1	IS:2116:1980	Specification of sand for masonry mortars (First revision) Reaff-1992.	16.5	D-1644-1988	Test methods for non volatile content of varnish
13.2	IS:2250:1981	Code of practice for preparation and use of masonry mortars. (First revision) Reaff-1990.	16.6	E-1347-1990	Test methode for color anf color difference measurements by Tristimulus (filter) Colorimetry.
14.0	Sealing Compound		17.00	PVC Water Stops	
14.1	IS:5256:1968	Code of practice for sealing joints in concrete lining on canals.	17.1	IS:8543(Part-4)-1984	Method of testing plastics.
14.2	IS:13143;1991	Joints in concrete lining of canals-sealing compound – specifications.	17.2	IS:12200-1987	Code of practice for provision of water stops at transverse contraction joints in masonry & concrete dams.
15.0	WATER (For construction)		17.3	ASTM:D:638:1991	Test for tensile properties of plastics
			17.4	ASTM:D:412:1992	Test for rubber properties in tension
15.1	IS:456:2000	Code of practice for plain and reinforced concrete. (Third revision) Amed – 2, Reaff-1991	17.5	ASTM:D:2240:1990	Test for rubber property Durometer hardness
15.2	IS:3025;Part 1,3,9 to 12,14, to 19,21 to 26,32)	Methods of sampling and test (physical and chemical for water and waste water.)			
16.00	CURING				

VOLUME – II (PART-A)
TECHNICAL SPECIFICATIONS-CIVIL WORKS

SECTION-B
TECHNICAL SPECIFICATIONS-CIVIL WORKS (PARTICULAR)

DEWATERING, RIVER DIVERSION AND COFFERDAM WORKS DURING CONSTRUCTION

General

This work shall comprise the design, construction, operation, maintenance and removal of all temporary river diversion, cofferdams, drainage and dewatering systems required for execution of the Cross Regulator-cum-Bridge across River Dhadhar at Village Magnad, Taluka Jambusar, District Bharuch.

The Contractor shall provide all temporary works necessary to keep foundations, excavations, raft foundations, aprons, piers, abutments, guide walls, protection works, embankments, approach roads and all associated works in a safe, stable and dry condition throughout the construction period.

The design and operation of the diversion and dewatering system shall consider:

- River flows and hydraulic conditions of River Dhadhar.
- Tidal fluctuations and backwater effects.
- Groundwater seepage and sub-surface water pressures.
- Monsoon runoff and flood conditions.
- Construction staging and sequencing requirements.
- Safety of existing structures, temporary works and completed works.

The Contractor shall be fully responsible for protection of the Works against flooding, overtopping, seepage, erosion, scour, tidal ingress and all other water-related risks during construction. Any damage arising from inadequate diversion, dewatering, cofferdam failure or negligence shall be repaired by the Contractor at his own cost.

Design and Submittals

Within twenty-one (21) days from the date of Letter of Acceptance, the Contractor shall submit detailed designs, calculations and method statements for approval of the Engineer-in-Charge.

The submission shall include:

- River diversion methodology and construction staging.
- Cofferdam design calculations and drawings.
- Dewatering calculations, anticipated inflows and pumping capacities.
- Layout of pumps, pipelines, drainage channels and sumps.
- Flood handling and emergency response procedures.
- Standby pumping and backup power arrangements.
- Method of collection, treatment and disposal of pumped water.
- Monsoon and tidal protection measures.

Approval by the Engineer-in-Charge shall not relieve the Contractor of responsibility for the adequacy, safety and performance of the proposed arrangements.

Cofferdams and River Diversion

The Contractor shall design and construct suitable cofferdams, diversion channels, temporary bunds or other approved arrangements required for execution of the Works.

The temporary works shall:

- Safely withstand hydraulic, tidal, seepage and construction loads.
- Prevent ingress of river water into working areas.
- Provide adequate protection against erosion and scour.
- Remain stable under anticipated flood and tidal conditions.
- Permit safe construction and inspection of permanent works.

The Contractor shall continuously inspect, monitor and maintain all temporary diversion and cofferdam works throughout the construction period.

Dewatering Operations

The Contractor shall provide and maintain adequate pumps, drainage channels, sumps, pipelines, power supply systems and standby equipment necessary to keep all work areas free from water.

Adequate standby pumps and backup power arrangements shall be available at all times to ensure uninterrupted operation.

Where excavation is carried out below groundwater level, the groundwater table shall be lowered sufficiently below the excavation level to permit safe excavation, foundation preparation and placement of concrete.

Foundation and excavation surfaces shall be maintained free from standing water, softening, disturbance and contamination.

Environmental Protection

All pumped water shall be discharged at approved locations without causing flooding, erosion, siltation, pollution or damage to adjoining properties and watercourses.

Water contaminated with silt, oil, grease or other pollutants shall be treated through settling basins, silt traps, oil separators or other approved methods prior to discharge.

The Contractor shall comply with all applicable environmental regulations and shall ensure that no adverse impact is caused to downstream users, agricultural lands or natural drainage systems.

Flood, Monsoon and Tidal Protection

The Contractor shall continuously monitor river levels, tidal conditions and weather forecasts and shall take all necessary precautions to safeguard the Works during monsoon and flood periods.

Emergency arrangements, including standby pumps, generators, materials, equipment and manpower, shall be maintained throughout the construction period.

Any flooding, erosion, scour, silting or damage occurring prior to completion and handing over of the Works shall be rectified by the Contractor at his own cost without entitlement to

additional payment.

Removal of Temporary Works

Upon completion of the permanent works, all temporary cofferdams, diversion arrangements, drainage systems, dewatering installations, pipelines, sumps and associated facilities shall be removed unless otherwise directed by the Engineer-in-Charge.

All disturbed areas shall be restored to their original or approved condition to the satisfaction of the Engineer-in-Charge.

Measurement and Payment

Measurement and payment shall be made under the relevant item of the Payment Schedule:

"Care and Diversion of River including Cofferdam, Dewatering and all Allied Temporary Works during Construction."

The Contract Price shall include all costs associated with:

- Design and construction of cofferdams and diversion works.
- Dewatering systems and pumping operations.
- Pipelines, drainage channels, sumps and discharge arrangements.
- Standby pumps, generators and backup systems.
- Flood, monsoon and tidal protection measures.
- Environmental protection and treatment of discharge water.
- Inspection, monitoring and maintenance.
- Removal of temporary works and restoration of affected areas.
- All labour, materials, equipment, fuel, power, consumables and incidental works.

Eighty percent (80%) of the payable amount under this item shall be released upon successful completion and operation of the approved river diversion, cofferdam and dewatering arrangements in connection with the permanent works.

The remaining twenty percent (20%) shall be released only after removal of all temporary works, restoration of affected areas and certification by the Engineer-in-Charge.

No separate payment shall be made for modifications, strengthening, repairs, replacement, maintenance, flood damage, tidal damage, additional pumping, emergency measures or any other temporary works required for successful completion of the Works, and all such costs shall be deemed included in the Contract Price.

CONCRETE

GENERAL

(1) This section covers the specifications for materials, equipment, workmanship, testing, quality control, and services related to all concrete works, including formwork, reinforcement support, batching, mixing, transportation, placing, compaction, curing, and finishing required for the EPC work of Construction of Cross Regulator-cum-Bridge on River Dhadhar at Village Magnad, Taluka Jambusar, District Bharuch.

The works include the Cross Regulator Structure, Bridge Structure, Raft Foundation, Upstream and Downstream Aprons, Upstream and Downstream Training/Protection Walls, Guide Bunds, Wing Walls, Retaining Walls, Approach Roads, Flood Protection Works, and all associated appurtenant structures.

(2) The general environment to which the concrete will be exposed during its service life shall be considered as “Severe” exposure condition as per IS 456:2000 or latest revision. All concrete mixes shall be designed considering the specified exposure conditions and durability requirements.

(3) Sulphate Resistant Cement (SRC) conforming to the relevant Indian Standards shall be used for all reinforced concrete and plain cement concrete works unless otherwise approved by the Engineer-in-Charge. The Contractor shall ensure that the cement used is suitable for the aggressive soil and water conditions likely to be encountered at the project site.

(4) The work under this Section includes all labour, materials, equipment, testing facilities, quality assurance measures, transportation, storage, handling, batching, mixing, placing, compaction, curing, finishing, and all incidental works necessary for completion of the concrete works. Dewatering required for foundation concreting, raft foundations, walls, bridge substructures, approaches, and associated structures shall be deemed included in the quoted rates.

(5) Approval by the Engineer-in-Charge of the Contractor’s materials, equipment, plants, methods of construction, or workmanship shall not relieve the Contractor of his responsibility for the quality, safety, durability, and satisfactory performance of the completed works.

STANDARDS

(1) Unless otherwise specified, all materials, workmanship, testing, and construction practices shall conform to the latest editions of relevant Indian Standards, IRC Codes, Ministry of Road Transport and Highways (MoRTH) Specifications, and Central Water Commission (CWC) guidelines.

(2) The following standards shall apply:

IS 456 – Plain and Reinforced Concrete – Code of Practice

IS 383 – Coarse and Fine Aggregates for Concrete

IS 2386 – Methods of Test for Aggregates

IS 516 – Methods of Tests for Strength of Concrete

IS 1199 – Sampling and Analysis of Concrete

IS 457 – General Construction of Plain and Reinforced Concrete for Dams and Massive Structures

IS 9103 – Concrete Admixtures

IS 7861 (Part-I) – Hot Weather Concreting

IS 2505 – Concrete Vibrators

IS 14591 – Temperature Control of Mass Concrete

Relevant Indian Standard for Sulphate Resistant Cement (SRC)

IRC Codes and MoRTH Specifications applicable to bridge works

(3) In the absence of relevant Indian Standards, the recommendations of ACI Manual of Concrete Practice and USBR Concrete Manual shall apply.

SUBMITTALS

Submission Before Construction

(1) Before commencement of any concrete work, the Contractor shall submit for approval detailed plans, drawings, calculations, specifications, quality assurance procedures, and method statements relating to:

- a) Aggregate Processing and Storage System
- b) Batching and Mixing Plant
- c) Concrete Transportation and Placement System
- d) Concrete Compaction and Curing Methodology
- e) Quality Control Laboratory and Testing Equipment
- f) Mix Design Reports for all grades of concrete
- g) Source and Quality Certificates of Sulphate Resistant Cement (SRC)
- h) Construction Methodology and Sequence of Concreting

(2) The Contractor shall submit details of:

- a) Source and manufacturer of Sulphate Resistant Cement (SRC)
- b) Proposed admixtures and supplementary cementitious materials
- c) Proposed formwork materials and construction joint treatment methods
- d) Concrete mix designs for all grades
- e) Quality Control and Quality Assurance Plan

(3) No concrete work shall commence until the submitted documents have been reviewed and approved by the Engineer-in-Charge.

Submissions During Construction

(1) Prior to each concrete pour, a pre-concreting checklist covering excavation, dewatering, formwork, reinforcement, embedded items, construction joints, and cleanliness shall be submitted to and approved by the Engineer-in-Charge.

(3) The Contractor shall maintain complete records of all concrete works including:

- a) Date and time of batching and placement

- b) Location and quantity of concrete placed
- c) Source and quantity of cement, aggregates, admixtures, and water
- d) Concrete temperature and ambient temperature
- e) Weather conditions
- f) Slump test results and cube test results
- g) Any special procedures adopted during concreting

(4) All records shall be maintained at site and made available for inspection by the Engineer-in-Charge at all times.

CONSTITUENTS OF CONCRETE

1 Cement

- (1) All concrete works shall be executed using Sulphate Resisting Cement (SRC) conforming to the relevant Indian Standards and approved by the Engineer-in-Charge.
- (2) The cement shall be procured only from approved manufacturers and shall comply with all requirements regarding strength, soundness, setting time, and durability.
- (3) Cement shall be obtained directly from the manufacturer. The Contractor shall identify at least two approved manufacturing sources to ensure uninterrupted supply during the execution period.
- (4) Each consignment of cement delivered to the Site shall be accompanied by the manufacturer's test certificate. The Engineer-in-Charge may independently sample and test any consignment at any stage.
- (5) Cement that does not comply with the specified requirements or has deteriorated during manufacture, transportation, handling, or storage shall be rejected and removed from the Site immediately.
- (6) Cement shall be stored in weatherproof godowns or approved silos, protected from moisture and contamination. Separate storage shall be maintained for different consignments.
- (7) Cement shall be used on a First-In-First-Out (FIFO) basis. Storage duration shall not exceed 30 days for bagged cement and 60 days for bulk cement unless otherwise approved by the Engineer-in-Charge.
- (8) Fly Ash, Pozzolanic Materials, Mineral Admixtures, or Supplementary Cementitious Materials shall not be used unless specifically approved by the Engineer-in-Charge and incorporated in the approved mix design.
- (9) The Contractor shall maintain sufficient stock of approved cement to ensure uninterrupted progress of the Works.

Aggregates

General

- (1) Aggregates shall conform to IS 383, IS 456, IS 2386 and other relevant Indian Standards.
- (2) Only hard, durable, clean, machine-crushed stone aggregates obtained from approved quarries shall be used for concrete works.

- (3) Aggregates shall be free from clay, silt, organic matter, salts, shale, mica, coal, lignite, soft fragments, and other deleterious materials that may adversely affect the strength or durability of concrete.
- (4) Particular attention shall be given to chloride and sulphate contents due to the saline and aggressive environmental conditions likely to be encountered at the project site. Aggregates exceeding permissible limits shall not be used.
- (5) Aggregate production, crushing, screening, washing, grading, storage, and handling shall be carried out in a manner approved by the Engineer-in-Charge.
- (6) Aggregates shall be stored separately according to size and shall be protected against contamination and segregation.
- (7) The Engineer-in-Charge may reject any source, quarry, or stockpile found unsuitable, notwithstanding previous approval.

Fine Aggregate

- (1) Fine aggregate shall consist of clean, hard, durable natural river sand conforming to IS 383.
- (2) Fine aggregate shall conform to Grading Zone-II unless otherwise approved by the Engineer-in-Charge.
- (3) Manufactured Sand (M-Sand) shall not be used without prior approval of the Engineer-in-Charge.
- (4) The maximum particle size of fine aggregate shall be 4.75 mm.
- (5) The fineness modulus shall generally be between 2.6 and 3.2.
- (6) Fine aggregate shall be free from harmful salts, organic impurities, and deleterious materials and shall comply with the requirements of IS 383.
- (7) Fine aggregate shall have a specific gravity not less than 2.60.
- (8) Moisture content shall be regularly monitored and suitable corrections shall be made in the approved mix design.

Coarse Aggregate

- (1) Coarse aggregate shall consist of hard, durable crushed stone retained on the 4.75 mm sieve and shall conform to IS 383.
- (2) Coarse aggregate shall be stored separately in the following size fractions:
 - a) 4.75 mm to 10 mm
 - b) 10 mm to 20 mm
- (3) The nominal maximum size of coarse aggregate shall be 20 mm for all reinforced concrete and hydraulic components unless otherwise approved by the Engineer-in-Charge.
- (4) Coarse aggregate shall comply with the deleterious material limits specified in IS 383.
- (5) Coarse aggregates shall satisfy the following requirements:

Property	Requirement
Aggregate Crushing Value	Not more than 30%

Aggregate Impact Value	Not more than 30%
Los Angeles Abrasion Value	Not more than 35%

- (6) The loss in weight during soundness testing using sodium sulphate solution shall not exceed 12% after five cycles.
- (7) Coarse aggregate shall have specific gravity not less than 2.50 and water absorption not more than 2.0%.
- (8) Aggregate delivered to the batching plant shall have uniform and stable moisture content.
- (9) The nominal maximum aggregate size shall not exceed:
- One-fifth of the narrowest dimension between form faces;
 - Three-fourths of the minimum clear spacing between reinforcement bars;
 - One-fourth of the slab thickness.
- (10) Aggregates proposed for use in concrete exposed to tidal water, sulphate-bearing soil, or aggressive environmental conditions shall be tested for chloride content, sulphate content, alkali-aggregate reactivity, and durability characteristics before approval by the Engineer-in-Charge.

Aggregate Storage

- (1) Aggregates shall be stored separately according to size in free-draining stockpiles on hard, clean, and properly prepared surfaces so as to minimize contamination, segregation, breakage, and deterioration. The storage arrangement shall be subject to approval by the Engineer-in-Charge.
- (2) Separate stockpiles shall be maintained for 4.75 mm to 10 mm and 10 mm to 20 mm coarse aggregates and for fine aggregates.
- (3) The Contractor shall maintain sufficient aggregate stocks at Site to ensure uninterrupted production and placement of concrete in accordance with the approved construction programme.
- (4) Aggregate stockpiles shall be adequately drained and managed to maintain reasonably uniform moisture content. Water stagnation around stockpiles shall not be permitted.
- (5) The preparation of stockpile areas, storage arrangements, and disposal of rejected materials shall be subject to approval by the Engineer-in-Charge.
- (6) Aggregates shall be withdrawn from stockpiles in a manner that minimizes segregation and degradation. Fine aggregate from the bottom 500 mm of any stockpile shall not be used for concrete production.
- (7) Aggregates contaminated by soil, clay, organic matter, saline water, or any other deleterious material shall be rejected and removed from the Site.

Water

- (1) The Contractor shall make his own arrangements for obtaining, storing, treating, and supplying water required for concrete production, curing, testing, and all associated works. The cost of such arrangements shall be deemed included in the Contract rates.

(2) Water used for washing aggregates, batching, mixing, curing, and testing of concrete shall conform to IS 456 and shall be clean and free from harmful quantities of oils, acids, alkalis, salts, sugars, organic matter, or other deleterious substances.

(3) Considering the saline and aggressive environmental conditions of the project area, special care shall be taken to ensure that water used in concrete production does not contain excessive chlorides or sulphates.

(4) Water shall satisfy the following limits unless more stringent requirements are specified in relevant Indian Standards:

a) Sulphates (as SO_4): Not more than 1000 mg/l

b) Chlorides (as Cl): Not more than 500 mg/l for reinforced concrete and 200 mg/l for prestressed concrete

c) pH Value: Between 6.0 and 8.5

d) Organic impurities: Within permissible limits of IS 456

(5) Water from tidal channels, estuaries, saline sources, or brackish water bodies shall not be used for concrete production or curing.

(6) Adequate storage facilities shall be provided at the batching plant to ensure uninterrupted concrete production.

(7) Where required, settling tanks, filtration systems, or treatment facilities shall be provided by the Contractor at his own cost.

Admixtures

(1) Admixtures shall be used only with prior written approval of the Engineer-in-Charge and shall conform to IS 9103 or equivalent internationally accepted standards.

(2) Admixtures shall be compatible with Sulphate Resisting Cement (SRC), reinforcement steel, and the approved concrete mix design.

(3) The following admixtures may be used with prior approval of the Engineer-in-Charge:

a) High Range Water Reducing Admixtures (Superplasticizers)

b) Air Entraining Admixtures

c) Accelerating Admixtures

d) Corrosion Inhibiting Admixtures

e) Waterproofing Admixtures

f) Shrinkage Reducing Admixtures

(4) Admixtures containing chlorides shall not be permitted in any reinforced concrete, prestressed concrete, or mass concrete work.

(5) Admixtures shall be stored, handled, and dispensed strictly in accordance with the manufacturer's recommendations.

(6) The dosage of admixtures shall be established through laboratory trials and approved mix designs. No change in dosage shall be made without prior approval of the Engineer-in-Charge.

(7) The Contractor shall demonstrate through trial mixes that the proposed admixtures achieve the required workability, strength, permeability, durability, and setting characteristics.

(8) The Contractor shall be fully responsible for the performance of admixtures and any adverse effects resulting from their use. No additional payment or extension of time shall be granted on account of difficulties arising from the selection or use of admixtures.

CONCRETE MIX DESIGN

General

(1) Concrete grades shall be designated in accordance with IS 456 and IS 10262 based on the characteristic compressive strength of standard 150 mm cubes at 28 days, expressed in N/mm².

(2) The characteristic compressive strength shall be determined and evaluated in accordance with IS 516 and IS 456.

