

TECHNICAL SPECIFICATION

CONSTRUCTION OF DESUMRI (DS 80Ft SPAN) BAILEY BRIDGE & WONGTHI SLAB BRIDGE (32.80Ft SPAN) ON LAURI GC ROAD

SAMDRUPJONGKHAR DZONGKHAG

Contents

1	General Conditions of Contract	4
1.1	Scope of Work.....	4
1.2	Site Acquaintance	4
1.3	Specifications	4
1.4	Reference to Bureau of Indian Standards Codes and Other Codes.....	4
1.5	Dimensions and Levels	4
1.6	Notice of operation	4
1.7	Works program.....	4
1.8	Time Schedule	4
1.9	Issue of Drawings.....	5
1.10	Sub-Contracting	5
1.11	Compliance	5
1.12	Rates	5
1.13	Supply of Materials.....	5
1.14	Ordering Materials.....	6
1.15	Material Quality	6
1.16	Safety Measures and Penalty.....	6
1.17	Lifting Equipment	6
1.18	Equipment and Facilities	6
1.19	Work Site Register (Site Order Book).....	6
1.20	Area for the Contractor.....	6
2	Method of Site Installation & Measurement	7
2.1	Method of Measurement	7
2.1.1	Description	7
2.1.2	Quantities.....	7
2.1.3	Unit of measurement	7
2.2	Site Installation.....	7
2.2.1	General Terms & Conditions.....	7
2.2.2	Site Infrastructure.....	7
2.3	Material & Protection	9
2.3.1	Tools & Plant.....	9
2.3.2	Miscellaneous.....	9
3	General Conditions & Site Clearance	9
3.1	Sub-soil Study.....	9
3.2	Drawings	9
3.3	Riverside Works	9
3.4	BOQ.....	10

4	Earthwork & Rock Cutting	10
4.1	Scope of Work.....	10
4.2	Submittals	10
4.3	Site Familiarity.....	11
4.4	Standards.....	11
4.5	Terminology “Soil”	11
4.6	Setting Out	11
4.7	Classification of Excavation.....	11
4.7.1	Clearing.....	11
4.7.2	Excavation in Soil	12
4.8	Excavation and Material Disposal	12
4.9	Excavation and Storage	12
4.10	Backfilling.....	12
4.10.1	General Conditions	12
4.10.2	Backfill Materials.....	13
4.11	Landscape Area	13
4.12	Measurement and Payments.....	13
4.13	Exclusions.....	13
5	Reinforced Concrete works	14
5.1	Scope of Work.....	14
5.2	Standards.....	14
5.3	Submittals	15
5.4	Constituents of Concrete.....	16
5.4.1	General.....	16
5.4.2	Cement.....	16
5.4.3	Aggregates.....	17
5.4.4	Admixtures.....	20
5.4.5	Water.....	21
5.4.6	Tests during Execution of Works.....	21
5.4.7	Measuring and Tolerances.....	21
5.5	Batching and Mixing	21
5.6	Conveyance	22
5.7	Placing of Concrete	22
5.7.1	General.....	22
5.7.2	Preparation for Placing of Concrete	23
5.7.3	Concrete Placement.....	24
5.7.4	Rate of Placing Concrete	24
5.7.5	Consolidation of Concrete.....	24
5.7.6	Chipping and Roughening of Concrete Surfaces	26
5.8	Finishing of Concrete	26
5.8.1	Finishing of Formed Surfaces	26
5.8.2	Finishing of Unformed Surfaces.....	26
5.9	Tolerance for Concrete Construction.....	27