(3) The project environment shall be considered as **Severe Exposure Condition** in accordance with Clause 8 of **IS 456:2000**. Accordingly, all concrete used in the Works shall be designed and produced to satisfy the durability, strength, impermeability and service life requirements applicable to severe exposure conditions.

The minimum grade of concrete for the **main structural components of the Cross Regulator-cum-Bridge**, including piers, abutments, deck slab, girders, bridge substructure and superstructure elements, regulator piers, gate supporting members and other primary load-carrying structural components, shall be **M30** grade concrete.

For other components of the Works, the minimum grades of concrete shall be as follows:

Component	Minimum Grade of Concrete
Plain Cement Concrete (PCC)	M15
Protection Walls	M25
Hydraulic Components and Non-Structural Concrete	M25
Upstream and Downstream Aprons	M30
Cut-off Walls	M30
Main Structural Components of Cross Regulator-cum-Bridge	M30

(4) All concrete shall be produced using **Sulphate Resisting Cement (SRC)** and designed to achieve the specified strength, durability, impermeability, and service life requirements.

(5) The maximum water-cement ratio for reinforced concrete exposed to severe environmental conditions shall not exceed **0.45**.

(6) Minimum cement contents shall not be less than those specified by the Narmada Water Resources, Water Supply and Kalpsar Department vide letter No. MICell-102010/17/K-1 dated 30.07.2018 or latest applicable departmental instructions.

Grade	Maximum Aggregate Size	Minimum Cement Content (kg/m ³)
M15	20 mm	300
M20	20 mm	360
M25	20 mm	380
M30	20 mm	410
M35	20 mm	425
M40	20 mm	440
M45	20 mm	450

(7) The minimum cement contents specified above are for bid evaluation and reference purposes only. Concrete mix designs for all grades shall be tested through GERI or any Government-approved laboratory as directed by the Engineer-in-Charge.

The Contractor shall adopt the cement content recommended in the approved mix design. Where the approved cement content is lower than the specified reference cement content, recovery shall be made for the difference at the rate of **Rs. 5.234 per kg of cement** based on the actual quantity of concrete executed.

Where the approved mix design requires cement content higher than the specified reference cement content, **no additional payment shall be made** for the excess cement consumed.

No claim for extra payment, compensation, or rate revision shall be entertained on account of the cement content adopted in the approved mix design.

(8) Prior to commencement of concrete works, the Contractor shall carry out laboratory trial mixes for each grade of concrete using the actual materials proposed for use in the Works.

(9) The mix design programme shall include determination of:

- a) Cement characteristics;
- b) Aggregate properties and grading;
- c) Water quality;
- d) Admixture characteristics;
- e) Aggregate proportions;
- f) Water-cement ratio;
- g) Workability;
- h) Density;
- i) Compressive strength;
- j) Permeability and watertightness;
- k) Durability characteristics;
- l) Chloride and sulphate resistance.

(10) Trial mixes shall be prepared using a computerized batching plant or equivalent approved equipment and shall demonstrate compliance with specified requirements for strength, workability, durability, and impermeability.

(11) Sampling, testing, acceptance criteria, and evaluation of concrete shall conform to IS 1199, IS 516, and IS 456.

(12) The mix design for each grade of concrete shall be got tested and approved through GERI or any Government-approved laboratory as directed by the Engineer-in-Charge.

(13) No concrete shall be placed until the mix design has been approved by the Engineer-in-Charge.

(14) During execution, the Engineer-in-Charge may require modification of approved mix proportions to improve strength, workability, durability, impermeability, economy, or constructability. Any such modification shall be supported by fresh trial mix results.

(15) The Contractor shall not alter any approved mix design without prior written approval of the Engineer-in-Charge.

(16) The quantity of mixing water shall be adjusted to account for aggregate moisture content. Under no circumstances shall the approved maximum water-cement ratio be exceeded.

(17) Slump values shall conform to IS 456 and shall be suitable for the method of transportation, placement, compaction, and the type of structure being concreted.

(18) For any pile foundations, if adopted in the approved design, concrete grade, slump, and other requirements shall conform to the latest applicable IRC provisions.

QUALITY CONTROL

General

(1) The Contractor shall establish and implement a comprehensive Quality Assurance and Quality Control (QA/QC) Programme for all concrete works, materials, workmanship, testing, inspection, and documentation required under the Contract.

(2) The Contractor shall be solely responsible for ensuring that all materials and workmanship comply with the requirements of the Contract Specifications, relevant Indian Standards, approved drawings, and instructions of the Engineer-in-Charge.

(3) Detailed records of all inspections, tests, calibrations, approvals, and quality control activities shall be maintained at Site and made available to the Engineer-in-Charge whenever required.

(4) Any proposed change in the approved Quality Control Programme shall be submitted to the Engineer-in-Charge at least fourteen (14) days in advance for approval.

(5) In addition to the Contractor's quality control testing, the Engineer-in-Charge, PMC, and/or Third-Party Inspection Agency (TPI) may carry out independent inspections, sampling, and testing at any time. The Contractor shall provide all necessary assistance, labour, equipment, materials, access, and records required for such inspections and testing.

(6) If test results indicate that materials, equipment, manufacturing processes, batching operations, or construction methods are not producing the specified quality, the Contractor shall immediately take corrective measures at his own cost and repeat the tests as directed by the Engineer-in-Charge.

(7) The Contractor shall ensure calibration of all testing equipment at regular intervals through NABL accredited laboratories or other laboratories approved by the Engineer-in-Charge.

Site Laboratory

- (1) The Contractor shall establish, equip, staff, operate, and maintain a fully functional Site Laboratory throughout the Contract Period. The laboratory shall be capable of carrying out all routine tests required for quality control of concrete and construction materials.
- (2) The laboratory shall be manned by qualified and experienced personnel and shall remain available for inspection and use by the Engineer-in-Charge, PMC, and TPI personnel.
- (3) Where specialized testing facilities are not available at Site, such tests shall be carried out at GERI, NABL Accredited Laboratories, Government Approved Laboratories, or other laboratories approved by the Engineer-in-Charge.
- (4) The laboratory shall maintain registers for material receipts, test reports, calibration records, concrete cube registers, inspection reports, and quality control records.
- (5) Suitable arrangements shall be made for curing and storage of concrete cubes under controlled conditions as specified in the relevant Indian Standards.
- (6) All quality records shall form part of the completion documentation and shall be submitted to the Engineer-in-Charge before issue of the Completion Certificate.

Concrete Sampling and Testing

Aggregates

- (1) Aggregate samples shall be collected from stockpiles, bins, conveyor belts, or batching plant storage facilities in accordance with IS 2430 and IS 2386.
- (2) Aggregate testing shall be carried out prior to commencement of work, whenever the source changes, and thereafter at frequencies approved by the Engineer-in-Charge.
- (3) The following tests shall be conducted:
 - a) Sieve Analysis
 - b) Specific Gravity
 - c) Water Absorption
 - d) Flakiness and Elongation Index
 - e) Aggregate Crushing Value
 - f) Aggregate Impact Value
 - g) Los Angeles Abrasion Value
 - h) Soundness Test
 - i) Organic Impurities Test
 - j) Moisture Content
 - k) Chloride and Sulphate Content, where required

Cement

- (1) All Sulphate Resisting Cement (SRC) shall be procured from approved manufacturers and shall be accompanied by manufacturer's test certificates for each lot.
- (2) The Engineer-in-Charge may independently sample and test cement at any stage.
- (3) Cement testing at Site shall include:
 - a) Fineness

- b) Standard Consistency
- c) Initial and Final Setting Time
- d) Soundness
- e) Compressive Strength

(4) Any cement failing to comply with relevant Indian Standards shall be rejected and removed from the Site.

Admixtures

(1) All admixtures shall conform to IS 9103 and shall be approved by the Engineer-in-Charge before use.

(2) Compatibility of admixtures with Sulphate Resisting Cement (SRC) shall be demonstrated through trial mixes.

(3) Each batch of admixture shall be accompanied by manufacturer's test certificates.

(4) Admixtures exceeding the manufacturer's recommended shelf life shall not be used.

Water

(1) Water used for concrete production and curing shall conform to IS 456.

(2) Water samples shall be tested before commencement of work or whenever the source or season changes.

(3) Water shall be tested for:

- a) pH Value
- b) Chloride Content
- c) Sulphate Content
- d) Total Dissolved Solids
- e) Organic Impurities

Fresh Concrete

(1) Fresh concrete shall be tested for:

- a) Slump
- b) Concrete Temperature
- c) Density, where required

(2) Slump tests shall be conducted:

- a) At the commencement of each concreting operation;
- b) Whenever the mix proportions are altered;
- c) As directed by the Engineer-in-Charge.

(3) Slump values shall conform to the approved mix design and IS 456 requirements.

(4) Concrete temperature shall be monitored during hot weather concreting in accordance with IS 7861.

Hardened Concrete

(1) Concrete cube samples shall be prepared, cured, and tested in accordance with IS 1199 and IS 516.

- (2) A minimum of one sample consisting of six cubes shall be taken from each grade of concrete as per IS-456.
- (3) The six cubes shall normally be tested as follows:
 - a) Three cubes at 7 days;
 - b) Three cubes at 28 days.
- (4) Additional cubes may be cast for durability, acceptance testing, or investigation purposes as directed by the Engineer-in-Charge.
- (5) Evaluation of compressive strength results shall be carried out in accordance with IS 456.
- (6) If test results indicate non-compliance, the Engineer-in-Charge may direct Core Tests, Rebound Hammer Tests, Ultrasonic Pulse Velocity Tests, Load Tests, or any other investigation deemed necessary.

Analysis of Results

- (1) The Contractor shall maintain complete records of all material tests, fresh concrete tests, and hardened concrete tests.
- (2) Daily, weekly, and monthly quality control reports shall be submitted to the Engineer-in-Charge.
- (3) Reports shall include:
 - a) Material Test Results;
 - b) Concrete Production Records;
 - c) Slump Test Results;
 - d) Cube Strength Results;
 - e) Non-Conformance Reports;
 - f) Corrective Actions Taken.

Concrete Batching Plant

- (1) All concrete shall be produced in a computerized weigh batching plant approved by the Engineer-in-Charge.
- (2) The batching plant shall be calibrated before commencement of work and thereafter at intervals not exceeding three months or or at such frequency as recommended by the manufacturer, or as directed by the Engineer-in-Charge, whichever is more stringent.
- (3) Weighing systems for cement, aggregates, water, and admixtures shall maintain an accuracy within $\pm 1\%$ of the specified quantity.
- (4) Calibration certificates shall be maintained at Site and made available for inspection.
- (5) Production records generated by the batching plant shall be preserved throughout the Contract Period and submitted whenever required by the Engineer-in-Charge.

BATCHING AND MIXING

General

- (1) All concrete shall be produced in a fully automatic computerized weigh batching plant approved by the Engineer-in-Charge. The batching plant shall have adequate capacity to meet

the approved construction programme and shall be capable of producing uniform quality concrete of the specified grades.

(2) Cement, water, fine aggregate, coarse aggregate, and admixtures shall be measured separately by weight, except liquid admixtures which may be measured by weight or volume as recommended by the manufacturer and approved by the Engineer-in-Charge.

(3) The accuracy of batching equipment shall comply with IS 4925 and shall not vary by more than the following permissible limits:

Material	Permissible Accuracy
Cement	±1%
Water	±1%
Aggregates	±2%
Admixtures	±1%

(4) Volume batching shall not be permitted for any structural or non-structural concrete work.

(5) The batching plant shall be calibrated before commencement of the Works and thereafter at intervals not exceeding three (3) months, or at such frequency as recommended by the manufacturer or directed by the Engineer-in-Charge, whichever is more stringent.

(6) The Contractor shall maintain calibration records and make them available for inspection by the Engineer-in-Charge at all times.

Automatic Batching Equipment

(1) The batching plant shall conform to IS 4925 and shall be equipped with computerized controls, automatic weighing systems, moisture correction facilities, and batch recording devices.

(2) The batching system shall be capable of storing and producing multiple approved concrete mix designs without manual resetting of weighing equipment.

(3) The plant shall automatically record the quantities of cement, water, aggregates, admixtures, batch time, and concrete grade for every batch produced.

(4) Moisture correction equipment shall be provided for aggregates, and automatic adjustments shall be incorporated in the batching system to maintain the approved water-cement ratio.

(5) Admixture dispensing equipment shall be automatic, accurate, and interlocked with the batching sequence to ensure correct dosage for each batch.

(6) The batching plant shall be provided with adequate storage silos for Sulphate Resisting Cement (SRC), aggregate bins, water storage facilities, and admixture tanks.

(7) Separate storage arrangements shall be provided for different aggregate sizes to prevent contamination and segregation.

(8) The batching and mixing operations shall be interlocked so that a new batch cannot

commence until the previous batch has been completely discharged.

(9) All batching data shall be electronically recorded and preserved throughout the Contract Period. Copies of production records shall be submitted to the Engineer-in-Charge whenever required.

(10) Suitable communication facilities shall be maintained between the batching plant and the concreting locations to ensure proper coordination of production, transportation, and placement operations.

(11) The weighing and recording systems shall be installed on stable foundations and protected from vibration, dust, moisture, and other factors that may affect their accuracy.

(12) The Engineer-in-Charge shall have unrestricted access to all batching plant records, calibration certificates, software-generated reports, and production data at any time.

Mixing

(1) Concrete shall be mixed in approved fully automatic batching and mixing plants conforming to IS 4925. The mixing equipment shall be maintained in clean and efficient working condition throughout the Contract Period.

(2) Mixing blades, liners, and other wear parts shall be inspected regularly and replaced whenever wear affects the uniformity and efficiency of mixing.

(3) Transit mixers may be used for transportation of concrete from the batching plant to the placement location. Concrete shall not be mixed manually under any circumstances except for minor emergency works specifically approved by the Engineer-in-Charge.

(4) The mixing equipment shall be capable of producing homogeneous concrete of uniform consistency, workability, strength, and durability without segregation.

(5) Cement, aggregates, water, and admixtures shall be introduced into the mixer in a sequence recommended by the manufacturer and approved by the Engineer-in-Charge.

(6) The quantity of concrete in any batch shall not exceed the rated capacity of the mixer.

(7) Mixing time shall be as recommended by the manufacturer and demonstrated during trial mixes to produce uniform concrete complying with the approved mix design requirements. The Engineer-in-Charge may require an increase in mixing time if uniformity is not achieved.

(8) Mixers shall operate at the rotational speed specified by the manufacturer.

(9) Each mixer shall be provided with automatic timing and batch recording devices to ensure proper control of mixing operations.

(10) The operator shall have adequate visibility and control over batching, mixing, and discharge operations.

(11) Any mixer that fails to produce concrete of the specified quality shall be immediately repaired, recalibrated, or replaced as directed by the Engineer-in-Charge.

(12) Mixers, hoppers, chutes, and associated equipment shall be cleaned at regular intervals and at the end of each working shift to prevent accumulation of hardened concrete and contamination.

(13) Concrete shall be transported and placed within the time limits specified in IS 456 and the manufacturer's recommendations. Transportation and handling shall prevent segregation, loss of workability, and contamination.

(14) No additional water, cement, aggregate, or admixture shall be added to the concrete after discharge from the batching plant without the prior written approval of the Engineer-in-Charge.

(15) Re-tempering of concrete by addition of water after batching shall not be permitted.

(16) Concrete production shall not commence unless all arrangements for placement, compaction, curing, quality control, reinforcement, embedded items, formwork, and access have been inspected and approved by the Engineer-in-Charge.

(17) The Contractor shall provide at least twenty-four (24) hours' notice prior to commencement of any major concreting operation and obtain written permission from the Engineer-in-Charge.

(18) During hot weather concreting, special precautions shall be taken in accordance with IS 7861 to control concrete temperature, prevent rapid evaporation, and maintain the specified quality of concrete.

CONVEYING OF CONCRETE

(1) The Contractor shall be responsible for the selection, operation, and maintenance of all equipment and methods used for conveying concrete from the batching plant to the final place of deposition. The proposed conveying system shall be submitted to the Engineer-in-Charge for review and approval prior to commencement of concreting operations.

(2) Concrete shall be transported by transit mixers, concrete pumps, boom placers, crane-mounted buckets, dumpers, or other approved means in such a manner that segregation, contamination, excessive loss of workability, and loss of mortar are prevented.

(3) The time between the addition of water to the mix and the placement of concrete shall comply with the provisions of IS 456 and the recommendations of the approved concrete mix design.

(4) Concrete shall be conveyed continuously and efficiently to ensure uninterrupted placement and proper compaction.

(5) Conveying equipment shall be of adequate capacity and maintained in good working condition to ensure a uniform supply of concrete at the placement location.

(6) Chutes may be used only with the approval of the Engineer-in-Charge and shall be designed to prevent segregation of concrete. The slope, length, and arrangement of chutes shall ensure continuous flow without separation of constituents.

(7) Concrete shall not be allowed to fall freely from a height exceeding 1.5 m unless suitable arrangements such as tremie pipes, elephant trunks, hoppers, pump delivery lines, or other approved devices are used to prevent segregation and displacement of reinforcement.

(8) Flexible elephant trunks, tremie pipes, or similar approved devices shall be used wherever required to control the placement of concrete and avoid segregation.

(9) Buckets used for transporting and placing concrete shall be watertight, properly designed,

and fitted with suitable discharge arrangements to ensure controlled placement.

(10) Conveying equipment shall be supported independently of formwork and reinforcement unless specifically approved by the Engineer-in-Charge.

(11) All conveying equipment, including transit mixers, pumps, pipelines, buckets, chutes, hoppers, and delivery systems, shall be cleaned regularly and kept free from hardened concrete, debris, and foreign materials.

(12) Concrete pumps and pipelines shall be operated and maintained in accordance with the manufacturer's recommendations. Suitable arrangements shall be made to avoid blockage and interruption during concreting operations.

(13) During transportation and placement, concrete temperature, workability, and quality shall be maintained within the limits specified in the approved mix design and relevant Indian Standards.

(14) The Contractor shall provide adequate standby equipment and arrangements to ensure continuity of concrete placement in the event of equipment breakdown.

PLACING OF CONCRETE

General

(1) Concrete shall be placed only after obtaining approval from the Engineer-in-Charge for the readiness of formwork, reinforcement, embedded items, construction joints, and other related works. Concrete placed without approval may be rejected and removed at the Contractor's cost.

(2) All concrete placement operations shall be carried out under the supervision of qualified site engineers and in the presence of the Engineer-in-Charge or his authorized representative.

(3) Adequate communication facilities shall be maintained between the batching plant, transit mixers, pump operators, and concrete placing crew throughout the concreting operation.

(4) Concrete shall be placed and compacted as rapidly as practicable after mixing and within the permissible time limits specified in IS 456. The concrete shall be placed before the commencement of initial setting and without causing segregation or loss of workability.

(5) Concrete shall be deposited as nearly as practicable in its final position and shall not be subjected to excessive handling or rehandling.

(6) The free fall of concrete shall not exceed 1.5 m unless suitable arrangements such as elephant trunks, tremie pipes, chutes, or other approved devices are used to prevent segregation.

(7) Concreting shall not be carried out during adverse weather conditions that may impair the quality, placement, compaction, finishing, or curing of concrete. During hot weather, suitable precautions shall be taken in accordance with IS 7861.

(8) The Contractor shall ensure continuous supply, placement, compaction, and finishing of concrete to avoid the formation of unintended construction joints.

Preparation for Concrete Placing

(1) Concrete shall not be placed until formwork, reinforcement, inserts, embedded parts,

water stops, sleeves, anchor bolts, and other embedded items have been inspected and approved by the Engineer-in-Charge.

(2) All formwork, reinforcement, previously cast concrete surfaces, and embedded components shall be thoroughly cleaned and made free from dirt, dust, oil, grease, loose rust, laitance, standing water, and other deleterious materials.

(3) All excavations, foundations, and surfaces receiving concrete shall be properly prepared, trimmed, compacted, and approved by the Engineer-in-Charge before concreting commences.

(4) Dewatering arrangements shall be maintained to ensure that no water enters the area where concrete is being placed. Concrete shall not be placed in standing or flowing water unless specifically approved by the Engineer-in-Charge.

(5) Pipes, conduits, inserts, dowels, anchor bolts, and other embedded items shall be accurately positioned and securely fixed prior to concreting. Adequate clear cover and spacing shall be maintained to permit proper placing and compaction of concrete.

(6) Where shown on the approved drawings or directed by the Engineer-in-Charge, a blinding layer of PCC of specified grade and thickness shall be provided before placing structural concrete.

(7) Immediately before concreting, all contact surfaces shall be cleaned and brought to the required condition to ensure proper bond between concrete and adjoining surfaces.

(8) Adequate manpower, vibrators, standby vibrators, concrete pumps, transit mixers, lighting arrangements, and all necessary equipment shall be available prior to commencement of concreting operations.

(9) Suitable protective arrangements such as tarpaulins, covers, or shelters shall be kept readily available to protect freshly placed concrete from rain, excessive heat, wind, or other adverse weather conditions.

(10) Before placing fresh concrete against previously hardened concrete, the existing concrete surface shall be prepared in accordance with the requirements specified under "Construction Joints".

(11) A pre-concreting checklist covering formwork, reinforcement, embedded items, cover blocks, construction joints, dewatering arrangements, equipment readiness, and quality control requirements shall be completed and approved by the Engineer-in-Charge before commencement of concrete placement.

Placing and Compaction of Concrete

(1) Concrete shall be carefully placed in its designated position to avoid segregation, displacement of reinforcement, embedded items, water stops, and formwork. The free fall of concrete shall not exceed 1.5 m unless approved methods such as elephant trunks, tremie pipes, or suitable chutes are used.

(2) Concrete shall be deposited as nearly as practicable in its final position and shall not be moved laterally by vibrators or other means that may cause segregation.

- (3) Addition of water to concrete after batching or during placement for improving workability shall not be permitted. Any adjustment in workability shall be achieved only through approved mix design modifications or admixtures.
- (4) Concrete shall be placed in successive horizontal layers of suitable thickness to ensure proper compaction and monolithic action. The thickness of each layer shall generally not exceed 300 mm to 450 mm depending upon reinforcement congestion, vibrator capacity, and placement conditions.
- (5) Each layer shall be placed and compacted before the underlying layer has commenced initial setting so that proper bonding between layers is achieved and cold joints are avoided.
- (6) If interruption in concreting results in the formation of a construction joint, further concreting shall be carried out only after preparation and approval of the joint surface by the Engineer-in-Charge.
- (7) No concrete shall be placed in standing or flowing water unless specifically approved by the Engineer-in-Charge and appropriate methods are adopted to prevent washout of cement and segregation.
- (8) Concrete shall be compacted immediately after placement using approved immersion-type mechanical vibrators conforming to IS 2505.
- (9) Vibrators shall operate at frequencies recommended by the manufacturer and shall be capable of producing dense, homogeneous, and void-free concrete.
- (10) Adequate numbers of vibrators, including standby units in working condition, shall be available at all times during concreting operations.
- (11) Vibrators shall be inserted vertically at regular intervals and shall penetrate into the previously placed layer to ensure proper bonding between successive layers.
- (12) Vibration shall be continued only for the time necessary to achieve full compaction without causing segregation, excessive bleeding, or displacement of reinforcement and embedded items.
- (13) Vibrators shall not be used for transporting concrete within the forms.
- (14) Particular care shall be taken while concreting around reinforcement, water stops, embedded parts, anchor bolts, gate groove inserts, and other congested locations to ensure complete compaction and elimination of honeycombing.
- (15) Concrete surfaces shall be free from honeycombing, segregation, excessive air voids, laitance, and other defects. Any defective concrete identified by the Engineer-in-Charge shall be repaired or replaced at the Contractor's cost.
- (16) Suitable steel formwork or high-quality shuttering plywood supported on adequately designed staging shall be used to achieve the specified line, level, dimensions, surface finish, and tolerances.
- (17) Concreting operations shall be planned and executed in a manner that ensures continuous placement, proper compaction, and uniform quality of concrete throughout the structure.

(18) Special care shall be exercised during hot weather concreting and curing in accordance with IS 7861 to maintain the required concrete quality and durability under severe exposure conditions.

Pumping of Concrete

(1) Concrete may be placed by means of concrete pumps, boom placers, or other approved pumping systems. The type, capacity, and arrangement of pumping equipment shall be subject to approval by the Engineer-in-Charge and shall be operated only by trained and experienced personnel.

(2) The pumping system shall be designed and operated to ensure continuous delivery of concrete without segregation, blockage, excessive pressure fluctuations, or loss of workability.

(3) Concrete shall be discharged into the forms at a controlled rate and velocity to avoid segregation, displacement of reinforcement, embedded items, water stops, and formwork.

(4) Concrete pumps, pipelines, bends, couplings, hoses, and all associated equipment shall be maintained in good working condition throughout the execution of the Works.

(5) All pumping equipment shall be thoroughly cleaned after completion of each concreting operation or whenever concreting is interrupted for a period likely to cause setting of concrete within the pipeline.

(6) Pump lines shall consist of steel pipes, heavy-duty rubber hoses, or other approved materials suitable for concrete pumping. All joints and couplings shall be leak-proof and capable of safely withstanding the operating pressure.

(7) Aluminium pipelines shall not be used for pumping concrete.

(8) Prior to commencement of pumping operations, the pump and pipeline shall be lubricated using cement slurry, mortar, or other approved priming material in accordance with the pump manufacturer's recommendations.

(9) Concrete mix proportions shall be suitable for pumping and shall be established through approved mix design trials.

(10) Pumping operations shall be planned to ensure uninterrupted concrete placement and proper bonding between successive layers of concrete.

(11) Adequate standby arrangements, including standby pumps, pipelines, power supply, and cleaning equipment, shall be available whenever continuous concreting operations are undertaken.

(12) In the event of interruption to pumping operations, necessary measures shall be taken to prevent setting of concrete within the pipeline and to avoid formation of cold joints in the structure.

(13) The Contractor shall be responsible for ensuring that pumping operations do not adversely affect the quality, strength, durability, or surface finish of the concrete.

(14) Special care shall be taken during pumping of M-30 structural concrete and M-25 hydraulic concrete to maintain the approved water-cement ratio, workability, and durability requirements specified for severe exposure conditions.

FORMWORK

General

- (1) Formwork shall include all moulds, supports, bracing, staging, and falsework required for placing and supporting concrete until it attains sufficient strength.
- (2) Formwork shall be designed, erected, and maintained to safely withstand all loads during concreting and shall produce concrete surfaces within the specified tolerances.
- (3) The Contractor shall submit formwork drawings and design calculations, where required, for approval of the Engineer-in-Charge. Such approval shall not relieve the Contractor of responsibility for safety and adequacy of the formwork.

Materials

- (1) Formwork shall be constructed using steel forms, film-faced plywood, or other approved materials capable of producing the specified surface finish.
- (2) All formwork surfaces shall be clean, smooth, watertight, and treated with approved release agents before concreting.
- (3) Damaged, warped, or deteriorated formwork shall not be used.

Form Ties and Supports

- (1) Form ties and supports shall be adequately designed and arranged to maintain the alignment and stability of formwork during concreting.
- (2) Tie rods, bolts, and supports shall be removed or cut back to provide the specified concrete cover.
- (3) Through-bolts shall not be permitted in water-retaining or hydraulic structures.
- (4) Holes left after removal of ties or supports shall be filled with approved non-shrink cement mortar and properly cured.

Design and Erection of Formwork

- (1) The Contractor shall be solely responsible for the design, fabrication, erection, maintenance, and removal of formwork and falsework in accordance with IS 456.
- (2) Detailed formwork drawings and design calculations shall be submitted to the Engineer-in-Charge for review before commencement of concreting. Such review shall not relieve the Contractor of his responsibilities.
- (3) Formwork and falsework shall be designed to safely withstand all dead loads, live loads, concrete pressures, equipment loads, and construction loads during all stages of work.
- (4) Formwork shall be erected strictly as per approved drawings and shall be sufficiently rigid, watertight, properly aligned, and capable of producing the specified surface finish and tolerances.
- (5) Exposed concrete surfaces shall be formed using steel or approved film-faced plywood formwork. Chamfers of 25 mm × 25 mm shall be provided at exposed corners unless otherwise specified.

- (6) All form surfaces shall be cleaned and coated with approved release agent before concreting. Release agents shall not come into contact with reinforcement or embedded items.
- (7) Formwork shall be inspected and approved by the Engineer-in-Charge before placement of concrete.
- (8) Any formwork found unsafe, damaged, distorted, or inadequate shall be removed and replaced by the Contractor at his own cost.
- (9) Special formwork required for gate grooves, embedded parts, inserts, anchor plates, and water-retaining elements shall be accurately positioned and securely fixed to maintain the specified alignment and tolerances.

Finished Tolerances and Removal of Formwork

- (1) Formwork shall be constructed to produce concrete surfaces true to line, level, dimensions, and specified tolerances, with a uniform surface finish.
- (2) Formwork shall not be removed without approval of the Engineer-in-Charge and until the concrete has attained sufficient strength to safely support its self-weight and imposed loads.
- (3) The minimum period for removal of formwork and props shall generally conform to the provisions of IS 456 and may be modified by the Engineer-in-Charge depending on concrete strength, weather conditions, and structural requirements.
- (4) Special care shall be taken during removal of formwork to prevent cracking, spalling, damage to edges, corners, or finished surfaces of concrete.
- (5) Any concrete damaged during formwork removal shall be repaired by the Contractor at his own cost as directed by the Engineer-in-Charge.
- (6) Approval for formwork removal shall not relieve the Contractor of responsibility for the safety and stability of the structure.

CONSTRUCTION JOINTS

- 1. Construction joints shall be provided only at locations shown on approved drawings or as directed by the Engineer-in-Charge (EIC). No additional joints shall be formed without prior written approval.
- 2. Joints shall be straight, continuous, and properly aligned. Feather-edged joints shall not be permitted.
- 3. Reinforcement continuity and detailing at construction joints shall conform to approved drawings.
- 4. Before placing fresh concrete against hardened concrete, the joint surface shall be thoroughly cleaned, roughened, and made free from laitance, loose particles, oil, dust, and other deleterious materials.
- 5. The existing concrete surface shall be saturated with clean water for at least 24 hours and brought to a Saturated Surface Dry (SSD) condition before placing new concrete.
- 6. Surface preparation shall be carried out by mechanical wire brushing, chipping, water jetting, sand blasting, or other approved methods to expose sound aggregate and ensure proper bond.

7. A cement slurry or approved bonding agent shall be applied immediately before placement of fresh concrete where directed by the EIC.
8. Fresh concrete shall be placed continuously against the prepared joint surface and compacted thoroughly using mechanical vibrators to achieve a monolithic bond.
9. Construction joints shall be protected from traffic, vibration, contamination, and drying until fresh concrete is placed.
10. All construction joints shall be inspected and approved by the Engineer-in-Charge prior to commencement of subsequent concreting operations.
11. For water-retaining, tidal, or marine-exposed structures, suitable water stops (PVC/HDPE or approved equivalent) shall be provided at construction joints wherever shown in the approved drawings or directed by the EIC.
12. Curing of construction joints shall be carried out in accordance with IS 456 and the approved specification requirements

CURING AND PROTECTION OF CONCRETE

1. Adequate facilities for curing and protection of concrete shall be available before commencement of concreting. Water used for curing shall conform to the requirements of IS 456.
2. Freshly placed concrete shall be protected from direct sunlight, rain, flowing water, vibration, and mechanical damage until sufficient strength is achieved.
3. All exposed concrete surfaces shall be kept continuously moist by ponding, spraying, wet hessian cloth, or other approved methods for a minimum period of:
 - 14 days for concrete made with Sulphate Resistant Cement (SRC).
 - 7 days for ordinary concrete where permitted by the Engineer-in-Charge.
4. Curing shall commence as soon as the concrete surface has hardened sufficiently without causing damage.
5. No load, equipment, or traffic shall be permitted on concrete surfaces until the concrete has attained adequate strength as approved by the Engineer-in-Charge.
6. Membrane curing compounds conforming to relevant standards may be used only with prior approval of the Engineer-in-Charge and shall not be used on surfaces where further concrete, coatings, waterproofing, or bonding treatments are to be applied.
7. Where curing compounds are used, they shall be applied uniformly in accordance with the manufacturer's recommendations to form a continuous moisture-retaining membrane.
8. All curing and protection measures shall comply with the requirements of IS 456 and shall continue for the specified curing period to ensure durability, strength, and watertightness of the structure.

REPAIR OF CONCRETE

General

1. All defective, honeycombed, damaged, segregated, or otherwise unsatisfactory concrete

shall be repaired or replaced as directed by the Engineer-in-Charge (EIC). No repair work shall commence without prior approval of the EIC.

2. Unsound concrete shall be removed up to sound concrete by approved mechanical methods. The repair surface shall be cleaned, roughened, and prepared to ensure proper bond with the repair material.
3. Repairs shall be carried out using approved cement mortar, polymer-modified mortar, micro-concrete, non-shrink grout, epoxy mortar, or other suitable repair materials as approved by the EIC.
4. Repair materials shall be placed, compacted, finished, and cured in accordance with the manufacturer's recommendations and relevant Indian Standards.
5. Repaired surfaces shall match adjacent concrete in line, level, finish, durability, and appearance.
6. In water-retaining, tidal, or abrasion-prone areas, epoxy bonding agents or specialized repair systems shall be used where directed by the EIC.

PARTICULAR REQUIREMENTS FOR CONCRETE STRUCTURES

Embedded Parts

1. Anchor bolts, embedded plates, gate groove components, ladders, machinery supports, and other embedded items shall be accurately positioned and securely fixed before concreting.
2. Embedded items shall be clean and free from rust, oil, grease, paint, or other substances that may impair bond.
3. Any block-outs or recesses required for installation shall be formed as shown in approved drawings and subsequently filled with approved non-shrink material.

Grouting

1. Grouting beneath equipment bases, bearing plates, anchor bolts, and embedded items shall be carried out using approved non-shrink cementitious grout or epoxy grout.
2. Grouting shall be executed in accordance with the manufacturer's recommendations and approved method statement.
3. No load shall be applied until the grout has attained the specified strength.

Precast Concrete

1. Precast concrete elements shall be manufactured, handled, transported, stored, and erected in a manner that prevents damage and distortion.
2. Precast units shall conform to the specified concrete grade, dimensions, tolerances, and finish requirements.
3. Any surface defects shall be repaired using approved repair materials and methods.

PAYMENT

Payment for concrete works shall be made in accordance with the relevant items and provisions of the Contract and Schedule of Prices. No separate payment shall be made for curing, testing, repair work, embedded items, grouting, or incidental works unless specifically provided in the Contract.

REINFORCEMENT STEEL

General

This Section covers the supply, storage, cutting, bending, fabrication, placing, fixing and protection of reinforcement steel, including binding wire, chairs, spacers, cover blocks, mechanical couplers and all accessories required for completion of reinforced concrete works for the Cross Regulator-cum-Bridge and associated structures.

All reinforcement steel shall be procured from approved primary manufacturers and shall be accompanied by manufacturer's test certificates. The Contractor shall prepare reinforcement detailing, bar bending schedules and shop drawings for approval prior to commencement of fabrication and placement.

Applicable Standards

Unless otherwise specified, reinforcement works shall conform to the latest editions of the following standards:

- IS 456 – Plain and Reinforced Concrete – Code of Practice
- IS 1786 – High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
- IS 2502 – Bending and Fixing of Bars for Concrete Reinforcement
- IS 5525 – Detailing of Reinforcement in RCC Works
- IS 9077 – Corrosion Protection of Reinforcement in RCC Construction
- IS 280 – Mild Steel Binding Wire
- IS 9417 – Welding of High Strength Reinforcement Bars
- IS 13920 – Ductile Detailing of Reinforced Concrete Structures

In case of any conflict, these Specifications shall govern.

Reinforcement Steel

All reinforcement shall consist of Corrosion Resistant Steel (CRS) bars of minimum Fe-500D grade conforming to IS 1786 and IS 9077 unless otherwise specified in the approved design.

Reinforcement shall be free from loose rust, mill scale, oil, grease, paint, mud and other deleterious substances before placement.

The Contractor shall submit manufacturer's test certificates and carry out all testing required by the Engineer-in-Charge at his own cost.

Cutting, Bending and Fixing

Cutting, bending and fixing of reinforcement shall conform to IS 2502 and the approved Bar Bending Schedules.

Reinforcement shall be accurately positioned, securely tied and adequately supported using approved chairs, spacers and cover blocks to maintain the specified cover and alignment during concreting.

Binding wire shall be annealed steel wire conforming to IS 280 and shall be of minimum 16 SWG (approximately 1.6 mm diameter).

The minimum clear spacing between parallel bars shall be the greater of:

- Bar diameter;
- 25 mm; or
- 1.33 times the nominal maximum aggregate size.

Reinforcement shall be protected from damage, contamination and displacement during handling, storage and concreting operations.

Splicing and Couplers

Splices shall be made by lapping, welding or approved mechanical couplers in accordance with IS 456, IS 1786 and IS 9417, as applicable.

Splices shall generally be located as shown on the approved drawings. Splices in adjacent bars shall be staggered and avoided in regions of maximum stress wherever practicable.

Lap lengths shall be as specified in IS 456 and the approved design drawings.

Mechanical couplers may be used where shown on the drawings or approved by the Engineer-in-Charge. Couplers shall comply with relevant standards and shall be tested and approved prior to use.

Welding of reinforcement shall not be permitted unless specifically approved by the Engineer-in-Charge and carried out in accordance with IS 9417.

No separate payment shall be made for laps, splices, welding, couplers, binding wire or associated materials.

Concrete Cover

Clear cover to reinforcement shall be as shown on the approved drawings and shall comply with IS 456 considering structural requirements and exposure conditions.

Cover blocks shall be of concrete grade not lower than the surrounding concrete or of other approved non-corrosive material. Wooden blocks, bricks or metal pieces shall not be used.

Unless otherwise specified in the approved drawings, the minimum cover for hydraulic structures exposed to severe environmental conditions shall generally not be less than 75 mm.

Reinforcement projecting from concrete and remaining exposed for extended periods shall be protected against corrosion by approved methods.

Inspection and Quality Control

No concreting shall commence until reinforcement, cover, spacing, laps, couplers, inserts, embedded items and associated works have been inspected and approved by the Engineer-in-Charge.

The Contractor shall provide all labour, access arrangements, measuring devices and assistance required for inspection and verification.

Quality assurance, inspection and testing shall be carried out by the Contractor and shall be subject to review by the Engineer-in-Charge and Third-Party Inspection Agency, wherever appointed.

Any reinforcement work not conforming to the approved drawings or Specifications shall be rectified by the Contractor at his own cost.

Measurement and Payment

Payment for reinforcement steel shall be made in accordance with the relevant item and provisions of the Contract.

The rate shall include supply, transportation, storage, cutting, bending, placing, tying, welding, laps, splices, mechanical couplers, binding wire, chairs, spacers, cover blocks, testing, wastage and all labour, materials, equipment and incidental works necessary for completion of the reinforcement works.

No separate payment shall be made for laps, splices, couplers, binding wire, chairs, spacers, cover blocks, testing or wastage.

EXCAVATION

GENERAL

This Section covers all excavation works required for the design, construction, testing and commissioning of the Cross Regulator cum Bridge across River Dhadhar at Village Magnad, Taluka Jambusar, District Bharuch, including all associated permanent and temporary works under this Contract.

The work shall include excavation in all types of materials encountered, including soil, silt, sand, clay, gravel, murum, weathered rock, soft rock, hard rock, boulders and mixed strata, to the lines, grades and levels required for completion of the Works.

Excavation shall include foundations of the Cross Regulator cum Bridge, piers, abutments, wing walls, cut-off walls, protection works, guide bunds, river training works, flood protection works, approach roads, drainage works and all associated structures, together with excavation required for temporary works such as cofferdams, diversion channels, working platforms, haul roads, site offices, camps and construction facilities.