5.9.1	General.....	27
5.9.2	Tolerances for Concrete Structural Components	27
5.9.3	Defective & Damaged Concrete.....	28
5.10	Curing & Protection of Concrete	28
5.10.1	Curing with Water.....	28
5.10.2	Protection of Concrete	29
5.11	Repair of Concrete	29
5.12	Concrete Pouring Quantity	30
5.13	Measurements & Payments	30
5.13.1	General.....	30
5.13.2	Structural Concrete	30
5.13.3	Cement.....	31
5.13.4	Admixtures	31
5.13.5	Exclusions.....	32
5.14	Formwork	32
5.14.1	Scope of Work.....	32
5.14.2	Definitions	32
5.14.3	Standards.....	32
5.14.4	Materials.....	33
5.14.5	Measurement and Payment	35
5.15	Steel Reinforcement.....	35
5.15.1	Scope of Work.....	35
5.15.2	Standards.....	36
5.15.3	Material	36
5.15.4	Fabrication.....	36
5.15.5	Splicing of Reinforcement Bars.....	37
5.15.6	Execution	38
5.15.7	Measurements and Payments.....	39
5.16	Reinforced Concrete (RC) Bill of Quantities (BOQ)	40
6	Structural Steel Works	40
6.1	Launching of Bailey Bridge.....	40

1 General Conditions of Contract

1.1 Scope of Work

The Scope of work under this contract is to execute the work of construction of the **Jomree Zam** including other works as mentioned in the different upcoming sections of this report hereafter.

1.2 Site Acquaintance

The Contractor shall be deemed to have made himself fully acquainted with the full nature of the work, the location and character of the site and means of access to the site, including any traffic restrictions imposed.

1.3 Specifications

The work shall be executed in accordance with the technical specifications, the drawings, the Bill of Quantities and the instructions issued by the Client from time to time. Wherever these specifications are found wanting in anyway, the latest edition of standard specification for Bridges as approved by the Client shall be followed.

1.4 Reference to Bureau of Indian Standards Codes and Other Codes

The Standard Specifications and Codes of Practices explicitly referred to in these Specifications or other related standard codes etc. shall be of latest editions, current at the time of tendering including all amendments published before that date.

1.5 Dimensions and Levels

All dimensions and levels shown on the Drawings shall be verified by the Contractor on the site and he will be laid responsible for the accuracy and maintenance of all dimensions and levels. Figured dimensions are in all cases to be accepted and no dimensions shall be scaled. Large scale details shall take precedence over small scale drawings. In case of discrepancy the Contractor shall ask for clarifications from the Engineer before proceeding with the work.

1.6 Notice of operation

The Contractor shall not carry out important operation without the consent in writing of the Client.

1.7 Works program

The Contractor shall submit to the Client before commencement of the work, for his approval, a detailed program in the form of a bar chart/Microsoft project etc. The submission and approval of such program shall not relieve the Contractor of any of his duties or responsibilities under the Contract.

1.8 Time Schedule

The Contractor shall follow the project master schedule and detailed activity schedule of the Client. The contractor may submit minor changes on schedule to the Clients for approval whenever necessary.

1.9 Issue of Drawings

The Contractor will receive free of cost one complete set of all drawings necessary to complete the Work and is to include in his Tender for any additional copies of drawings required by him. One copy of each of the drawings shall be retained at the site.

1.10 Sub-Contracting

Should the Contractor consider it necessary to sub-contact any of his work, approval of his Sub-Contractor and the scope of the work shall be obtained from the Client before proceeding. It will be the responsibility of the Contractor to ensure that any work through sub-contracting is carried out in accordance with the specifications and relevant drawings.

1.11 Compliance

All workmanship, materials and tests (where required) shall comply with the appropriate Indian or American Standards as specified or approved and be in accordance with the drawings all to the satisfaction of the Client/Engineer.

1.12 Rates

The rates of the various items and work description have to include all materials, activities and costs required to complete the work. No payment will be made for additional work or cost whatsoever. The fact that the work has to be done at, on and in the river has to be accounted for in setting the rates. The providing, erecting, use, maintaining and dismantling of necessary platforms, scaffolding or related structures have to be included in the rates. The rates have to include all works, materials and efforts necessary to complete the task. No additional payments will be made for further handling, loading, offloading, transport, water keeping, pumps, or any activities and costs. These notes apply to all items, serial numbers, works, and descriptions in the tender documents. These specifications are valid for every item and rate of the documents and for any part and any kind of works necessary to construct the bridge. These conditions are an integral part of these tender documents.

1.13 Supply of Materials

- i) All construction materials such as cement, steel for reinforcement, fine and coarse aggregates, bricks, doors and windows, glazing, water supply and sanitary pipes and all other materials as may be required for completion of the works in all respect shall be supplied by the Contractor and cost of supply of the same shall be included in the quoted rates.
- ii) The Contractor shall supply certificates of compliance with specified Indian Standards for all materials supplied for the works. Manufacturer's catalogues and samples of materials proposed for procurement and to be used in the works shall be submitted to the Client for approval, before procurement.
- iii) Materials procured without specific approval of the Client shall not be allowed to be used in the works.
- iv) The Contractor's quoted rate shall include but not limited to:
 - a) Preparation and submission of shop drawings wherever necessary, calculation sheets, schedule of materials, and providing catalogues about, and samples of materials, and obtaining approval from the Client.
 - b) Transporting to the Site, including loading and unloading.
 - c) Providing certificates of compliance with required relevant standards, as specified.
 - d) Storing and protecting at the Site.

1.14 Ordering Materials

The Contractor is entirely responsible for assessing the quantities of materials to be ordered for using these in permanent works.

1.15 Material Quality

The Contractor should note that the qualities of all materials used on site shall be scrutinized, monitored and checked by the Client. All materials used have to fulfill the requirements and specifications given in the drawings and in the relevant code of practice. If the Contractor is asked to supply certificate of origin of the supplied and used materials, he has to do so within one week.

1.16 Safety Measures and Penalty

If any laborers, worker and personnel are found on the bridge construction site without the proper safety equipment (safety helmets, safety belts etc.), the Contractor will be subjected to penalty of Ngultrum 200.00 for each case and the same shall be deducted from his running bill. The Contractor is not allowed to recover this fine from his workers. He has to bear the fine by himself. The proof of a picture or witness that workers did not use the proper safety equipment, will directly lead to the fact that the Contractor has to pay the penalty. The Contractor agrees by signing the contract. The only exception to having a safety line attached to the anchor hooks allowable is when alternative means have been set up, such as safety rails. The alternative means have to be approved by the Client.

1.17 Lifting Equipment

The Contractor shall provide all lifting equipment and facilities to lift, shift, stack, load, unload and handle all type of steel parts and materials at the bridge site as well as at the Contractor's yard.

1.18 Equipment and Facilities

The Contractor shall provide and operate equipment and facilities to load, offload, shift, move, transport, stack and place all types of steel parts and materials at the bridge site as well as at the Contractor's yard.

1.19 Work Site Register (Site Order Book)

The Contractor shall keep a Work Site Register (Site Order Book) at the Site in which all the remarks, instructions, decisions of the Client and the essential details of the work shall be recorded. The Contractor shall keep the records of all daily information of the works in this register as required by the Client. It shall be readily available in the office for inspection.

1.20 Area for the Contractor

- i) The Contractor shall be allocated an area for his equipment, materials and site offices within the site area.
- ii) The Contractor shall maintain a proper furnished office, which will include but not necessarily limited to lock up drawers for construction drawings, filing cabinets, large sized soft board panels etc., with toilet facilities in the allocated area at the site for his own use as well as for use of the Client and his representatives. These shall be provided by the Contractor at no extra cost.

2 Method of Site Installation & Measurement

2.1 Method of Measurement

2.1.1 Description

The descriptions identify the work covered by the respective items, but the exact nature and extent of the work is to be ascertained from the Drawings, Specifications and Conditions of Contract, as the case may be, read in conjunction with the Bills of Quantities.

2.1.2 Quantities

The quantities shall be computed net using dimensions from the drawing, unless directed otherwise by the Client. No allowance shall be made for bulking, shrinkage or waste. No other type, terms or regulation for computing the quantities will be used and accepted. For any kind of work and item, the net dimension will be used for computing the quantities. Quantities may be rounded up or down where appropriate. Fractional quantities are not generally necessary and should not be given to more than two places of decimals.

2.1.3 Unit of measurement

The following units of measurement and abbreviations shall be used.

Unit	Abbreviation
Millimetre	mm
Metre	m
Square millimetre	mm ²
Square metre	m ²
Hectare	ha
Cubic metre	m ³
Kilogramme	kg
Tonne	t
Sum	sum
Number	no.
Hour	hr
Week	wk (7 days)

2.2 Site Installation

(Facilities, tools, plant, equipment and so forth)

2.2.1 General Terms & Conditions

For all items and descriptions, the relevant and enclosed drawings are an integral part of this bill of quantities. The site installations plan has to be implemented by the Contractor. Any change to the installation plan and to the contract documents by the Contractor and/or sub-Contractor has to be approved by the Client or his designated representative. In addition, all terms and conditions of contract have to be fulfilled. It is understood, that the bridge site is an area within a range of 5 km around the bridge.