The Contractor shall provide all temporary works necessary for safe execution of excavation, including shoring, strutting, sheet piling, slope stabilization, cofferdams, diversion arrangements and dewatering systems.

Suitable excavated material approved by the Engineer-in-Charge shall be utilized, to the maximum practicable extent, in embankments, backfilling and other permanent works. Surplus or unsuitable material shall be disposed of at approved locations.

All excavation works shall be carried out in accordance with approved methods and with due regard to safety, environmental protection and stability of adjacent structures and works.

STANDARDS

Unless otherwise specified, excavation works shall conform to the latest editions of applicable Indian Standards, MoRTH Specifications, IRC Guidelines and relevant CWC recommendations.

- IS 3764 – Safety Code for Excavation Work
 - IS 7293 – Safety Code for Working with Construction Machinery
- or equivalent approved standards.

SUBMITTALS

The Contractor shall submit for approval:

- Excavation methodology and construction programme.
- Temporary works design including cofferdams, diversion arrangements and support systems.
- Dewatering and drainage plans.

- Spoil disposal and stockpiling plans.
- Safety, environmental and traffic management plans.
- Joint survey records of existing ground levels and cross-sections for measurement purposes.

Cross-sections shall normally be recorded at intervals of 15 m to 30 m longitudinally and at intervals not exceeding 5 m transversely unless otherwise directed by the Engineer-in-Charge.

LINES AND GRADES

The Contractor shall be responsible for setting out and maintaining all lines, grades and reference points required for excavation works.

Any over-excavation beyond approved limits shall be made good at the Contractor's cost using approved materials and methods.

Excavation beyond the approved limits for the Contractor's convenience shall not be measured for payment.

EXECUTION

General

Excavation shall be carried out using approved equipment and methods in accordance with the approved methodology and construction programme.

The Contractor shall:

- Maintain stable excavation faces and slopes.
- Control groundwater, seepage, rainfall, river inflow and tidal ingress.
- Protect existing structures, utilities and adjacent works.
- Prevent contamination of soil and water resources.
- Implement dust suppression measures.
- Maintain safe working conditions at all times.

Approval of construction methods by the Engineer-in-Charge shall not relieve the Contractor of responsibility for safety, stability or performance of the Works.

Foundation Preparation

Foundation surfaces shall be cleaned and prepared for inspection prior to placement of permanent works.

Cleaning shall include removal of loose material, silt, mud, weathered material, organic matter and other unsuitable deposits using approved methods.

The Contractor shall provide all labour, equipment and assistance required for inspection and verification of foundation conditions.

Classification of Excavation

Excavation may include:

- a) Clearing, grubbing and stripping.
- b) Excavation in soil, silt, sand, clay, gravel and murum.

c) Excavation in weathered rock, soft rock and mixed strata.

d) Excavation in hard rock and boulders.

e) Excavation below groundwater level including dewatering and desilting.

The Contractor shall be deemed to have allowed for all such conditions in the Contract Price.

Excavated Materials

Suitable excavated materials approved by the Engineer-in-Charge shall be used in embankments, backfilling and other permanent works.

Materials shall be handled and stockpiled to prevent contamination or deterioration.

Oversized boulders, unsuitable materials and surplus materials shall be removed or disposed of as directed.

Disposal of Excavated Materials

Unsuitable and surplus materials shall be disposed of at approved locations.

No excavated material shall be deposited in River Dhadhar, natural drains or watercourses.

Disposal areas shall be graded, stabilized and drained to prevent erosion, ponding and environmental impacts.

The Contractor shall be responsible for all consequences arising from improper disposal or stockpiling.

Protection of Excavation Surfaces

Excavation surfaces intended to receive permanent works shall be maintained in a clean, stable and dry condition.

Any loosened, disturbed or deteriorated material shall be removed and replaced or recompacted as directed by the Engineer-in-Charge at the Contractor's expense.

MONSOON, FLOOD AND TIDAL PROTECTION

Until completion and handing over of the Works, the Contractor shall protect all excavations, foundations, embankments, roads, cofferdams, diversion works, temporary works and permanent works against rainfall, floods, tidal effects, erosion, scour and other foreseeable site conditions.

The Contractor shall provide and maintain all necessary protection measures, including drainage arrangements, diversion channels, earth bunds, pumping systems, erosion control works and temporary flood protection measures.

Any damage occurring before completion of the Works shall be repaired and restored by the Contractor at his own cost, except where expressly provided otherwise under the Contract for Exceptional Events.

Accumulated silt, debris and water shall be removed promptly and affected works restored to the required lines, levels and specifications.

The Contractor shall be deemed to have fully considered the hydraulic and tidal characteristics of River Dhadhar while planning and executing the Works, and no separate

payment shall be made for protection, pumping, dewatering, desilting, restoration or repair works arising therefrom.

MEASUREMENT AND PAYMENT

The Contract Price shall include all costs associated with excavation, dewatering, cofferdams, diversion arrangements, temporary support systems, slope stabilization, stockpiling, transportation, disposal of excavated material, foundation preparation, protection against flooding and tidal effects, environmental protection and all incidental works necessary for completion of the excavation works.

Payment shall be made in accordance with the EPC Contract and the Payment Schedule

BACKFILLING AND EMBANKMENT WORKS

General

This Section covers the design, supply of materials, transportation, placement, compaction, testing, protection and maintenance of all backfilling, trench filling, plinth filling, embankment construction, foundation improvement, guide bunds, flood protection embankments, slope protection works and associated earthworks required for the Cross Regulator cum Bridge across River Dhadhar at Village Magnad, Taluka Jambusar, District Bharuch.

The work shall include, but not be limited to:

Backfilling behind abutments, wing walls, return walls, flank walls, guide walls, cut-off walls, navigation channels, fish pass structures and other retaining structures.

Filling around foundations, pits, trenches, drainage structures and utility crossings.

Plinth filling and site grading.

Construction of guide bunds, flood protection embankments and approach embankments.

Foundation improvement works including sand filling, granular filling, geotextiles, geogrids and other ground improvement measures.

Filter layers, drainage arrangements, PVC drainage pipes, non-return valves and associated appurtenances.

Slope protection by pitching, rip-rap, gabions, geosynthetics or other approved systems.

Protection, maintenance and repair of completed earthworks until handing over of the Works.

To the maximum practicable extent, suitable material obtained from excavation shall be utilized in backfilling and embankment construction subject to approval of the Engineer-in-Charge.

Where suitable excavated material is insufficient, the Contractor shall arrange approved borrow material at his own cost.

The Contractor shall be fully responsible for the stability, safety and performance of all embankments, backfills and foundation improvement works throughout the construction period and Operation & Maintenance period.

Standards

Unless otherwise specified, all materials, workmanship, testing and quality control shall comply with the latest editions of applicable Indian Standards, IRC Codes, MoRTH Specifications and relevant Gujarat WRD/NWRWS&KD specifications.

The following standards shall apply:

IS 1498 – Classification and Identification of Soils

IS 2720 (Relevant Parts) – Methods of Test for Soils

IS 2720 (Part 2) – Water Content

IS 2720 (Part 3) – Specific Gravity

IS 2720 (Part 8) – Heavy Compaction Test

IS 2720 (Part 28) – Field Density by Sand Replacement
IS 2720 (Part 29) – Field Density by Core Cutter
IS 10379 – Field Control of Moisture and Compaction
IS 7894 – Stability Analysis of Earth Dams
ASTM D2216
ASTM D698
ASTM D4254
USBR Earth Manual
Relevant IRC and MoRTH Specifications

In case of conflict, the more stringent requirement shall govern.

Materials

Backfill and embankment materials shall consist of:

(a) Selected Excavated Material

Suitable excavated material obtained from permanent works excavation and approved by the Engineer-in-Charge.

The material shall be free from:

Organic matter
Vegetation and roots
Deleterious substances
Rubbish
Clay lumps
Oversized stones
Unsuitable materials

(b) Granular Material

Granular material shall consist of approved sand, gravel, crushed stone, granular soil or filter material.

The material shall be:

Clean and well graded
Free from clay, silt and organic matter
Suitable for drainage and filter applications

(c) Borrow Material

Where suitable excavated material from the Works is insufficient or unsuitable for embankment, backfilling, approach roads, guide bunds, protection works, or any other permanent works, the Contractor shall arrange approved borrow material from identified borrow areas at his own cost.

The Contractor shall be solely responsible for locating, investigating, testing, obtaining approvals, acquiring permissions, and developing borrow areas required for the Works. Prior

to use, the Contractor shall submit details of the proposed borrow areas, material characteristics, laboratory test results, environmental clearances (where applicable), and haul routes for approval of the Engineer-in-Charge.

The Contractor shall be deemed to have satisfied himself regarding the availability, quality, quantity, location, accessibility, lead, lift, haulage distance, transportation arrangements, and all other factors affecting the procurement of borrow material before submission of his Bid.

No claim for additional payment, extra rate, variation, compensation, extension of time, additional lead, additional lift, or any other reimbursement shall be entertained on account of non-availability, insufficiency, poor quality, environmental restrictions, land acquisition issues, increased haul distance, increased lead and lift, or any difficulty encountered in obtaining suitable borrow material from nearby or identified sources.

The Government does not guarantee the availability of suitable borrow material within any particular distance from the Site. The Contractor shall make his own arrangements for procuring approved material from any required source and the Contract Price shall be deemed to include all costs associated with investigation, testing, royalties, permits, excavation, loading, transportation, lead, lift, unloading, stockpiling, environmental compliance, restoration of borrow areas, and all incidental works necessary for completion of the Works.

Borrow areas shall be developed, operated, and restored in accordance with applicable statutory requirements and the approved Environmental Management Plan. Upon completion of borrowing operations, the Contractor shall restore the borrow areas to the satisfaction of the Engineer-in-Charge and the concerned authorities.

(d) Clay Core Material

Impervious material used for clay cores shall:

Have permeability not exceeding 10^{-6} cm/sec.

Contain sufficient fines to achieve impervious characteristics.

Be approved by the Engineer-in-Charge.

Backfilling Around Structures

Backfilling shall commence only after:

Concrete or masonry has attained sufficient strength.

Foundations and structures have been inspected and approved.

Drainage arrangements have been completed.

Backfill shall be placed in horizontal layers not exceeding 200 mm compacted thickness.

Backfilling shall proceed uniformly on both sides of structures to avoid unequal loading.

Granular drainage layers, filters and geosynthetics shall be provided where shown on approved drawings.

Backfill around structures shall be compacted to not less than **95% of Maximum Dry Density (MDD)** determined in accordance with IS 2720.

Filling Around Foundations, Pits and Trenches

Spaces around foundations, pits, trenches and similar excavations shall be cleaned of debris and standing water before filling.

Fill material shall be placed in layers not exceeding 200–225 mm thickness and compacted using approved equipment.

Special care shall be exercised near structures, pipelines and embedded components.

Backfilling around pipes shall be carried out simultaneously on both sides to avoid unequal pressure.

Material used around pipes shall be free from stones and materials likely to damage coatings or pipe surfaces.

Plinth Filling and Site Grading

Plinth filling shall be carried out using approved earth, murum or granular material.

The material shall be placed in layers not exceeding 225 mm compacted thickness and compacted to a minimum of **95% MDD**.

The finished surface shall be flooded, allowed to dry where directed by the Engineer-in-Charge and re-compacted to eliminate future settlement.

Site grading shall be carried out to approved levels and slopes.

Soft spots and unsuitable materials shall be removed and replaced with approved material.

Embankment Construction

Guide bunds, flood protection embankments and approach embankments shall be constructed using approved excavated material and/or approved borrow material.

Construction shall proceed in uniform horizontal layers over the full width of the embankment.

Layer thickness after compaction shall not exceed 200 mm unless otherwise approved.

The Contractor shall maintain sufficient extra width during construction to ensure proper compaction at edges.

Finished slopes shall be trimmed to design lines and grades.

Compaction Requirements

General embankment: Minimum **95% MDD**

Approach embankment within 30 m of bridge abutments: Minimum **97% MDD**

Clay core: Minimum **98% MDD**

Moisture content during compaction shall be maintained within $\pm 2\%$ of Optimum Moisture Content (OMC).

Clay Core

Where required by the approved design, embankments shall incorporate a central impervious clay core.

Clay core material shall be placed in continuous horizontal layers and compacted to a minimum of 98% MDD.

The levels of adjacent embankment zones shall be maintained substantially equal during construction.

Watering and Compaction

Compaction shall be carried out using approved rollers, vibratory compactors, tampers or other approved equipment.

The Contractor shall establish suitable layer thickness and rolling pattern through field trials.

No subsequent layer shall be placed until the underlying layer has been approved.

Areas inaccessible to rollers shall be compacted using mechanical tampers or plate compactors.

Slope Protection and Dressing

All embankment slopes shall be neatly trimmed and dressed to the approved profile.

Slope protection works including:

Stone pitching

Rip-rap

Gabions

Geotextiles

Geogrids

Concrete protection works

shall be provided where specified in the approved drawings.

Any erosion, settlement or damage occurring prior to handing over shall be rectified by the Contractor at his own cost.

Drainage Pipes and Non-Return Valves

PVC drainage pipes shall be installed through retaining walls, guide walls and similar structures at locations shown on approved drawings.

The pipes shall:

Conform to IS 4985.

Have minimum diameter of 75 mm unless otherwise specified.

Be laid with suitable outward slope.

Be fitted with approved PVC Non-Return Valves (NRV).

Testing and Quality Control

The Contractor shall establish and maintain a fully equipped site laboratory.

Testing shall include:

Moisture Content

Specific Gravity

Grain Size Distribution

Atterberg Limits

Proctor Compaction Test

Field Density Test

Relative Density

Permeability Test where required

Minimum frequency:

One field density test per 1000 m³ of compacted fill.

Minimum two field density tests per layer.

The Engineer-in-Charge may increase testing frequency whenever required.

Any material or layer failing to meet requirements shall be removed, reworked and retested at the Contractor's cost.

Protection Against Monsoon and Tidal Damage

Until completion and handing over of the Works, the Contractor shall protect all backfill, embankments, guide bunds, foundations, approach roads and associated works against:

Rainfall

Monsoon conditions

River flooding

Tidal effects

Erosion

Scour

Surface runoff

The Contractor shall provide all necessary temporary protection measures including drainage channels, berms, bunds, pumping arrangements and diversion works.

Any damage occurring before handing over shall be repaired by the Contractor at his own cost except where specifically covered under Exceptional Events defined in the Contract.

Measurement and Payment

The Contract Price shall be deemed to include:

Borrow excavation with all lead and lift

Loading and transportation

Placement and spreading

Moisture conditioning

Compaction

Testing

Protection works

Geotextiles and filters

Drainage arrangements

Slope dressing

Temporary works

Maintenance and rectification

No separate payment shall be made unless specifically identified in the Price Schedule.

Payment shall be made in accordance with the EPC Contract and Payment Schedule.

Cut-Off Wall

Cut-off walls shall be constructed at the locations, dimensions, levels, and alignments shown on the approved drawings or as directed by the Engineer-in-Charge. The purpose of the cut-off wall shall be to reduce seepage, prevent piping and undermining, improve hydraulic stability, and provide protection against scour beneath and adjacent to the Cross Regulator-cum-Bridge structure.

The Contractor shall carry out all excavation required for the cut-off walls in all types of strata encountered, including soil, sand, silt, gravel, murum, soft rock, hard rock, boulders, and mixed strata. Excavation shall be performed to the specified lines, grades, and depths and shall include all temporary works necessary for safe execution of the works.

The Contractor shall design, provide, install, maintain, and remove all temporary support systems, including shoring, strutting, sheet piling, bracing, trench supports, cofferdams, dewatering arrangements, and other measures required to maintain the stability of excavation and keep the trench dry during construction.

The trench width shall be sufficient to accommodate the cut-off wall, specified sand filling on both sides of the wall, formwork, reinforcement, and adequate working space for construction activities. Continuous dewatering shall be maintained throughout excavation, foundation preparation, reinforcement fixing, concreting, and backfilling operations.

Where required due to depth, ground conditions, groundwater conditions, tidal influence, or construction constraints, advanced construction techniques such as diaphragm wall technology, trench cutters, grab excavation systems, bentonite/polymer slurry-supported trenches, or other approved methods may be adopted subject to approval of the Engineer-in-Charge.

Upon completion of the cut-off wall, approved filter material, sand filling, backfilling, and compaction shall be carried out as shown on the approved drawings. Any damage caused by collapse of excavation, flooding, inadequate dewatering, or failure of temporary works shall be rectified by the Contractor at his own cost.

Measurement and Payment

Measurement and payment for Cut-Off Walls shall be made in accordance with the relevant provisions of the Contract and Payment Schedule.

RCC BORED CAST-IN-SITU PILES

1. General

Where pile foundations are adopted in the approved design of the Cross Regulator-cum-Bridge, RCC piles shall be designed, constructed, tested and completed by the Contractor as part of the EPC Contract.

The Contractor shall carry out detailed geotechnical investigations, hydraulic studies, structural analysis, and foundation design to determine the suitability, type, diameter, length, spacing, founding level, safe load carrying capacity, and arrangement of piles required for the Works.

The Contractor shall be fully responsible for the adequacy, safety, stability, serviceability and long-term performance of the pile foundation system.

All foundation designs, including pile foundations, shall be prepared by the Contractor's Design Consultant and shall be vetted by a reputed institution such as IIT, NIT or CDO Gandhinagar. The cost of investigation, design, vetting, approvals, testing and revisions shall be borne entirely by the Contractor.

The Contractor shall submit detailed design calculations, pile layout drawings, pile schedules, geotechnical reports, construction methodology, quality assurance plans and testing procedures for approval before commencement of piling works.

2. Applicable Standards

Pile works shall conform to the latest editions of:

- IS 2911 (Part 1 Section 2) – Bored Cast-in-Situ Concrete Piles
- IS 2911 (Part 4) – Load Testing of Piles
- IS 456 – Plain and Reinforced Concrete
- IS 1786 – High Strength Deformed Steel Bars
- IS 9077 – Corrosion Resistant Steel Reinforcement
- IS 10262 – Concrete Mix Design
- IS 516 – Concrete Testing
- IS 1199 – Sampling and Testing of Concrete
- Relevant IRC Codes for Bridge Foundations
- Any other relevant BIS codes

In case of conflict, these Specifications shall prevail.

3. Geotechnical Investigation

Prior to finalization of pile design, the Contractor shall carry out detailed geotechnical investigations at all proposed foundation locations.

The investigation programme shall include:

- Boreholes at each foundation location.
- Standard Penetration Tests (SPT).
- Collection of disturbed and undisturbed soil samples.
- Groundwater observations.
- Laboratory testing.
- Chemical analysis of soil and groundwater.
- Determination of chloride and sulphate content.
- Assessment of scour and erosion characteristics.

The depth of exploration shall extend below the anticipated pile founding level as required by relevant standards and approved by the EIC.

The Contractor shall prepare a detailed Geotechnical Investigation Report forming the basis of foundation design.

4. Type of Piles

Unless otherwise approved by the EIC, piles shall be Bored Cast-in-Situ Reinforced Concrete Piles constructed using rotary hydraulic drilling rigs.

The Contractor may propose:

- Straight Shaft Piles.
- Large Diameter Bored Piles.
- Under-Reamed Piles.
- Rock Socketed Piles.
- Permanent Cased Piles.
- Any other suitable pile system.

5. Materials

Concrete

All piles shall be constructed using Sulphate Resisting Cement (SRC).

Concrete shall be Design Mix Concrete of minimum Grade M30 or higher grade as required by approved design.

Concrete shall satisfy severe exposure requirements and shall provide adequate durability against sulphate attack, chloride ingress and aggressive groundwater conditions.

Unless otherwise approved:

Particular	Requirement
Grade of Concrete	M30 Minimum
Cement Type	Sulphate Resisting Cement (SRC)
Maximum Water Cement Ratio	As per IS
Slump	As per IS

Placement Method

Tremie Concrete

Concrete shall remain workable throughout the entire concreting period without segregation or excessive bleeding.

Approved superplasticizers compatible with SRC may be used.