2.2.2 Site Infrastructure

This includes the infrastructure at bridge site, access roads, Contractor's yard, construction site, laborers camp and so forth. All necessary accommodations, stores, workshops, etc. required for proper execution of the works shall be provided, built, maintained and removed by the Contractor at his own costs and within the working time program. The following points are important and to be fulfilled by the Contractor:

2.2.2.1 Safety Measures

All necessary safety measures and efforts to avoid accidents and damages to the property shall be strictly maintained at site.

2.2.2.2 Labor Camps

Labor camp with sufficient and maintained sanitary facilities, sufficient drinking water and sufficient supply of electric power, if any, shall be provided and installed at site. Sufficient drinking water has also to be made available at the construction site and at the labor camp.

2.2.2.3 Waste Management

A proper waste management at site and labor camp shall be maintained.

2.2.2.4 Material Storage

Construction materials to be deposited and stored well under shed constructions to avoid quality drops and loss.

2.2.2.5 Temporary Drainage System

A temporary drainage system has to be provided at the site. The Contractor shall build no drainage and other infrastructure without prior approval by the Client. The Client shall inspect the Contractor's site infrastructure and give instructions. These instructions are binding and shall be strictly implemented by the Contractor.

2.2.2.6 Site Water Supply and Electricity

The Contractor shall make his own connections for water and electric supply and energy, if any, whatsoever and pay for it.

2.2.2.7 Communication Facilities

The Contractor cannot use the infrastructure like telephone, fax, photocopies, etc. from the Client. The Contractor has to set up his own equipment.

2.2.2.8 Site Clearances

Clearance of the site shall be done according to the instructions of the Client. Clearance has to be carried out during construction period and at the end of every phase of the phased construction tasks. If the Client finds, that additional clearance has to be done during construction works, the Contractor has to do additional part – clearances. After completion of the works the Contractor shall clear away and remove from the site all tools and plant, surplus materials, rubbish, garbage, temporary constructions, and temporary work of every kind and leave the whole site clean and to satisfaction of the Client. The site area of the camp, storage area, access road and so forth shall be rebuilt and brought into the same shape, state and condition as before starting the work.

2.2.2.9 Disposal of Material

The Contractor is not allowed to dispose anything into the river. The Contractor will be fined for doing so. Removal of surplus material needs prior approval from the Client.

2.2.2.10 Time for Final Site Clearance

The final clearance shall be done within 4 (four) weeks, after the certificate of completion is issued.

2.3 Material & Protection

2.3.1 Tools & Plant

The Contractor shall build sufficient shelter buildings so that all materials can be stored without being exposed to the rain and hot sun. All the construction materials, particularly cement and the steel has to be protected. The crushed stones and gravel as aggregate for the concrete have to be cleaned and washed. The contractor has to secure the site installation place with an adequate fence and security system. The Contractor shall supply and provide all materials, plants, equipment, spare parts whatsoever to execute the works in accordance with the contract and all descriptions in the bill of quantities. The Contractor has to provide sufficient spare parts and equipment, that the work can be executed without delay. The tools, materials and plants to erect all temporary building and scaffolding have to be on site. Tools, equipment and plant have to be provided in sufficient numbers and in good working condition. The Contractor is responsible for the maintenance. The Client reserves the right to stop on-going work in case materials, tools and plants are not meeting the requirement and/or are in unsafe condition. The concrete shall be made by using a concrete mixing plant for the bridge construction. The Contractor shall also provide a concrete mixing plant at the bridge construction site, which can cover a concreting volume up to 100 m³ in a day. The concrete has to be made by using concrete vibrators. Spare immersion needles in the correct diameters have to be available at all times. All concrete has to be compacted by mechanical vibrations. As the natural coarse aggregate/coarse gravel has to be washed after crushing sufficient water has to be available. In order to keep the construction schedule a 24 hours working shift might be necessary. This possibility has to be included in the site installation.

2.3.2 Miscellaneous

It is understood that all the items listed and explained above have to be included in the site installation cost. By signing the contract, the Contractor confirms that all efforts and costs to fulfill the task are included in his rates. He agrees not to ask for additional payment.

3 General Conditions & Site Clearance

3.1 Sub-soil Study

The detail subsoil investigation of the bridge site was not carried out due to fund and time constraints. Therefore the Client is not able to provide the details of the sub soil condition. But the contractor has to study the site carefully and satisfy itself with the possible subsoil conditions depending on surface soil condition and the geological characteristic of the terrain in the vicinity prior to submission of the tender. The Contractor shall also be deemed to have made himself fully acquainted with the with the full nature of the work, the location and character of the site and means of access to the site, including any traffic restrictions imposed.

3.2 Drawings

The relevant drawings are an integral part of these tender documents. The Contractor has to study all drawings in detail. By submitting the tender, the Contractor is declaring that he has understood the drawings and all the works involved and is prepared to complete all construction works in a competent manner. Only the highest degree of accuracy and quality will be accepted.

3.3 Riverside Works

The fact that the work has to be done at, on and in the river has to be accounted for while setting the rates. The providing, erecting, use, maintaining and dismantling of necessary platforms, scaffolding, or related structures have to be included in the rates. Other required facilities,

equipment and their maintenance, materials, personnel and services have to be included in the rates.

3.4 BOQ

It is understood that, for the complete bills of quantities, the supply, providing, transportation, loading and offloading, handling, and all efforts and required materials have to be included in the rate.

4 Earthwork & Rock Cutting

4.1 Scope of Work

- i) The specifications described herein cover the surface excavation and backfilling for all relevant tasks such as piping, foundations, trenches, pits, channel, cable ducts, underground facilities & similar works and shall include all labor, materials, plant, and equipment necessary to carry out the excavation in all materials, the transportation and stockpiling or disposal of all excavated materials into stockpiles or disposal areas including all leads and lifts as shown on the drawings or as approved by the Client.
- ii) Excavation shall be made to the lines, grades and dimensions shown on the drawings or as otherwise directed by the Client.
- iii) The Contractor shall maintain the excavated slopes, drainage, and trenches and prepare foundations as shown on the drawings or as required by the Client.
- iv) Where, in the opinion of the Client, clearing is necessary, the area of surface excavation shall be cleared of all trees, bushes; rubbish and other matter and the materials removed shall be burnt or otherwise disposed off as directed by the Client.
- v) When the Contractor for his own convenience requires additional excavation outside the lines and grades shown on the drawings, such additional excavation shall be required to be backfilled with acceptable material and compacted by the Contractor in a manner satisfactory to the Client. The Contractor shall submit his plans for such proposed work in writing for Client's acceptance prior to the commencement of the Work.
- vi) When necessary, or when requested by the Client, the Contractor shall remove mud and slush resulting from heavy rains or flooding of the sites in order to ensure the safe and effective performance of the Work.
- vii) At all times during construction, the Contractor shall adopt excavation procedures such that at no time shall the stability of any slope be impaired.
- viii) The approval given by the Client to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for a proper and safe execution of excavations, or of liability for injuries to, or death of persons, or any obligations under this Contract.
- ix) The Contractor shall comply with all safety procedures and requirements.
- x) Seepage water from springs or rainwater shall be suitably collected and drained away by gravity, wherever it is possible to do so. Where, however, drainage by gravity is not feasible, pumping could be resorted to.
- xi) The Contractor shall install an adequate illumination system on the work sites.

4.2 Submittals

- i) To enable the Client to verify all necessary setting out and elevations carried out by the Contractor, the latter shall notify the Client in writing, his intentions to start excavation.
- ii) The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.

4.3 Site Familiarity

By submitting the tender documents (bills of quantities with the rates) the Contractor confirms that he will not ask for any increase in payment for any reason whatsoever. He also confirms to be fully aware of the soil conditions. He agrees not to ask for additional payments due to changed soil conditions.