Reinforcement

Reinforcement shall consist of CRS Fe-500D steel conforming to IS 1786 and IS 9077.

The reinforcement cage shall be sufficiently rigid to withstand lifting, handling and lowering operations.

Concrete cover shall not be less than 75 mm unless otherwise specified in the approved design.

Suitable spacer wheels and centralizers shall be provided at adequate intervals.

Drilling Fluid

Bentonite slurry or approved polymer slurry shall be used where necessary for stabilization of boreholes.

The Contractor shall maintain slurry properties within permissible limits throughout drilling and concreting operations.

6. Construction of Piles

Pile boring shall be carried out using approved rotary hydraulic drilling rigs.

The Contractor shall ensure that boreholes remain stable throughout construction.

Temporary casing, permanent casing, bentonite slurry, polymer slurry, dewatering systems or any combination thereof shall be adopted as required by site conditions.

Where unstable strata, soft marine clay, loose sand, cavities or aggressive soils are encountered, suitable measures shall be implemented to prevent collapse of boreholes.

Pile diameters and lengths shall be as specified in approved drawings.

The borehole shall be cleaned thoroughly before lowering of reinforcement cage.

7. Concreting of Piles

Concrete shall be placed through tremie pipes extending to the bottom of the bore.

The tremie system shall be watertight and of adequate diameter.

Concreting shall proceed continuously without interruption from pile toe to pile cut-off level.

The lower end of the tremie pipe shall remain embedded in fresh concrete at all times.

Concrete shall not be allowed to fall freely through water or drilling slurry.

Theoretical and actual concrete consumption shall be recorded continuously.

Any abnormal loss of concrete shall be immediately reported to the EIC.

The pile head shall be cast sufficiently above cut-off level to ensure sound concrete at the finished level.

8. Pile Testing

The Contractor shall carry out pile testing at his own cost.

Testing shall include:

- Initial Compression Load Tests.
- Routine Load Tests.
- Lateral Load Tests.
- Pull-Out Tests.
- Pile Integrity Tests.
- Low Strain Integrity Tests.
- Any additional tests directed by EIC.

The number of test piles shall be as directed by the EIC.

Pile testing shall be carried out before commencement of production piling wherever required.

Acceptance criteria shall comply with IS 2911.

9. Concrete Cube Testing

Concrete used in piles shall be sampled and tested in accordance with IS 456, IS 1199 and IS 516.

The cubes shall normally be tested as follows:

- Three cubes at 7 days.
- Three cubes at 28 days.

Additional cubes shall be cast whenever required for investigation or acceptance purposes.

Concrete failing to meet specified strength requirements shall be investigated and the Contractor shall carry out all remedial measures at his own cost.

10. Tolerances

Permissible tolerances shall be as follows:

Item	Permissible Tolerance
Pile Diameter	+50 mm / -10 mm
Verticality	1 in 150
Position at Platform Level	±75 mm
Cut-Off Level	±25 mm

11. Records

The Contractor shall maintain detailed records for every pile including:

- Pile number.
- Coordinates.
- Diameter.
- Length.
- Founding level.

- Bore log.
- Soil strata.
- Groundwater level.
- Reinforcement details.
- Concrete quantity.
- Cube test results.
- Slump results.
- Time of concreting.
- Pile testing records.
- Any unusual occurrences.

12. Measurement and Payment

Payment for pile foundations, if adopted in the approved design, shall be made only under the relevant Payment schedule.

The rate shall include geotechnical investigations, design, vetting by IIT/NIT/CDO, boring, drilling, temporary casing, permanent casing, dewatering, bentonite/polymer slurry, reinforcement, concrete, tremie concreting, pile testing, cube testing, integrity testing, replacement of defective piles, labour, plant, equipment, leads, lifts and all incidental works necessary for complete execution of the pile foundation system.

No separate payment shall be made for pile testing, design revisions, temporary works, casing, slurry, dewatering, replacement piles, overbreak, obstruction removal or any other incidental item.

WATER STOPS AND MOVEMENT JOINTS

1. General

This Section covers the design, supply, testing, storage, installation and protection of water stops, joint fillers, joint sealants, sealing compounds, bond breakers and all accessories required for construction, contraction, expansion and movement joints in concrete structures of the Cross Regulator-cum-Bridge and associated works.

All joints shall be designed and detailed by the Contractor as part of the approved structural design and drawings. The location, spacing, dimensions and type of movement joints shall be subject to approval by the Engineer-in-Charge (EIC).

The Contractor shall ensure complete water-tightness, durability and long-term performance of all joints throughout the design life of the structure.

The work shall conform to the latest editions of:

- IS 15058 – PVC Water Stops
- IS 12200 – Installation of Water Stops
- IS 1838 (Part 1) – Preformed Joint Fillers
- IS 1834 – Hot Applied Joint Sealing Compound
- IS 11433 – Joint Sealants
- IS 456 – Plain and Reinforced Concrete
- Relevant BIS Standards and Manufacturer's Recommendations

In case of conflict, these Specifications shall govern.

2. Submittals

At least Two (2) weeks before procurement, the Contractor shall submit the following for approval:

- Manufacturer's catalogues.
- Technical data sheets.
- Test certificates.
- Material samples.
- Installation methodology.
- Joint layout drawings.
- Quality assurance procedures.
- Proposed joint details and sections.

No material shall be brought to Site or incorporated in the Works without approval of the Engineer-in-Charge.

3. Movement Joints

Movement joints shall include expansion joints, contraction joints, construction joints and other joints shown on approved drawings or directed by the Engineer-in-Charge.

The Contractor shall provide all materials, accessories, supports, fixing arrangements and

workmanship necessary to achieve a durable and watertight joint system.

No embedded metal component shall pass continuously through a movement joint unless specifically shown on approved drawings.

Expansion Joints

Expansion joints may consist of:

- PVC Water Stops.
- Joint Fillers.
- Joint Sealants.
- Hot Applied Sealing Compounds.
- Bituminous Coating.
- Backer Rods.
- Any other approved sealing system.

Contraction Joints

Contraction joints may consist of:

- PVC Water Stops.
- Bond Breakers.
- Bituminous Coating.
- Joint Sealants.
- Other approved systems.

4. PVC Water Stops

PVC water stops shall be extruded polyvinyl chloride conforming to IS 15058.

Water stops shall be suitable for severe exposure conditions and shall remain flexible, watertight and resistant to ageing, chemicals, chlorides, sulphates, sunlight and environmental deterioration.

Unless otherwise specified:

- Type: Dumbbell with Central Bulb.
- Width: Minimum 300 mm.
- Thickness: Minimum 10 mm.
- Centre Bulb: Hollow type for expansion joints.
- Edge Profile: Ribbed or Corrugated for improved bond.

Water stops shall be homogeneous, free from cracks, voids, porosity, blisters or manufacturing defects.

Factory-manufactured intersections, tees, crosses, reducers and corner pieces shall be used wherever possible.

Field joints shall be heat welded using approved thermostatically controlled welding equipment.

Damaged water stops shall not be used.

5. Joint Fillers

Joint fillers shall consist of preformed bituminous fibre board conforming to IS 1838 (Part 1).

Unless otherwise shown on approved drawings:

- Thickness: 12 mm minimum.
- Density and compressibility shall comply with relevant standards.
- Filler shall be resilient, non-extruding and durable.

Joint fillers shall extend continuously throughout the full depth and width of the joint unless otherwise specified.

6. Joint Sealants

Joint sealants shall conform to IS 11433 and shall be suitable for hydraulic structures exposed to severe environmental conditions.

Sealants shall possess:

- Excellent adhesion.
- Elastic recovery.
- Weather resistance.
- Water resistance.
- Chloride resistance.
- Sulphate resistance.

The sealant system shall be compatible with adjacent concrete surfaces and joint filler materials.

7. Joint Sealing Compound

Hot applied sealing compounds shall conform to IS 1834.

The material shall be capable of accommodating joint movement without cracking, loss of adhesion or deterioration.

Application temperatures shall be strictly in accordance with manufacturer's recommendations.

8. Bituminous Coating

Bituminous coating shall conform to IS 290.

Unless otherwise approved, two coats shall be applied at locations shown on approved drawings.

Each coat shall be allowed to dry before application of the subsequent coat.

9. Installation

Water stops shall be securely fixed to reinforcement using approved clips, clamps or supporting systems to prevent displacement during concreting.

The centre line of the water stop shall coincide exactly with the centre of the joint.

Special care shall be taken to prevent folding, twisting, stretching or displacement during placement of concrete.

Concrete adjacent to water stops shall be thoroughly compacted using suitable vibrators to eliminate honeycombing and voids.

Water stops exposed prior to concreting shall be protected from sunlight, oil, grease, mechanical damage and contamination.

10. Preparation and Sealing of Joints

Before installation of joint sealants, the joint shall be cleaned thoroughly.

All laitance, dust, oil, grease, curing compounds, loose particles and foreign matter shall be removed by grinding, wire brushing, compressed air or other approved methods.

Joint surfaces shall be dry and primed where required.

Sealants shall be installed strictly in accordance with the manufacturer's recommendations.

The concrete temperature during sealant application shall generally not exceed 30°C unless otherwise approved.

Fresh sealant shall be protected against rain, dust, vibration and mechanical damage until fully cured.

Any defective, cracked, debonded or damaged sealant shall be removed and replaced by the Contractor at his own cost.

11. Inspection and Testing

All water stops, fillers and sealants shall be inspected before installation.

The Engineer-in-Charge may require:

- Physical testing.
- Tensile strength testing.
- Elongation testing.
- Hardness testing.
- Water-tightness testing.
- Manufacturer's certification.

Any material failing to comply with Specifications shall be rejected and removed from Site.

12. Measurement and Payment

Payment shall be made under the relevant Payment schedule.

The rate shall include supply, transportation, storage, cutting, welding, fixing, testing, joint fillers, sealants, sealing compounds, supports, accessories, labour, equipment and all incidental works necessary for complete and watertight execution of movement joints.

No separate payment shall be made for welding, factory-made intersections, supports, testing, wastage, protection, repairs or replacement of defective work.

BRIDGE

General

1. This section covers the design, procurement, construction, testing, commissioning and maintenance during the Defect Liability/O&M Period of the bridge forming an integral part of the proposed Hydraulic Structure across the Dhadhar River at Village Magnad, Taluka Jambusar, District Bharuch.
2. The bridge shall serve as an approach and inspection bridge over the Hydraulic Structure and shall be designed considering all dead loads, live loads, impact loads, wind loads, seismic loads, hydraulic forces, construction loads and any other loads as per relevant IRC, IS and applicable standards.
3. The entire bridge including foundations, substructure, superstructure, bearings, wearing coat, railings, crash barriers, service walkway, gate operation platform, stop-log handling arrangements and all ancillary works shall be designed by the Contractor through his Design Consultant. The design shall be vetted by an IIT, NIT, CDO Gandhinagar. Final approval shall be obtained from the Engineer-in-Charge before commencement of construction.

Design Criteria and Standards

1. The bridge shall be designed in accordance with the latest editions of relevant IRC Codes, IS Codes and Ministry of Road Transport & Highways specifications, unless otherwise specified.
2. The bridge shall be designed for **IRC Class AA Loading** including impact, braking, traction and other applicable forces.
3. The bridge shall provide a **minimum clear carriageway width of 5.50 m.**
4. In addition to the carriageway, a separate platform/service width shall be provided for:
 - Operation and maintenance of gates.
 - Hoisting arrangements.
 - Inspection activities.
 - Movement of maintenance personnel and equipment.
5. Suitable arrangements for handling, lifting and storage of **two complete sets of stop logs** shall be incorporated in the design.
6. The number of spans, span lengths, pier locations, deck configuration and structural system shall be finalized based on approved hydraulic and structural design.
7. The bridge shall be designed to ensure durability under Severe Exposure Conditions as specified in IS 456:2000.
8. Minimum concrete grade shall be:
 - Superstructure Components – M30
 - Substructure Components – M30
 - Wearing Coat – As per approved design
 - Other ancillary RCC components – Minimum M25 unless otherwise approved.

Submittals

The Contractor shall submit the following for approval:

- Detailed bridge design calculations.
- Structural analysis report.
- General Arrangement Drawings.
- Foundation design.
- Reinforcement drawings.
- Bearing details.
- Expansion joint details.
- Crash barrier and railing details.
- Wearing coat details.
- Construction methodology.
- Quality Assurance and Quality Control Plan.
- Design vetting certificate from IIT/NIT/CDO Gandhinagar.

Construction shall commence only after obtaining written approval from the Engineer-in-Charge.

Superstructure**Concrete**

Concrete shall conform to the requirements specified under Section "Concrete" of these Specifications.

Reinforcement

Reinforcement shall conform to Section "Reinforcing Steel" and shall generally be Fe-500D grade CRS bars.

Bearings

Suitable elastomeric, pot-PTFE or other approved bearings shall be provided wherever required as per the approved design. Bearings shall comply with relevant IRC and IS standards.

Railings and Crash Barriers

Bridge railings, parapets and crash barriers shall be designed as per relevant IRC provisions and shall ensure safety of vehicular and maintenance traffic.

Cement Concrete Wearing Coat

1. Cement concrete wearing coat shall be laid over the bridge deck after completion of structural concrete.
2. The minimum thickness of wearing coat shall be **75 mm** or as specified in the approved design.
3. Concrete grade, reinforcement, joints and finishing shall conform to the approved drawings and applicable IRC specifications.
4. Proper surface preparation, bonding and curing shall be ensured before placing the wearing coat.

Expansion Joints

1. Expansion joints shall be provided at locations shown in the approved drawings or as required by design.
2. Expansion joints shall accommodate thermal movements, shrinkage, creep and structural deformations without distress.
3. Joint systems shall comply with relevant IRC standards and manufacturer's recommendations.
4. Expansion joints shall be watertight, durable and suitable for the environmental conditions at site.
5. The minimum joint gap shall generally be 10 mm to 12 mm unless otherwise required by design.
6. All accessories, anchorages, sealing systems and protection arrangements shall be included in the Contractor's scope.

Stop Log Handling Arrangement

1. The bridge design shall include all necessary arrangements for installation, removal, handling and storage of stop logs.
2. A minimum of **two complete sets of stop logs** shall be considered in the design.
3. Adequate lifting points, handling platforms, storage areas and maintenance access shall be provided.
4. The arrangement shall permit safe operation during normal maintenance and emergency conditions.

Measurement and Payment

Payment for bridge works shall be made as per the Payment Schedule of the Tender. The quoted rates shall include complete design, vetting, procurement, construction, testing, commissioning, maintenance during the O&M period and all incidental works necessary for satisfactory completion of the bridge and its appurtenant structures. No separate payment shall be made for design, vetting, drawings, bearings, expansion joints, service platforms, stop-log handling arrangements, temporary works or any item required for completion of the works.

RIVER FLOOR AND BANK PROTECTION WORKS

General

1. This Section covers the design, procurement, construction, testing, commissioning and maintenance of all river floor protection works, bank protection works, aprons, filters, launching aprons, concrete block protection, gabions, pitching, cut-off arrangements and all associated works required for the protection of the Hydraulic Structure and adjoining river reaches.
2. The protection arrangements indicated in the tender drawings are indicative only and provided for guidance. The Contractor shall carry out detailed hydraulic studies, river morphology assessment, geotechnical investigations, scour analysis, sediment transport studies and stability calculations and shall design the complete river training and protection system.
3. The design of river floor and bank protection works shall be prepared by the Contractor through a qualified Design Consultant and shall be vetted by IIT, NIT, CDO, GERI or any other Government-approved institution acceptable to the Engineer-in-Charge. Final approval shall be obtained from the Engineer-in-Charge prior to commencement of construction.
4. The design shall adequately protect the barrage, bridge, guide bunds, embankments, foundations, aprons and all associated structures against scour, erosion, undermining, piping, settlement, river meandering, flood flows and all other hydraulic actions throughout the design life of the structure.
5. The Contractor shall be fully responsible for the adequacy, safety, stability and performance of the river protection works during construction, Defect Liability Period and O&M Period. Any damage, settlement, erosion, failure or deficiency observed during this period shall be rectified by the Contractor at his own cost.

Design Requirements

1. River protection works shall be designed considering, but not limited to, the following:
 - Design flood discharge.
 - HFL and MWL.
 - Maximum afflux.
 - Hydraulic jump conditions.
 - Velocity distribution.
 - General and local scour depth.
 - River morphology and meandering characteristics.
 - Sediment transport.
 - Uplift pressure.
 - Seepage forces.
 - Bank stability.
 - Foundation safety.

2. The protection system may consist of one or more of the following components as required by the approved design:
 - Stone pitching.
 - Stone spalls.
 - Graded filter layers.
 - Launching aprons.
 - Gabion mattresses.
 - Gabion boxes.
 - Precast concrete blocks.
 - RCC protection walls.
 - Cut-off walls.
 - Geotextile filters.
 - Guide bunds.
 - River training works.
 - Energy dissipation arrangements.
 - Any other approved protection system.
3. Notwithstanding anything contained elsewhere in the Contract, the Contractor shall provide river bank protection works of minimum **100 m length on both banks at the upstream side and minimum 100 m length on both banks at the downstream side** of the Hydraulic Structure.
4. The bank protection works shall consist of either:
 - RCC Protection Wall constructed in minimum **M25 grade concrete**, or
 - Gabion Protection Wall of minimum **1.0 m thickness**,
 - or any superior protection arrangement proposed by the Contractor and approved by the Engineer-in-Charge.
5. The final dimensions, depth of foundation, thickness, extent and type of protection shall be established through approved hydraulic and structural design calculations.
6. The protection works shall be designed to prevent erosion, scour, bank failure, undermining and river meandering and shall ensure the long-term stability of the Hydraulic Structure and adjoining river reaches.
7. Dimensions, thicknesses, stone sizes, block sizes, filter gradation, apron widths and depths shown in the tender drawings shall be treated as indicative only and may be modified as per the approved design without any additional payment to the Contractor.

Materials

1. All materials used in river protection works shall conform to the latest applicable IS, IRC, MoRTH and other relevant standards.
2. Stone used for pitching, aprons, gabions and protection works shall be hard, dense, durable, free from weathering, cracks, seams and other defects and shall be obtained from approved quarries.
3. Gabions shall be manufactured from heavily galvanized or PVC-coated galvanized wire

mesh and shall conform to relevant IRC and MoRTH specifications.

4. Geotextiles, where provided, shall be non-woven or woven geotextiles of approved quality and strength suitable for filtration and separation purposes.
5. Concrete used in precast blocks, protection walls and other RCC components shall conform to Section "Concrete" of these Specifications. RCC Protection Walls shall be constructed using minimum M25 grade concrete.
6. Filter media shall satisfy the filter criteria specified in relevant IRC/MoRTH provisions and approved design requirements.

Construction

1. River protection works shall be executed only after approval of detailed design drawings, construction methodology and quality assurance plan by the Engineer-in-Charge.
2. All excavation, dewatering, foundation preparation, bedding, filter placement, stone pitching, gabion installation, concrete works and associated activities shall be carried out in accordance with the approved drawings and specifications.
3. Filter layers shall be placed over properly prepared surfaces and compacted to the required thickness and density.
4. Gabions shall be properly assembled, filled, tied and anchored to prevent displacement during flood conditions.
5. Concrete blocks, protection walls and RCC works shall be cast, cured and placed in accordance with approved specifications and drawings.
6. The Contractor shall take all necessary precautions to prevent damage to completed works during monsoon and flood periods.
7. Any erosion, settlement, displacement, scour or damage occurring during construction, Defect Liability Period or O&M Period shall be rectified by the Contractor at his own cost and no additional payment shall be made.

Measurement and Payment

1. Payment shall be made as per the Payment Schedule of the Tender.
2. The quoted rates shall include complete design, hydraulic studies, geotechnical investigations, surveys, vetting, procurement, transportation, handling, testing, construction, maintenance during O&M Period and all incidental works necessary for satisfactory performance of the river floor and bank protection system.
3. No separate payment shall be made for design modifications, additional protection measures, temporary works, dewatering, river diversion, maintenance during O&M Period, repairs due to floods, scour protection measures or any item required to ensure stability, safety and satisfactory performance of the protection works.
4. The Contractor shall be deemed to have included all costs necessary for the satisfactory completion and performance of the river floor and bank protection works in the quoted rates.

Dismantling of Existing Structure

Scope of Work

The Contractor shall carry out detailed survey, investigation, assessment of the existing structure and prepare the design for the proposed hydraulic structure on the Dhadhar River at Village Magnad, Taluka Jambusar, District Bharuch under the EPC Contract. The new structure shall be constructed at the location of the existing structure in accordance with the approved design, drawings, specifications and directions of the Engineer-in-Charge (EIC).

Wherever required for the execution of the new works, dismantling of the existing structure or any part thereof shall be undertaken only after obtaining prior written approval of the Engineer-in-Charge/Competent Authority. The Contractor shall submit a detailed dismantling methodology, safety plan, sequence of demolition and disposal plan for approval before commencement of dismantling activities.

The Contractor shall be solely responsible for the adequacy, stability, safety and performance of the adopted design, temporary works, dismantling methodology and construction procedures throughout the execution period.

Execution Requirements

1. Dismantling shall be carried out in a safe, systematic and controlled manner so as not to endanger personnel, adjoining structures, utilities, riverbanks, river flow or public property.
2. Necessary barricading, warning signs, traffic management, dewatering arrangements, temporary supports and safety measures shall be provided by the Contractor at his own cost.
3. The Contractor shall take all precautions to prevent damage to portions of the structure intended to remain, nearby properties, roads, utilities and environmental features.
4. All debris resulting from dismantling shall be removed promptly from the site and disposed of at locations approved by the Engineer-in-Charge and in compliance with applicable environmental regulations.

Recovery and Handover of Serviceable Materials

1. All serviceable materials recovered from dismantling, including but not limited to reinforcement steel, structural steel, gates, hoisting components, embedded metal parts and other reusable items, shall remain the property of the Department.
2. The Contractor shall carefully separate serviceable materials from demolished materials without causing damage and shall stack them systematically at locations designated by the Engineer-in-Charge.
3. All recovered steel and other metallic materials shall be weighed at the nearest weighbridge in the presence of Department officials. The Contractor shall arrange transportation, loading, unloading and weighing at his own cost.

4. Certified weighbridge slips duly signed by the Contractor's representative and Department officials shall be submitted to the Engineer-in-Charge.
5. The recovered serviceable materials shall be handed over to the Department against proper inventory records and acknowledgement receipts.

Record Keeping

1. The Contractor shall maintain a day-to-day dismantling register indicating:
 - Location and description of dismantling work carried out.
 - Quantity of material dismantled.
 - Quantity of serviceable and unserviceable materials recovered.
 - Weighbridge records of recovered steel and other metallic materials.
2. The dismantling register shall be kept at site and shall be made available for inspection by the Engineer-in-Charge at all times.

Measurement and Payment

No separate payment shall be made for survey, investigation, dismantling methodology, segregation of materials, stacking, loading, unloading, transportation, weighment, maintenance of records, handing over of recovered materials, disposal of debris, safety measures or any incidental works required for complete dismantling and site clearance. The cost thereof shall be deemed to be included in the Contractor's quoted rates under the EPC Contract.

Completion

Upon completion of dismantling activities, the site shall be cleared of all debris and unwanted materials and made ready for construction of the new hydraulic structure to the satisfaction of the Engineer-in-Charge. The Contractor shall ensure that river flow, adjoining areas and public infrastructure remain protected throughout the dismantling and construction period.

Solar Street Lighting System

Scope of Work

The Contractor shall supply, install, test, operate and maintain a minimum of **20 Nos. Solar LED Street Lights** complete with solar photovoltaic modules, maintenance-free batteries, LED luminaires, mounting structures, poles, controllers, cables, foundations and all accessories required for satisfactory operation of the system.

The solar lighting system shall be provided at locations identified by the Engineer-in-Charge (EIC) within the project area, including approach roads, operation areas, gate operating platforms and other locations as directed by the EIC to ensure adequate illumination and safety.

Technical Requirements

1. The Solar Street Lights shall be of integrated or semi-integrated type and conform to the latest applicable **MNRE/BIS specifications and guidelines**.
2. Each Solar Street Light shall have:
 - LED Luminaire: Minimum **30 Watt LED**.
 - Solar PV Module: Minimum **75 Wp** or as required for satisfactory operation.
 - Battery: Lithium Ferro Phosphate (LiFePO4) or approved equivalent with adequate backup.
 - Automatic dusk-to-dawn operation.
 - Minimum autonomy of **2 nights** without sunshine.
 - Corrosion-resistant mounting arrangement suitable for outdoor conditions.
3. The lighting arrangement shall provide sufficient illumination for safe movement, operation and maintenance activities during night hours.
4. Pole height shall generally be **6.0 metres minimum** above bridge level unless otherwise approved by the EIC.
5. All components shall be of approved make and sourced from reputed manufacturers having adequate service support in Gujarat.

Approved Makes

The Solar PV Modules, LED Luminaires, Batteries and Controllers shall be of approved makes such as:

- Tata Power Solar
- Waaree Energies
- Adani Solar
- Havells
- Crompton
- or equivalent makes approved by the Engineer-in-Charge.

Operation and Maintenance

1. The Contractor shall be responsible for the operation, maintenance, repair and replacement of all solar lighting system components throughout the entire O&M period of the EPC Contract.
2. Any defective component including solar modules, batteries, controllers, LED fixtures, poles, wiring or accessories shall be repaired or replaced by the Contractor at no additional cost to the Department.
3. The Contractor shall ensure that not less than **100% of the installed solar lights remain functional at all times** during the O&M period.
4. Regular cleaning of solar panels, inspection of batteries and preventive maintenance shall be carried out by the Contractor to ensure optimum performance.

Measurement and Payment

The cost of providing a minimum of **20 Nos. Solar LED Street Lights**, including all materials, labour, equipment, operation and maintenance obligations up to the completion of the O&M period, shall be deemed to be included in the Contractor's quoted rates for the **EPC Work for Design, Procurement and Construction of Hydraulic Structure on Dhadhar River at Village Magnad, Taluka Jambusar, District Bharuch**, and no additional payment whatsoever shall be made on this account. Any replacement of defective or damaged components during the O&M period shall also be carried out by the Contractor at his own cost.

PVC Pipes for Drainage, Weep Holes and Bridge Drainage

This work shall consist of providing, laying and fixing PVC pipes conforming to Schedule-80 (SCH-80) requirements for drainage arrangements, weep holes, bridge deck drainage, retaining walls, wing walls, abutments and other locations as required in the approved EPC design and as directed by the Engineer-in-Charge. The Contractor shall, during the design stage, consider the provision of SCH-80 PVC pipes of suitable diameter, spacing and arrangement to ensure efficient drainage and pressure relief. Under no circumstances shall pipes of a lower specification than Schedule-80 (SCH-80) be used for these purposes.

Approved Makes

The PVC pipes shall be sourced from approved manufacturers such as:

- Astral Pipes
- Supreme Industries
- Finolex Industries
- Prince Pipes and Fittings
- Ashirvad Pipes

or equivalent makes approved by the Engineer-in-Charge (EIC).

Material Requirements

1. All PVC pipes shall be **heavy-duty Schedule-80 (SCH-80) PVC pipes** suitable for outdoor and hydraulic structure applications.
2. Pipes shall be resistant to corrosion, chemicals, weathering and ultraviolet exposure.
3. The pipes shall have smooth internal surfaces and shall be free from cracks, blisters, dents, holes or other manufacturing defects.
4. The diameter and wall thickness of the pipes shall be as shown in the drawings or as approved by the Engineer-in-Charge.

Installation

1. PVC pipes used as weep holes shall be installed with a minimum outward slope of **1 in 20** or as directed by the Engineer-in-Charge to ensure free drainage.
2. Weep holes shall be provided with suitable filter media, geotextile wrapping or other approved arrangements to prevent clogging and loss of backfill material.
3. Bridge drainage pipes shall be securely fixed and aligned to effectively drain stormwater from the bridge deck without causing erosion or damage to structural components.
4. All joints, fittings, bends and connections shall be watertight and installed in accordance with the manufacturer's recommendations.
5. Adequate protection shall be provided during concreting operations to prevent displacement or blockage of the pipes.

Testing and Inspection

1. All pipes shall be visually inspected before installation.
2. Damaged, cracked or defective pipes shall not be used and shall be removed from the site.
3. The Engineer-in-Charge may require additional inspection or testing if deemed necessary.

Measurement and Payment

The cost of pipes, including all materials, labour, equipment, operation and testing obligations, shall be deemed to be included in the Contractor's quoted rates for the **EPC Work for Design, Procurement and Construction of Hydraulic Structure on Dhadhar River at Village Magnad, Taluka Jambusar, District Bharuch**, and no additional payment whatsoever shall be made on this account.

Gabion Work

General

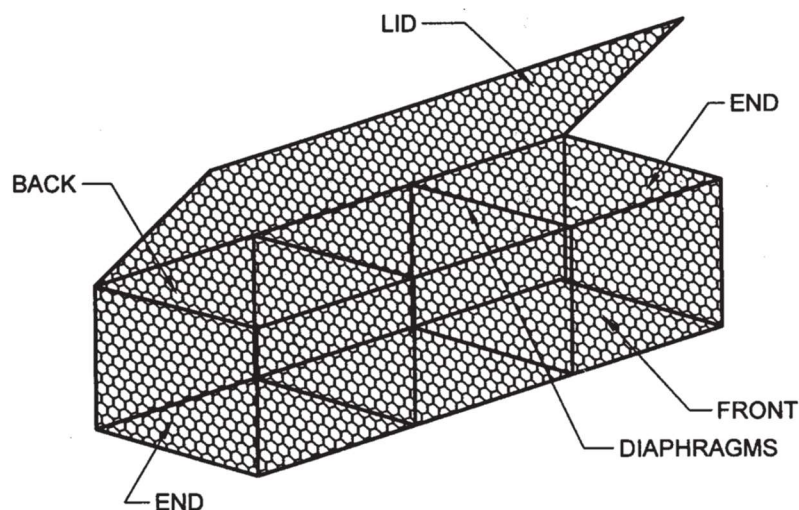
The gabions shall be used for riverbank protection, toe protection, retaining structures, slope protection, launching aprons, scour protection and other hydraulic protection works as required by the approved EPC design and as directed by the Engineer-in-Charge.

The gabion boxes shall be fabricated from **mechanically woven double-twisted hexagonal wire mesh**, manufactured from heavily galvanized steel wire with an additional PVC coating, conforming to the latest relevant IS, IRC and international standards applicable to gabion works.

The dimensions of gabion boxes may be selected by the Contractor based on the approved design, hydraulic requirements and site conditions. However, the minimum thickness (depth) of any gabion unit used for riverbank protection shall not be less than 1.0 metre. The Contractor shall ensure adequate stability, durability and performance of the gabion protection system under the design hydraulic and geotechnical conditions.

2. Materials

Gabion — A wire mesh container of variable sizes, uniformly partitioned into internal cells, interconnected with other similar units, and filled with stone at the project site to form flexible, permeable monolithic structures for earth retaining and erosion control purposes, such as retaining walls, sea walls, channel linings, revetments, offshore bunds, dykes and weirs.

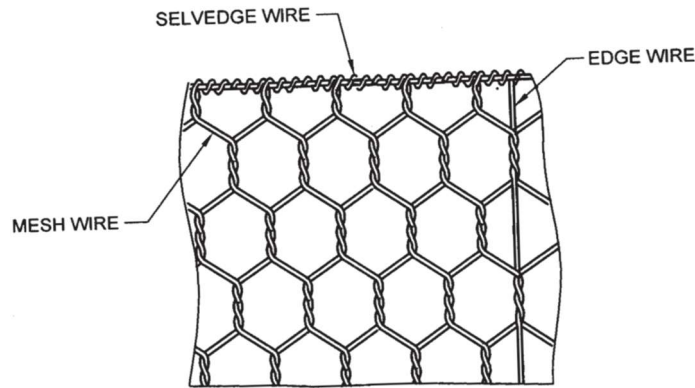


Double - twisted wire mesh - A non-raveling mesh made by twisting continuous pairs of wires through three one half turns (commonly called double twisted) to form hexagon shaped opening which are then interconnected to adjacent wires to form hexagonal opening.

Selvedge wire - A terminal wire used to edge the wire mesh perpendicular to the double twist by mechanically wrapping the mesh wire around at least 2.5 times.

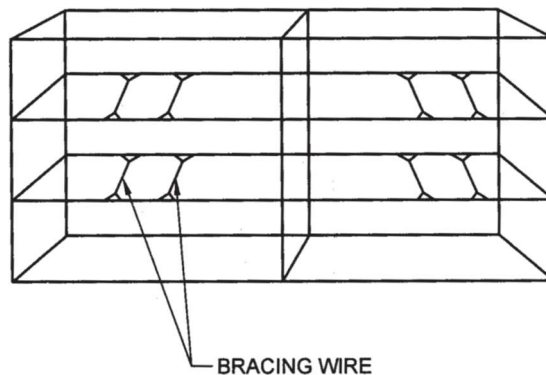
Edge wire- A terminal wire of same diameter as the selvedge wire used to edge the wire mesh parallel to the double twist by continuously weaving it mechanically into the wire mesh.

Lacing wire- A galvanized wire or galvanized wire with PVC coating used to assemble and interconnect empty units, to close and secure stone-filled units, and internal stiffeners.

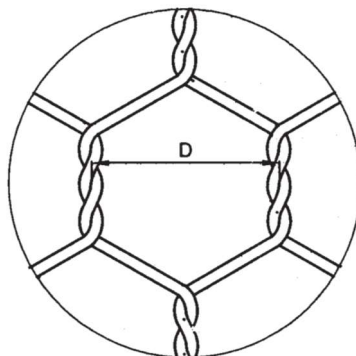


Stiffener- A length of galvanized wire with PVC coating used for support of facing by connecting the front panel to the back panel Rubble/Stone.

For 1-meter height gabions, evenly spaced two number of stiffeners shall be provided: At one-third ($1/3$) of the gabion height, measured from the base.



Mesh Size — The average distance, measured at right angles between twisted sides over 10 meshes.



CLASSIFICATION

Double-twisted wire mesh gabions, revet mattresses and rock fall netting are classified according to coating, as follows:

- a) *Class 1* — Consists of double-twisted wire mesh made from wire which is zinc coated before being double-twisted into mesh. Lacing wire and stiffeners are produced from zinc-coated wire; and
- b) *Class 2* — Consists of double-twisted wire mesh, lacing wire and stiffeners as Class 1 and over coated with PVC.

Material Testing and Approval

Prior to placing the order for procurement of gabions, the contractor shall ensure that the materials proposed to be used for manufacturing the gabion boxes are properly tested. All tests shall be carried out in the manufacturer's in-house laboratory, which must be equipped with adequate facilities for performing the required tests as mentioned below.

The contractor shall obtain Material Test Certificates (MTC) from the manufacturer for all materials supplied for the gabion work. These certificates shall clearly indicate that the materials conform to the contract specifications, relevant standards, and required quality parameters. Based on the submitted test certificates and supporting laboratory reports, the Engineer-in-Charge shall issue a written approval permitting the contractor to proceed with the procurement and supply of the gabions.

Materials and Manufacture:

The wire used in the manufacture of double twisted mesh for use in gabions shall conform to the specification as described hereinafter.

Double - twisted mesh shall be manufactured from the same type of galvanized steel wire with an additional PVC coating extruded on to the galvanized steel wire.

Lacing wire and stiffeners shall be made of wire having the same coating materials as the double twisted wire mesh confirming to specification IS 4826 or IS16014.

Mesh and Box Characteristics for Gabions

Mesh Type - 10 × 12, D = 100 mm

Sr.	Characteristics	Only zinc coated	Zinc + PVC coated
1	Mesh wire dia, mm	2.70	3.70
2	Edge/Selvedge wire dia, mm	3.40	4.40
3	Lacing wire dia,	2.20	3.20

	mm		
4	PVC coating thickness, mm	-	Nominal – 0.50 Minimum – 0.40
5	Tolerances in size of Gabion Box Length and Width ± 5 percent Height ± 5 percent		

Material Tests required to be carried out for G.I. wire and P.V.C. coating.

Galvanized wire			
Test	Value	Tolerance	Ref. Code
Tensile strength	350 to 550 MPa	-	IS 280
Elongation	10% min	-	IS 280
Mesh wire dia (Zinc coated)	2.7 mm	+/- 0.07	IS 16014
Edge and Selvedge wire dia (Zinc coated)	3.4 mm	+/- 0.09	IS 16014
Lacing wire dia (Zinc coated)	2.2 mm	+/- 0.06	IS 16014
Mesh Panel Strength			
Parallel to twist, kN/m	32.0 min	-	IS 16014
Perpendicular to twist, kN/m	15.5 min	-	IS 16014
Minimum Mass of Zinc Coating			
Nominal Dia of Galvanized wire	Mass of Zinc coating g/m ²		
2.7 mm	260	-	IS 16014
3.4 mm	270	-	IS 16014
2.2 mm	240	-	IS 16014
	No		IS

Adhesion of ZN	Flakes	-	4826
Mesh Types and Sizes			
10 × 12	'D' Nominal Size 100	+16 percent to -4 percent	IS 16014

PVC Coating Material			
Test	Value	Tolerance	Ref. Code
Color	Grey RAL 7037		ASTM D 1482
Specific gravity	1.30 to 1.35	-	IS 13360
Tensile strength	Not less than 20.6 MPa	-	IS 13360
Hardness	Shore 'D' between 50 and 60		IS 13360
Resistance of PVC coating to sodium chloride solution	No loss of mass		IS 16014
Salt spray exposure	No effect after 3000 h of salt spray exposure		IS 13360

WORKMANSHIP

Wire of proper grade and quality, when fabricated in the manner herein required, shall result in a strong, serviceable mesh type product have substantially uniform openings. It shall be fabricated and finished with good workmanship as determined by visual inspection and shall conform to this standard.

MARKING

Each finished product shall be marked legibly and indelibly with the following details:

- Name of manufacturer
- Product type (gabions)

- c) Mesh type (10 × 12)
- d) Class of coating;
- e) Mesh wire size, in mm;
- f) Size, in m (length × width × height — For gabions)
- g) Batch No. or date of manufacturing; and
- h) Any other information as specified by the purchaser.

Quality Control Tests for site of work:

Every 2000 Nos of wire gabion shall have deemed to be a lot. Three representative wire gabions shall be selected from the lot by authorized representative of department and the same shall be tested for the following parameter at Govt. or Govt. approved laboratory.

- 1.0 Mesh, Edge/Selvedge and Lacing wire diameter with and without PVC coating
- 2.0 Physical dimensions of Gabion Box and mesh size
- 3.0 Mesh Panel Strength (Parallel and Perpendicular to twist)
- 4.0 Tensile strength
- 5.0 Elongation
- 6.0 Minimum Mass of Zinc Coating

Rubble stone

(i) Stone Quality and Weight

The stones used for gabion filling shall be hard, durable, angular, sound and free from cracks, weathered surfaces, clay, organic matter or other deleterious materials. The stones shall be resistant to abrasion, impact and disintegration under hydraulic conditions.

The individual stone pieces used for filling the gabions shall generally weigh between 10 kg and 40 kg and shall be of suitable dimensions to ensure proper interlocking and prevent escape through the mesh openings.

The Contractor shall ensure dense hand packing of stones, particularly on exposed faces, to minimize voids and obtain a stable and durable gabion structure.

For measurement and quality control purposes, the filled gabion unit shall have a minimum bulk weight of 1,650 kg per cubic metre of completed gabion volume. Any gabion found to have insufficient stone packing, excessive voids or a bulk density less than the specified requirement shall be dismantled and refilled by the Contractor at no additional cost to the Department.

Tolerance

Stones of the specified weight shall be used for the work.

At least 80% of the stones shall fall within the specified weight range.

The remaining 20% stones may be used for packing and interlocking purposes.