4.4 Standards

The methods and practices for surface excavation shall conform to the latest editions of the following Indian Standards or, where not covered by these Standards, to the equivalent International Standards subject to the approval of the Client:

- IS: 1200 Methods of measurement of building and civil engineering work: Part 1 Earthwork.
- IS: 2720 Methods of test for soils.
- IS: 3764 Excavation work - code of safety.
- IS: 4081 Safety code for blasting and related drilling operations.
- IS: 9759 Guidelines for de-watering during construction. Indian Explosives Act 1940, as updated.

4.5 Terminology "Soil"

The word "soil" in this contest refers to all type of soil, earth, rock, stone, sand, boulders, gneiss, clay, gravels, mica schist and so on. No additional payment will be granted and made for any kind of rock cutting or hard rock blasting whatsoever. There might be areas, where blasting is prohibited.

4.6 Setting Out

- i) The Contractor shall establish, at suitable points, to the satisfaction of the Client permanent reference marks on the centre lines, as may be necessary and directed. The permanent marks shall be inscribed on permanent pegs, set in concrete blocks where they will be free from any likelihood of disturbance. Suitable benchmarks shall be established.
- ii) As the work progresses, centre line marks shall be made on pegs, inserted at convenient intervals to the satisfaction of the Client, for checking alignment, grades, levels etc. The Contractor shall at all times, remain responsible for the sufficiency and accuracy of all such benchmarks and reference points.
- iii) The fact that some of the excavation works will be at the riverside and below the water level will also not justify any increase in the costs. The schedule of rates notes, which works might be below the water level. No additional transportation will be paid. The Contractor has to study the site layout carefully.

4.7 Classification of Excavation

4.7.1 Clearing

- i) Clearing shall consist of cutting and disposing of all trees, stumps, roots, rubbish, bushes, any other vegetation and existing structures, foundations of structures, fences or any other objectionable materials.
- ii) All flammable material resulting from clearing shall be either burnt or disposed of by the Contractor in a manner acceptable to the Client. The Contractor shall be responsible for taking all safety measures required for burning of the materials, and he shall be responsible for any damage done by fire resulting from his work. The fire shall, at no time be left unattended, until it has been fully extinguished. The Contractor shall have suitable equipment and supplies for fighting fire. None of the disposed material shall be piled in

stream of river or in a location, where in the opinion of Client it is liable to be washed away by floods.

4.7.2 Excavation in Soil

- i)** This group shall include all overburden dry or wet restricted to materials such as silt, earth, clay, sand, gravel, soft morus, soft and hard rock of any shape and size with or without blasting. This shall also include removal of all material wet or dry deposited during the monsoon over the portion excavated prior to monsoon.
- ii)** Stripping consists of removing all or part of the organic topsoil in the areas and to the depth as indicated on the construction Drawings or as directed by the Client.
- iii)** Loose excavation means general excavation of material such as organic topsoil, clay, silt, sand, gravel, and boulders of up to 0.75 m³ in volume and soft or disintegrated rock, which can be removed by earth moving equipment without ripping or blasting.
- iv)** Stripping and loose excavation shall be accomplished by proper excavation and hauling equipment suitable for the work, which allows for an efficient work progress adopted to the soil conditions encountered.

4.8 Excavation and Material Disposal

The rate for the excavation shall also include the disposal of the materials within the necessary lead including the excavation works which may be required by the side, in or under the river. The excavation shall be paid as solid volume.

4.9 Excavation and Storage

Excavation and storing of the materials close to the abutments. These materials shall be used as backfilling around and behind foundation.

4.10 Backfilling

Handling, loading, offloading, transportation, watering, compaction and all necessary work has to be included in the rate. The volume of backfilling materials is calculated as solid volume. No additional payment will be made to complete the task. Further details on backfilling are as given below:

4.10.1 General Conditions

- i)** The Contractor shall place and compact backfill to the specified type of the lines, grades and dimensions in the locations shown on the Construction Drawings, behind structures, in over excavation, or where directed by the Client. Dewatering is imperative if there is water before backfilling work commences.
- ii)** Material to be used as backfill shall be approved by the Client, and shall be, as far as possible, obtained from required excavation for Permanent or Temporary Works.
- iii)** The distribution and gradation of backfill material shall be such that the finished backfill is free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation from the surrounding material. Backfill material shall include no organic matter, and the Client reserves the right to reject entire loads of material that contain unacceptable percentages of organic matter, and which cannot be satisfactorily removed.
- iv)** The traffic over the backfill shall be adequately controlled to avoid rutting or cutting the placed backfill. Each load of material shall be placed in such a way as to achieve an even distribution of material. The operation of trucks and heavy equipment shall be restricted near buildings, walls, piers or other facilities to avoid damage to any Permanent Works.
- v)** Any material that is objectionable or inadequate shall be removed by the Contractor at his own expense. If the compacted surface of any layer of material is determined to be too

Technical Specifications

smooth to bond properly with the subsequent layer it shall be loosened by harrowing, or by any other method approved by the Client, before the subsequent layer is placed thereon.

- vi) Backfilling adjacent to concrete structures 1 m and over in height, shall not commence before 7 days from the time the concrete has been cast. Prior to backfilling, forms shall be removed and the areas cleaned of trash and debris. All Works to be covered by backfill shall be inspected and approved by the Client prior to start of backfilling. Backfill shall be placed in proper sequences so that no substantial differential earth pressures occur on footings, pipes, or other structures. A substantial differential earth pressures is deemed to occur if backfill on one side of an object exceeds the other side by more than one layer difference, unless calculations are done to show that a higher differential pressure is acceptable.
- vii) Backfilling operation shall not be performed with frozen materials & lumps and at low temperatures if the material will affect adversely the Works.
- viii) The Contractor shall maintain and protect the finished backfill in satisfactory conditions at all times until completion and acceptance of the Works. After backfilling operations have been finished and prior to finish grading, the Contractor shall slope the surfaces with at least a 0.5% grade to prevent ponding of water.

4.10.2 Backfill Materials

Selected backfill from excavation:

- i) Selected backfill from excavation shall consist of specified or approved gradation of earth and/or rock,
- ii) Selected backfill from excavation shall be compacted to at least 97% Standard Proctor in accordance with IS: 2720,
- iii) The moisture content prior and during compaction shall be near the optimum moisture content distributed evenly throughout each layer of material.

4.11 Landscape Area

Not applicable

4.12 Measurement and Payments

- i) Measurements for surface excavation shall be made by volume in cubic meters, of material excavated, as measured in place from the surface of the natural ground or the surface exposed by previous excavation or clearing, to the lines and grades shown on the drawings, or to rock or as required by the Client.
- ii) The elevation of the natural ground or surface exposed by previous excavation shall be established and agreed by the Contractor and Client before starting excavation of any section of the work by actual survey of the area.
- iii) The item of excavation includes both clearing and backfill

4.13 Exclusions

No extra measurement or payment shall be made for the following:

- a. Over excavation beyond the excavation lines shown on the drawings, removal of material or backfilling with concrete or acceptable material and compaction where and when as required by the Client,
- b. Replacement of survey points fixed by the Client' which are damaged due to Contractor's negligence,

Technical Specifications

- c. Formation of ramps, sump pits for installation of dewatering pumps at places, which fall beyond the specified excavation lines,
- d. Treatment of rain cuts, gullies and holes left by removal of boulders by properly packing with excavated rock spoil,
- e. Methods adopted for specially controlled excavation at foundation level or near the faces where plain surfaces are required,
- f. Replacement or repair of concrete or other works damaged by blasting,
- g. Working of all rock surfaces of excavation when required by the Client,
- h. Additional work of removing materials and backfilling voids with approved material where over-excavation occurs due to Contractor's poor working method or negligence,
- i. Silt/slush deposit, if any, during the course of construction due to rain and floods etc. shall be removed and properly deposited by the Contractor and no extra payment shall be made on this account and deemed to have been included in the item of excavation of Bill of Quantities of bid.
- j. Over-excavation required for Contractor's convenience and this will include the additional excavation made for working space, inclined cutting of the excavation slope etc. The concrete required to fill such excavation shall also be at the Contractor's expense.
- k. Clearing and backfill.
- l. Construction of coffer dams, sheet piles, guide bunds, installation and use of water pumps or any other river diversion efforts required to carry out the excavation works...all these have to be accounted for while setting the rates.