The following tolerances shall be allowed:

Weight tolerance: ± 5%

Variation in above proportion: ± 5%

(ii) Testing

The contractor shall supply, at his own cost, all test specimens and samples required for testing. The samples shall be tested in Government laboratories or Government-approved laboratories, and the test results shall be submitted to the Engineer-in-Charge for approval. All test results shall comply with the specified requirements.

Sr. No.	Particulars of Test	Frequency	Acceptance Criteria
1	Water Absorption (as per IS 1124)	1 test per week	Not more than 5%
2	Specific Gravity (as per IS 1122)	1 test per week	Value shall generally not be less than 2.5
3	Compressive Strength (as per IS 1121)	2 sets of tests per working season or whenever source changes	Basalt – minimum 400 kg/cm ²
4	Weathering Test (as per IS 1125)	2 sets of tests per working season or whenever source changes	Loss not exceeding 10%

Note:

All tests required for rubble stones shall be carried out as per the relevant Indian Standard provisions.

(iii) Rejection

Rubble stones shall be rejected if they fail to comply with any of the requirements specified above.

3. Preparation of Foundation Surface

The area where gabions are to be placed shall be cleared of vegetation, loose soil, and debris. The surface shall be properly levelled and prepared to the required line and level before

placing gabions.

4. Placement and Assembly of Gabions

Empty gabion boxes shall be **placed in position and assembled at site**. Adjacent gabions shall be **properly connected with lacing wire** to ensure structural continuity. Gabions shall be arranged **to the required line, level, slope and section** as shown in the drawings.

5. Filling of Gabions with Stones

The stones used for filling the gabions shall generally weigh between 10 kg and 40 kg per stone and shall conform to the following gradation:

- 10 kg to 40 kg stones: 80 %
- 0 kg to 10 kg stones: 20 %

The smaller stones within the above gradation shall be used for filling voids and interstitial spaces between the larger stones in order to obtain dense packing and better stability of the gabion structure.

6. Closing and Lacing

After filling, the lid of the gabion box shall be properly closed and tightly laced with lacing wire. All joints shall be securely tied to prevent opening during service.

7. Arrangement in Layers

Gabions shall be placed in required layer thickness and arrangement as shown in the drawings or as directed. Each layer shall be properly aligned and securely connected to the adjacent gabions.

8. Record of Work

The contractor shall maintain records including:

Source and supply of gabion mesh and stones

Weight receipts from authorized weighbridge for stone supply

Royalty passes for quarry material when required

Initial and final levels where applicable

Photographic documentation **before, during, and after installation**

Verification of Weight of Individual Stones

The contractor shall ensure that the specified weight of individual trap rubble stones used in the work is strictly maintained as per the item specification. For this purpose, the contractor shall provide a suitable weigh balance at the site for checking the weight of individual stones during execution of the work.

The weigh balance provided at site shall be of adequate capacity and accuracy to measure the specified range of stone weights and shall be properly calibrated by an authorized agency. The calibration certificate of the weigh balance shall be made available for inspection by the

Engineer-in-Charge or departmental representatives whenever required.

The weigh balance shall be kept readily available at site throughout the execution period of the work, and the Engineer-in-Charge or his authorized representative shall have the right to verify the weight of any individual stone at any time during the course of work.

If any stone is found to be below the specified weight range or outside the permissible tolerance, such stones shall be immediately rejected and removed from the work site by the contractor at his own cost.

MEASUREMENT AND PAYMENT

Payment shall be made in accordance with the EPC Contract and the Payment Schedule

Geo Fabric

General

The nonwoven geo textile shall be manufactured from high quality polypropylene staple fibres. The fibres shall be mechanically bonded needle through needle-punching to create a strong, flexible and dimensionally stable fabric structure, with optimum pore sizes and high permeability. The geo textile shall be resistant to chemicals and biological organisms normally founded in soils and shall be stabilized against degradation due to shorter exposure to ultraviolet radiation.

Testing

Prior to placing the order of non woven geo febric. Testing of the material shall got testated at Manufacturer laboratory. The Manufacturer must have in house laboratory facility for carrying out all tests as specified in below table. If the test results from the Manufacturer's laboratory are found satisfactory, the Engineer-in-Charge shall: Issue a written approval for the Contractor to proceed with procurement. The Contractor shall bear all expenses related to the approval of the Manufacturer, including: Transportation and Accommodation of departmental officals.

In addition to the above testing, the Contractor shall arrange for independent quality verification testing of non-woven geotextile filter specimens at:

1. BTRA (Bombay Textile Research Association), Mumbai, or
2. An equivalent laboratory approved by the Engineer-in-Charge.

Sampling of non-woven geotextile filter specimens for independent quality verification testing shall be conducted in the presence of authorized representative of contractor and department. If any parameter fails to meet the specified requirements during independent quality verification testing, the Engineer-in-Charge reserves the right to: Reject all materials brought to the site by the Contractor and Declare the materials unfit for purpose. For which no extra claim shall be entertained.

In the event of a change in the source or Manufacturer of the non-woven geotextile filter for any reason, the following procedures shall apply:

1. The testing procedure outlined above shall be repeated.
2. Approval from the Engineer-in-Charge shall be obtained before proceeding with procurement.

TABLE SHOWING THE PHYSICAL PROPERTIES OF NON-WOVEN GEO FABRIC FILTER

Sr.No	Physical properties	Test Method	Value
1	Mass per unit area	ASTM D 5261	≥ 235 g/m
	Mechanical		
1	Grab tensile strength	ASTM D 4632	≥ 750 N
2	Grab elongation	ASTM D 4632	$\geq 50\%$
3	puncture strength	ASTM D 4833	≥ 450 N
	Hydraulic		
1	Apparent opening size	ASTM D 4751	≤ 200 Micron
2	Water flow rate	ASTM D 4491	≥ 45 l/sqm/sec
Standard Roll Dimensions normal to the plane		Roll length 100 m. Roll width 5.0 m.	

Certification:

Material test certificate of supplied materials by the manufacturer shall be produced by the contractor. The certificate shall mention that the material meets the contract specification.

VOLUME – II (PART-A)

SECTION-C

SCOPE OF WORK (DESIGN REQUIREMENTS)

Scope of Work

1. Objective

Design, procure and construction of Hydraulic structure with all necessary arrangements on Dhadhar river at Village Magnad Ta.Jambusar Dist.Bharuch that will:

- Prevent tidal water ingress into the freshwater so as to prevent the salinity ingress in upstream areas.
- Ensure safe regulation and control of river flows.
- Facilitate continued transportation for local farmers
- Provide upstream and downstream bank protection works to prevent erosion.

2. Design Criteria

- The new structure shall be constructed on same location of the existing old structure after performing a detailed survey investigation, technical feasibility and as per approved design specifications. If required dismantling can be done accordingly with prior approval of the Engineer-in-Charge/Competent Authority. The Contractor shall be solely responsible for the adequacy, safety, and performance of the adopted design.
- The structural design shall be done by considering proposed structure in fully submerged conditions.
- All structural components shall be designed to withstand bidirectional hydrodynamic pressure (freshwater as well as tidal water), buoyancy effects, structural loads and other relevant pressure conditions.
- The crest level of the new structure shall be maintained identical to that of the existing structure.
- The top level of the bridge deck shall remain same as that of the

existing structure.

- The effective Water way of the proposed structure shall not be less than the effective water way of existing structure.
- To ensure separation of tidal and freshwater, a manually operated gate shall be designed for the Highest Tide Level (HTL) plus 0.50 m freeboard with Hoist arrangement.
- To avoid any land acquisition and to facilitate easy operation, handling and maintenance of the gates, the maximum height of any individual gate panel shall be limited to 0.50 m.
- The structure shall be designed to safely withstand a minimum flood discharge of 1,20,000 cusecs.
- The bridge shall be designed for IRC Class AA Loading and shall provide a minimum clear carriageway width of 5.50 m.

In addition, a separate service width/platform shall be provided for operation, maintenance and hoisting of gates.

Suitable arrangements for handling and storage of stop logs (2 sets) shall also be incorporated in the design.

3. Materials & Construction

- Protection Wall / Non-Structural Concrete
The Contractor shall provide protection work of minimum 100 meters length on both the sides of upstream and downstream.
- **Reinforcement:**
- Minimum FE-500D Corrosion Resistant Steel (CRS) reinforcement bars shall be used to ensure long-term durability

4. Preliminary Works

- Topographic survey of site and approaches.
- Hydrological & hydraulic studies: flood flows, tide levels, HFL, LWL, discharge, afflux.
- Geotechnical investigation: foundation depth, soil bearing Capacity, swelling pressures.

5. Civil Works

- Include all dismantling, diversion, and temporary works necessary for construction without disruption to downstream flow or flooding.
- All necessary River diversion & cofferdam works.

6. Vetting and Approval of design

The Bidder shall prepare and submit all designs through a qualified and experienced design consultant. The designs shall be vetted by a reputed institution IIT, NIT, or CDO Gandhinagar. After vetting, the designs shall be submitted to the EIC for review and final approval. All costs associated with the preparation, vetting, review, modifications, and approval of the designs shall be borne entirely by the Bidder.

7. Miscellaneous Items

- The Contractor shall include all essential items for safe and durable operation, including but not limited to:
- Weep holes, drainage, access, safety railings, Solar lighting, PVC water stops, Protective coatings/painting etc.
- Any other item necessary for make the structure fully operational, safe, and durable, even if not explicitly listed in the tender, falls under necessary work. The contractor cannot skip these items.

8. Quality Assurance

- All works to conform to IS/IRC codes.
- QA/QC plan with third-party

9. Operation & Maintenance

- Operation & Maintenance Period - 5 years
- During the Operation and Maintenance Period, the Contractor shall carry out inspection, maintenance, operation of gates, and defect rectification of the entire works to ensure safe and satisfactory performance.

10. Additional Requirement:

a) Site Office: The Contractor has to provide office, a Computer System with Internet facilities as approved by the Engineer-in-Charge, these facilities shall made available till the completion of project.

b) Vehicle: The Contractor has to provide Two no. of SUV vehicle of model manufactured after 2025 in working condition with the provision of licensed driver and is expected to run up-to 2500 kms/month for the department staff. The vehicle to be deployed from the date of work order till the completion of project. All expenses of operation and maintenance of the vehicles shall have to be bear by the contractor itself.

VOLUME – II (PART-B)

**TECHNICAL SPECIFICATIONS
MECHANICAL WORKS**

TECHNICAL SPECIFICATIONS FOR GATES

GENERAL

The NWRWS & Kalpasar Department, Government of Gujarat, proposes the EPC (Engineering, Procurement and Construction) work for Design, Procurement, Construction, Testing, Commissioning and Operation & Maintenance of a Cross Regulator-cum-Bridge across River Dhadhar near Village Magnad, Taluka Jambusar, District Bharuch, Gujarat, including gates, stop logs, manual hoisting arrangements, river training works, bank protection works and all allied civil and mechanical components.

The objective of the project is to regulate river flows, prevent ingress of tidal saline water into upstream freshwater reaches, improve local connectivity and provide adequate protection against erosion and scour. The completed works shall ensure safe, reliable and sustainable operation throughout the design life of the structure.

These General Technical Specifications shall form an integral part of the Contract and shall be read in conjunction with the Particular Technical Specifications. In case of any discrepancy, the Particular Technical Specifications shall prevail.

1.0 LOCATION

The proposed Cross Regulator-cum-Bridge is located across River Dhadhar near Village Magnad, Taluka Jambusar, District Bharuch, Gujarat.

1.1 PROJECT LAYOUT

The principal gated components shall comprise:

- a) Vertical Lift Gates complete with gate leaves, embedded parts, guide frames, seals and accessories.
- b) Manual Hoisting Arrangements including operating platforms, lifting devices, operating mechanisms and supporting structures.
- c) Two (02) complete sets of Stop Logs including stop log elements, lifting beams, guides and accessories required for maintenance and emergency isolation.
- d) Access platforms, walkways, ladders and associated civil interfaces.
- e) Auxiliary equipment and safety provisions necessary for operation and maintenance.

The detailed dimensions, number of bays, gate sizes, sill levels, operating levels and all other design parameters shall be determined by the EPC Contractor based on hydraulic, structural and geotechnical investigations and applicable standards.

1.2 ATMOSPHERIC CONDITIONS

All equipment shall be suitable for continuous outdoor operation under the following site conditions:

- Maximum Ambient Temperature: 45°C
- Minimum Ambient Temperature: 5°C
- Relative Humidity: Up to 95%
- Tropical and corrosive riverine environment

- Exposure to saline and tidal influences
- Heavy monsoon rainfall and flood conditions

1.3 SCOPE OF CONTRACT

The Contractor shall be responsible for complete design, vetting, manufacture, supply, inspection, testing, transportation, storage, erection, commissioning and Operation & Maintenance of all gates, stop logs, hoisting arrangements, embedded parts and associated equipment required under the Contract.

The scope shall include:

- a) Hydraulic and structural design.
- b) Vetting of design and drawings through IIT, NIT, CDO Gandhinagar or any other institution approved by the Engineer-in-Charge (EIC), at Contractor's cost.
- c) Preparation and submission of design calculations, drawings, manuals, QAP and related documents.
- d) Procurement and supply of all materials, bought-out items and accessories.
- e) Fabrication, shop assembly, testing, erection and commissioning.
- f) Surface preparation, painting and corrosion protection.
- g) Supply of special tools, lifting beams, tackles and maintenance equipment.
- h) Five (5) years Operation & Maintenance after successful commissioning.
- i) Rectification or replacement of defective components during the O&M period at no additional cost to the Department.

Any item not specifically mentioned but necessary for safe, reliable and satisfactory operation of the system shall be deemed included in the Contractor's scope.

The Contractor shall provide safe access arrangements for operation, inspection and maintenance of all equipment.

2.0 WASTAGE OF STEEL

No compensation shall be payable for wastage of steel under the price variation clause.

Price adjustment for steel shall be limited to the net theoretical weight of structural steel incorporated in the works as determined from approved fabrication drawings and standard sectional weights published by BIS/SAIL.

The weight of bolts, nuts, washers, rivets, welding consumables and fabrication wastage shall not be considered for price adjustment purposes and shall be deemed included in the Contractor's rates.

3.0 SCHEDULE AND PROGRESS

3.1 Submission of Design and Drawings

The Contractor shall submit detailed design calculations, drawings and design vetting reports within 180 (One Hundred Eighty) calendar days from the date of commencement of work.

3.2 Fabrication and Erection Schedule

Within 15 (Fifteen) calendar days from approval of the design, the Contractor shall submit a detailed programme covering:

- Procurement of materials
- Fabrication schedule
- Shop inspection and testing
- Erection and installation programme
- Testing and commissioning programme

The programme shall clearly identify all milestones for monitoring and inspection.

4.0 WARRANTY AND PERFORMANCE GUARANTEE

The Contractor shall provide a comprehensive Warranty and Performance Guarantee for all gates, stop logs, hoisting arrangements, embedded parts and associated equipment for the entire Operation & Maintenance period of Five (5) years from the date of successful commissioning.

The warranty shall cover:

- a) Quality, strength and durability of materials.
- b) Adequacy and safety of design.
- c) Structural integrity and operational reliability.
- d) Proper functioning of seals, guides, embedded parts and operating mechanisms.
- e) Protection against corrosion, wear and environmental deterioration.
- f) Satisfactory performance under all specified operating conditions.

Any defect, deficiency, malfunction or failure occurring during the Warranty/O&M period shall be rectified or replaced by the Contractor at his own cost within the time specified by the Engineer-in-Charge.

Approval of designs, drawings or calculations by the Engineer-in-Charge shall not relieve the Contractor of responsibility for the adequacy, safety, durability and performance of the works.

5.0 DRAWINGS, DESIGN CALCULATIONS AND DATA TO BE FURNISHED BY THE CONTRACTOR

5.1 General

The EPC Contractor shall be responsible for the complete design, vetting, preparation of drawings, fabrication details and technical documentation for gates, stop logs, hoisting arrangements, embedded parts, operating platforms, supporting structures and all associated components covered under the Contract.

5.2 Submission of Documents

Within 180 (One Hundred Eighty) calendar days from the date of issue of Letter of Acceptance/Notice to Proceed and before commencement of fabrication, the Contractor shall submit:

- a) Design calculations, design reports and design basis documents.

- b) Design vetting certificate issued by IIT, NIT, CDO Gandhinagar or any institution approved by the Engineer-in-Charge (EIC). The cost of vetting shall be borne by the Contractor.
- c) General Arrangement Drawings, fabrication drawings and erection drawings.
- d) Hydraulic and structural design calculations covering all applicable loading conditions.
- e) Bill of Materials, material specifications and technical particulars of bought-out items.
- f) Fabrication, transportation, erection, testing and commissioning methodology.
- g) Quality Assurance Plan (QAP), Inspection & Test Plan (ITP) and inspection schedules.
- h) Operation & Maintenance Manuals, erection manuals and safety procedures.

5.3 Approval of Documents

No fabrication, procurement of major components or erection work shall commence until the relevant designs and drawings have been reviewed and approved by the Engineer-in-Charge. Any work executed prior to approval shall be entirely at the Contractor's risk and any resulting modification, replacement or rectification shall be carried out without additional cost to the Department.

The Engineer-in-Charge may require modifications or additional details necessary to ensure compliance with the Contract requirements, and the Contractor shall incorporate such changes without additional financial implication to the Department.

5.4 Contractor's Responsibility and Performance Guarantee

Approval, review or acceptance of any design, drawing, calculation or document by the Engineer-in-Charge shall not relieve the Contractor of responsibility for the adequacy, safety, stability, durability, serviceability and performance of the works.

The Contractor shall remain fully responsible for ensuring that the gates, stop logs, hoisting arrangements, embedded parts, sealing systems and all associated equipment are properly designed, manufactured, erected, tested and commissioned and perform satisfactorily under all specified operating, flood, tidal and emergency conditions throughout the design life of the project.

All materials, components, accessories, tools, tackles and incidental items necessary for safe, reliable and satisfactory operation of the works, whether specifically mentioned or not, shall be deemed included in the Contractor's scope and shall be provided without additional cost to the Department.

The Contractor shall rectify or replace, at his own cost, any defect, deficiency or failure arising from defective design, materials, workmanship, fabrication, erection or installation during the Warranty and Operation & Maintenance period.

6.0 STANDARDS

The design, manufacture, fabrication, testing, transportation, erection, commissioning, operation and maintenance of all gates, stop logs, hoisting arrangements and associated equipment shall conform to the latest applicable Indian Standards (BIS). Where BIS standards are unavailable or inadequate, internationally recognized standards such as ISO, ASTM, ASME, DIN, BS, EN, IEC or equivalent approved standards may be adopted with prior approval of the Engineer-in-Charge.

In case of conflict between standards, the more stringent requirement shall govern unless otherwise directed by the Engineer-in-Charge.

The order of precedence shall be:

- a) Contract Agreement and Special Conditions of Contract
- b) Particular Technical Specifications
- c) General Technical Specifications
- d) Approved Drawings
- e) Applicable Standards and Codes

The Contractor shall be solely responsible for ensuring compliance of all designs, materials, fabrication procedures, testing methods and workmanship with the approved standards and intended service conditions.

7.0 COMPONENTS OF GATES AND EMBEDDED PARTS

7.1 Gate Dimensions and Freeboard

The dimensions of gates, embedded parts and associated equipment shall be determined by the Contractor based on hydraulic studies, tidal levels, design flood conditions, sedimentation, operational requirements and applicable standards.

The top of the gate in the fully closed position shall be kept **at least 0.50 m above the Highest Tide Level (HTL)** or governing design water level, whichever is higher. The Contractor shall demonstrate through design calculations that the proposed gate dimensions, operating levels and freeboard are adequate for safe operation under all specified conditions.

To avoid any land acquisition and to facilitate easy operation, handling and maintenance of the gates, the maximum height of any individual gate panel shall be limited to 0.50 m.

7.2 Gate Skin Plate

The gate skin plate shall be designed considering hydrostatic pressure, differential water head, impact, handling and operational loads, including corrosion allowance.

The minimum thickness of the skin plate shall be 12 mm unless otherwise justified by design and approved by the Engineer-in-Charge (EIC). Adequate stiffeners shall be provided to maintain stresses and deflections within permissible limits.

7.3 Seals and Seal Seats

Suitable side, bottom and top seals conforming to relevant Indian Standards or equivalent approved standards shall be provided to limit leakage and prevent saline water ingress.

Seal seats shall be fabricated from stainless steel with a minimum finished thickness of 10 mm after machining. The sealing surfaces shall be accurately aligned, smoothly finished and free from defects affecting sealing performance.

Seal fixing arrangements, including bolts, nuts, washers and inserts, shall be of corrosion-resistant stainless steel and designed to withstand all operating forces.

7.4 Seal Seat Bases and Sill Beams

Seal seat bases, sill beams and associated embedded components shall be fabricated from

structural steel conforming to applicable standards.

Components exposed to tidal or saline water shall be provided with suitable corrosion-resistant protection such as stainless steel cladding, wearing surfaces or approved equivalent systems.

Proper alignment of guide tracks, seal seats and sill beams shall be ensured during fabrication and installation.

7.5 Embedded Parts

Embedded parts including guide frames, sill beams, seal supports, brackets and anchor assemblies shall be designed to safely resist hydraulic, operational, impact and construction loads and transfer such loads effectively to the concrete structure.

Provision shall be made for alignment and adjustment during erection.

7.6 Anchorages, Block-outs and Second Stage Concrete

The Contractor shall design and provide all anchor bolts, studs, inserts, dowels, block-outs and embedment arrangements required for installation and fixation of embedded parts.

Anchor bolts, studs and dowel bars shall generally not be less than 16 mm diameter unless otherwise justified by design calculations.

Where second-stage concreting is adopted, the concrete grade shall not be less than M-30 and shall be equal to or higher than the adjoining structural concrete.

Adequate shear connectors, dowels or equivalent load-transfer devices shall be provided to ensure monolithic action between parent concrete and second-stage concrete.

All surfaces receiving second-stage concrete shall be properly roughened and cleaned before concreting.

Provision shall be made for final alignment and adjustment of embedded parts before permanent fixation.

7.7 Corrosion Protection

All gates, stop logs, embedded parts and associated components shall be provided with a corrosion protection system suitable for the tidal and saline environment of the project site.

The protection system shall include surface preparation, protective coatings, stainless steel contact surfaces and other approved measures necessary to achieve the specified design life with minimum maintenance requirements. Detailed requirements for painting and corrosion protection shall comply with **Clause 13.0** of these Specifications.

8.0 MATERIALS AND MATERIAL SPECIFICATIONS

All materials used for gates, stop logs, hoisting arrangements, embedded parts and associated components shall conform to the latest applicable Indian Standards (BIS) or equivalent internationally recognized standards approved by the Engineer-in-Charge (EIC).

The materials listed in Table-1 represent the minimum acceptable requirements. The Contractor shall be responsible for selecting materials suitable for the design loads, service

conditions, tidal and saline environment, durability requirements and specified design life of the structure.

Prior to procurement and fabrication, the Contractor shall submit detailed material specifications, manufacturer's test certificates and relevant technical data for approval by the Engineer-in-Charge.

TABLE-1
RECOMMENDED MATERIALS FOR GATES, STOP LOGS AND HOISTING ARRANGEMENTS

Sl. No.	Component / Article	Recommended Material	Applicable Standard
1	Gate skin plates, stop log skin plates, stiffeners, girders, diaphragms, seal bases, track bases, guides, anchor plates, lifting lugs and other structural members	Structural Steel Grade E250 or higher	IS 2062
2	Seal seats	Stainless Steel SS 316 / SS 316L	Relevant BIS Standards
3	Track plates and wearing surfaces	Stainless Steel SS 316 / SS 316L	Relevant BIS Standards
4	Embedded part face plates exposed to tidal or saline water	Stainless Steel SS 316 / SS 316L	Relevant BIS Standards
5	Side and Bottom Seals	Rubber Seals conforming to IS 11855 / IS 15466 or equivalent approved standard	IS 11855 / IS 15466
6	Seal Fasteners	Stainless Steel SS 316	Relevant BIS Standards
7	Anchor bolts, studs and embedded fasteners	Galvanized steel or Stainless Steel	Relevant BIS Standards
8	Hoisting arrangement components	Structural Steel, Alloy Steel or other suitable materials as per design	Relevant BIS Standards

Notes

a) Latest revisions of all applicable standards shall govern.

- b) Equivalent materials may be used only with prior approval of the Engineer-in-Charge.
- c) Stainless Steel SS316/SS316L shall be preferred for components continuously exposed to tidal water, saline splash zones or submerged conditions.
- d) The Contractor shall submit complete material details and obtain approval before commencement of fabrication.

9.0 GENERAL MATERIAL REQUIREMENTS

All materials incorporated in the works shall be new, unused, free from defects and conform to the approved specifications and applicable standards.

The Contractor shall submit material specifications, manufacturer's test certificates, technical data sheets and details of proposed manufacturers for approval by the Engineer-in-Charge prior to procurement and fabrication.

All bought-out items shall be procured from reputed manufacturers having proven performance records. Any material or equipment incorporated without approval of the Engineer-in-Charge shall be liable for rejection and replacement at the Contractor's cost.

10.0 MINIMUM THICKNESS REQUIREMENTS

The thickness of gate skin plates, stop log plates and structural members shall be determined by detailed design calculations considering all applicable loads, fabrication requirements and corrosion allowance.

The minimum thickness requirements shall be as follows:

Component	Minimum Thickness
Gate Skin Plate	12 mm
Primary Structural Members (Girders, Lifting Beams, Columns, Hoist Supports, etc.)	10 mm
Rolled Structural Sections	8 mm
Corrosion Allowance for Carbon Steel Components	2 mm

Where plate joints are unavoidable, full-strength butt welds conforming to approved welding procedures shall be provided.

The Contractor shall demonstrate the adequacy of all component thicknesses through detailed structural design calculations.

11.0 DESIGN STRESSES

The gates, stop logs, hoisting arrangements, embedded parts and supporting structures shall be designed such that the stresses under the most adverse combination of loading conditions do not exceed the permissible limits specified in the applicable standards.

The design shall consider all applicable loads, including:

- a) Hydrostatic and hydrodynamic loads
- b) Differential water pressure
- c) Tidal and saline water effects

- d) Sediment, debris and impact loads
- e) Hoisting, handling and operational loads
- f) Wind loads
- g) Seismic loads
- h) Temperature effects
- i) Construction and maintenance loads

Permissible stresses in structural members, welds, bolts, anchorages and mechanical components shall comply with the relevant standards. The Contractor shall submit complete design calculations demonstrating compliance with the specified requirements.

12.0 FABRICATION, MACHINING AND WORKMANSHIP

12.1 General

All fabrication, machining, assembly and erection works shall be carried out in accordance with approved drawings, specifications, applicable standards and good engineering practice.

All materials shall be new, free from defects and properly prepared before fabrication. Components shall be accurately aligned and assembled to achieve the required strength, rigidity, dimensional accuracy, water-tightness and operational reliability.

Where transportation limitations require subdivision of assemblies, detailed transportation and field assembly procedures shall be submitted for approval.

12.2 Tolerances and Fits

Manufacturing tolerances and fits shall conform to relevant BIS standards or equivalent approved standards. The Contractor shall establish suitable tolerances considering fabrication, erection and operational requirements.

12.3 Structural Steel Fabrication

Structural steel fabrication shall conform to applicable BIS standards. Cutting, forming, straightening and assembly operations shall be carried out using approved procedures that do not impair the mechanical properties of the material.

Cut edges shall be smooth and free from defects. Structural members shall be free from twists, bends and distortions.

12.4 Welding

All welding shall conform to applicable BIS standards and shall be performed by qualified welders using approved welding procedures and consumables.

Weld preparation, fit-up, preheating, interpass temperature control and post-weld treatment shall comply with approved procedures. Completed welds shall be free from cracks, porosity, undercuts and other unacceptable defects.

Non-Destructive Testing (NDT)

The extent of NDT shall comply with the approved Quality Assurance Plan (QAP). As a minimum:

- a) Critical full-penetration butt welds in major load-carrying members shall undergo 100% Ultrasonic Testing (UT) or Radiographic Testing (RT).
- b) Secondary welds shall undergo visual inspection and random Magnetic Particle Testing

(MPT) or Dye Penetrant Testing (DPT).

c) Defective welds shall be repaired and re-tested at the Contractor's cost.

12.5 Castings and Forgings

Castings and forgings shall conform to applicable standards and shall be free from defects detrimental to service performance. Inspection and testing shall be carried out in accordance with the approved QAP.

12.6 Bolted Connections

Bolted connections shall conform to relevant BIS standards. Bolt holes shall be accurately drilled and aligned. All bolts, nuts and washers exposed to the atmosphere or moisture shall be provided with suitable corrosion protection.

The Contractor shall supply not less than 15% additional quantity of field erection bolts, nuts and washers of each size for maintenance purposes.

12.7 Machining and Surface Finish

Machined surfaces shall be finished to the tolerances and surface roughness specified in the approved drawings and applicable standards. Sliding, sealing, bearing and wearing surfaces shall receive suitable machining to ensure proper operation and service life.

12.8 Stress Relieving

Stress relieving shall be carried out wherever required by design, welding procedures or applicable standards.

12.9 Interchangeability and Identification

Components of similar type shall, as far as practicable, be interchangeable.

All gates, stop logs, embedded parts, hoisting equipment and transportable assemblies shall be permanently identified and match-marked in accordance with approved fabrication and erection drawings.

13.0 PAINTING AND CORROSION PROTECTION

13.1 General

Considering the tidal and saline environment at the project site, all gates, stop logs, hoisting arrangements, embedded parts and associated steel components shall be provided with an approved corrosion protection system designed to achieve the specified service life.

The Contractor shall submit the proposed coating system, manufacturer's data sheets, application procedures and test certificates for approval by the Engineer-in-Charge (EIC) before commencement of painting works.

13.2 Surface Preparation

All steel surfaces shall be cleaned and prepared in accordance with applicable standards. Surface preparation shall include removal of oil, grease, rust, mill scale, welding slag and other contaminants.

Unless otherwise approved, abrasive blast cleaning shall be carried out to Sa 2½ finish or equivalent. Primer coating shall be applied immediately after surface preparation.

Stainless steel, machined, bearing and other unpainted surfaces shall be adequately protected during painting operations.

13.3 Coating System

The coating system shall consist of approved primer, intermediate and finish coats suitable

for immersion, splash zone and atmospheric exposure conditions.

Unless otherwise approved, the minimum total Dry Film Thickness (DFT) shall be 350 microns for gates, stop logs and exposed embedded parts.

Alternative coating systems may be adopted subject to approval by the EIC and demonstration of equivalent or superior performance.

13.4 Surfaces Not to be Painted

The following surfaces shall generally not be painted:

- a) Stainless steel surfaces
- b) Bronze, brass and galvanized surfaces
- c) Machined, bearing, sliding and rolling contact surfaces
- d) Surfaces embedded in concrete
- e) Name plates and identification plates

Suitable protective compounds shall be applied wherever required.

13.5 Inspection, Handling and Warranty

The Contractor shall carry out coating inspection, thickness measurement, adhesion testing and holiday testing, wherever applicable, in accordance with the approved Quality Assurance Plan.

Damaged coatings shall be repaired using the approved coating system before final acceptance.

The Contractor shall remain responsible for satisfactory performance of the corrosion protection system during the Warranty and O&M period and shall rectify any coating failure attributable to defective materials or workmanship at no additional cost to the Department.

14.0 QUALITY ASSURANCE, TESTING AND INSPECTION

14.1 Quality Assurance

The Contractor shall establish and maintain a comprehensive Quality Assurance (QA) and Quality Control (QC) system covering procurement, fabrication, assembly, transportation, erection, testing and commissioning of all equipment under the Contract.

Quality Assurance Plans (QAP), Inspection & Test Plans (ITP), inspection procedures and acceptance criteria shall be submitted for approval before commencement of the respective activities.

All materials and bought-out items shall be supported by Material Test Certificates (MTCs), inspection reports and traceability records.

14.2 Inspection and Testing

Inspection and testing shall be carried out in accordance with the approved QAP, applicable standards and approved procedures and shall include, as a minimum:

- a) Verification of material certificates and traceability
- b) Dimensional inspection of fabricated components
- c) Inspection of welding procedures and welder qualifications
- d) Non-Destructive Testing (NDT)
- e) Shop assembly and fit-up checks
- f) Coating inspections

g) Functional testing of gates, stop logs and hoisting arrangements

No equipment shall be dispatched without inspection and clearance by the Engineer-in-Charge.

14.3 Non-Destructive Testing

NDT shall be carried out in accordance with approved standards and the approved QAP using appropriate methods such as VT, UT, RT, MPT and DPT.

Defective welds or components shall be repaired and re-tested at the Contractor's cost.

14.4 Shop Assembly and Factory Acceptance Tests

Gates, hoisting arrangements and other critical assemblies shall be shop assembled and tested to verify dimensional accuracy, alignment, fit-up, interchangeability and workmanship prior to dispatch.

All components shall be permanently identified and match-marked for site erection.

14.5 Site Testing and Commissioning

After installation, the Contractor shall conduct operational, leakage and performance tests in the presence of the EIC.

Any defects observed during testing shall be rectified and the tests repeated until satisfactory performance is achieved.

The permissible leakage through a fully closed gate shall not exceed **5 litres per minute per gate**, unless a more stringent criterion is established during detailed design and approved by the EIC.

14.6 Documentation

The Contractor shall submit six (6) hard copies and one electronic copy of:

- a) Material Test Certificates
- b) Inspection and Test Reports
- c) NDT Reports
- d) Factory Acceptance Test Reports
- e) Coating Inspection Reports
- f) Calibration Certificates
- g) As-built Drawings
- h) Operation & Maintenance Manuals

14.7 Packing and Transportation

All equipment shall be properly packed, protected and transported to prevent damage, corrosion or deformation during handling and transit.

Equipment shall remain the responsibility of the Contractor until successful erection, testing and acceptance of the works.

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PART-C

OPERATION & MAINTENANCE WORKS

SECTION 1.0 – OPERATION & MAINTENANCE (O&M)

1.1 General

The Contractor shall be fully responsible for the operation, maintenance, repair, upkeep, safety, security, and satisfactory performance of all works executed under the Contract throughout the Operation and Maintenance (O&M) Period. The Contractor shall exercise due care, diligence, and professional skill to ensure that all facilities remain fully functional and serviceable at all times.

The Contractor shall provide, at his own cost, all necessary manpower, supervisory personnel, machinery, equipment, tools, vehicles, consumables, spare parts, materials, communication systems, testing equipment, and any other resources required for the effective operation and maintenance of the Project.

All provisions, obligations, conditions, specifications, standards, and requirements contained in the Tender and Contract Documents shall remain applicable during the O&M Period. The Contractor shall comply with all instructions issued by the Engineer-in-Charge (EIC) and shall promptly implement any measures, modifications, repairs, replacements, or improvements directed by the EIC for the proper operation and maintenance of the Project.

1.2 Scope of Operation and Maintenance

The O&M Period shall be Five (5) Years, including a Defect Liability Period (DLP) of Three (3) Years, commencing from the date specified in the Completion Certificate or as otherwise stated in the Contract.

During the O&M Period, the Contractor shall be responsible for the operation, maintenance, inspection, monitoring, repair, replacement, servicing, and upkeep of all components of the Project, including but not limited to:

- a) All civil structures, protection works, roads and associated infrastructure.
- b) All gates, hoisting arrangements, mechanical equipment, and associated components.
- C) Any other works, systems, equipment, or facilities forming part of the completed Project.

The Contractor shall, at a minimum, carry out the following activities:

- Repair and rectify any leakage, seepage, defects, deterioration, damage, malfunction, or failure occurring during the O&M Period.
- Carry out preventive, predictive, routine, breakdown, emergency, and seasonal maintenance.
- Undertake oiling and greasing of all gates, hoisting equipment, and associated mechanisms.
- Perform jungle clearance, vegetation removal, and site cleaning throughout the Project area, including upstream and downstream protection works, approaches,

and any other locations identified by the EIC, at least twice every year.

- Paint all gates, railings, platforms and other structures during the O&M Period as directed by the EIC.
- Keep all roads, work areas, and operational premises clean and free from debris.
- Resurface approach roads as required or at intervals directed by the EIC to ensure satisfactory serviceability.

The Contractor shall maintain sufficient stocks of consumables, spare parts, maintenance materials, lubricants, repair materials, and emergency equipment throughout the O&M Period.

Any additional activity not specifically mentioned herein but necessary for safe, reliable, efficient, and uninterrupted operation of the Project shall be deemed included within the Contractor's scope of work.

The Contractor shall be responsible for compensating any third-party losses, damages, or claims arising due to negligence, improper maintenance, or actions of his personnel. In the event of failure by the Contractor to settle such claims, the Employer may recover the associated costs from monies due or becoming due to the Contractor.

Upon completion of the O&M Period, the Contractor shall hand over the Project to the Employer in a fully operational, defect-free, clean, safe, and well-maintained condition to the satisfaction of the Engineer-in-Charge.

1.3 Administrative Requirements

1.3.1 Responsibility and Risk

The Contractor shall assume full responsibility for the care, custody, operation, maintenance, and protection of the Works, including all materials, equipment, and facilities, from the date of issuance of the Completion Certificate until expiry of the O&M Period.

Any loss, damage, deterioration, malfunction, or defect occurring during this period shall be rectified by the Contractor at his own cost and to the satisfaction of the Engineer-in-Charge.

The Contractor shall remain responsible for any damage arising from his operations, maintenance activities, negligence, omissions, or failure to comply with contractual requirements.

1.3.2 O&M and Defect Liability Period

The O&M Period shall be Five (5) Years, including a Defect Liability Period of Three (3) Years, commencing from the date of issue of the Completion Certificate.

Should the Employer elect to extend the O&M Period, written notice shall be provided to the Contractor at least 180 days prior to expiry of the existing O&M Period. Such extension shall be subject to mutually agreed terms and conditions unless otherwise provided in the Contract.

In the event of termination or foreclosure of the O&M Contract, the Defect Liability

obligations shall remain enforceable in accordance with the Contract provisions.

1.3.3 Insurance

The Contractor shall obtain and maintain, at his own cost, all insurance policies required under the Contract, including but not limited to:

- a) Insurance covering the Works and all materials incorporated therein for their full replacement value.
- b) Insurance covering the Contractor's equipment, machinery, tools, vehicles, and other assets brought to the Site.
- c) Third-party liability insurance.
- d) Workmen compensation and statutory employee insurance.

The insurance policies shall remain valid throughout the O&M Period.

The Contractor shall indemnify and hold harmless the Employer against all claims, losses, damages, liabilities, costs, expenses, injuries, deaths, and property damage arising out of the Contractor's operation and maintenance activities.

1.3.4 Personnel

The Contractor shall provide qualified, experienced, and competent personnel necessary for the efficient operation and maintenance of the Project.

All personnel shall comply with applicable labour laws, safety regulations, health requirements, and statutory obligations.

1.3.5 Records

The Contractor shall maintain all O&M records, inspection reports, maintenance schedules, inventories, breakdown reports, and other documentation in both electronic and hard-copy formats.

1.3.6 Assignment and Subcontracting

The Contractor shall not assign, transfer, subcontract, or otherwise delegate any part of his O&M obligations without the prior written approval of the Engineer-in-Charge.

Any approval granted shall not relieve the Contractor of his responsibilities, liabilities, or obligations under the Contract.

1.3.7 Completion and Handover

Upon expiry or termination of the O&M Period, the Contractor shall hand over the entire Project, including all facilities, systems, equipment, structures, and records, in a fully operational, safe, clean, and serviceable condition to the satisfaction of the Engineer-in-Charge.

The Employer shall be entitled to conduct inspections, tests, audits, and assessments prior to acceptance of the handover.

The Final Completion Certificate shall be issued in accordance with the Conditions of Contract after satisfactory completion of all O&M obligations and rectification of any outstanding defects.