5 Reinforced Concrete works

5.1 Scope of Work

- i. The Specifications described here under cover all labor, materials, equipment and services related to the concrete work to be carried out by the Contractor under this Contract.
- ii. The concrete Work shall be performed to the dimensions as shown on the drawings or as otherwise directed by the Client.
- iii. The approval given by the Client to the Contractor's plants and equipment or their operation or of any construction methods shall not relieve the Contractor of his full and sole responsibility for the proper and safe execution of concrete Work or any obligations under this Contract.
- iv. The rates of the various items and work description have to include all materials, activities and costs required to complete the work. No payment will be made for additional work or cost whatsoever.
- v. The fact that the work has to be done at, on and in the river has to be accounted for in setting the rates. The providing, erecting, use, maintaining and dismantling of necessary platforms, scaffolding and river diversion structures such as coffer dams, sheet piles, guide bunds or related structures have to be included in the rates.

5.2 Standards

The concrete materials, production, methods, testing and admixtures shall conform to the latest revisions of the following Indian Standards or, where not covered by these standards, to the equivalent International Standards:

IS: 269	33 grade ordinary Portland cement.
IS: 8112	43 grade ordinary Portland cement.
IS: 12269	53 grade ordinary Portland cement.

Technical Specifications

IS: 383	Coarse and fine aggregates from natural sources for aggregates.
IS: 456	Code of practice for plain and reinforced concrete.
IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS: 516	Method of test for strength of concrete.
IS: 875	Code of practice for design loads (other than earthquake) for buildings and structures.
IS: 1199	Methods of sampling and analysis of concrete.
IS: 1489	Portland Pozzolana cement.
IS: 2386	Methods of test for aggregates for concrete.
IS: 2505	Concrete vibrators – immersion type – general.
IS: 2506	General requirements for screed board concrete vibrators.
IS: 4082	Stacking and storage of construction materials and components at site– recommendations.
IS: 7861	Code of practice for extreme weather concreting.
IS: 9103	Admixtures for concrete.
IS: 10262	Recommended guidelines for concrete mix design.

In cases of conflict between or among the above standards and the specifications given herein, the decision of the Client should prevail.

5.3 Submittals

- i)** Submittals listed herein are related to the items, which require the consent of the Client and are to be made by the Contractor before the appropriate work proceeds.
- ii)** Within 7 days from the date of issue of the Letter of Acceptance, but before procuring or mobilizing to the site, the Contractor shall submit to the Client, updated and detailed plans and descriptions, consistent with those submitted with his bid and any subsequent amendments and additions agreed to by the Client.
- iii)** Before any concrete work being carried out on the site, the Contractor shall submit to the Client following information:
 - a)** Details of any admixture and Cement, which the Contractor proposes to use, name of manufacturers thereof, and information about the chemical names of the principal admixtures, or additives and the likely effect of under or over dosage. Should the Contractor intend to use an accelerator in any concrete work for his own convenience he shall give full details of the type, dosage, influence on construction, and the cost saving involved,
 - b)** Details of all surface finishes, treatment of construction joints, and construction techniques which the Contractor proposes to use in order to achieve the required concrete surfaces and allowable tolerances,
 - c)** Mode and methodology of concrete curing,
 - d)** Sampling and Testing of Materials, listing and giving details of equipment for sampling and testing, detailed program for quality control of concrete work, and qualification and experience of the proposed controlling personnel.
- iv)** At least 7 days in advance of any permanent concrete work at Site, or as instructed by the Client prior to procuring or dispatching to the Site of the particular item of work to which the submittal relates, the Contractor shall submit to the Client, the following:
 - a)** Details of curing compounds, Notification of the source, analysis, method of delivery, and storage of water for concrete manufacture, Details of the material for formwork, and for shoring and re-shoring. Before commencement of the concrete placement the Contractor shall prepare a checklist regarding all preparations for the specified work such as foundations, cleaning, formwork, reinforcement, embedding, and submit this list to the Client, who after his satisfaction about the work preparations will permit

the Contractor in writing to commence concrete placement. During the performance of the concrete work, the Contractor shall maintain **concrete pouring records** where he shall record the construction procedures related to concreting. This diary shall be made available to the Client, upon request. The records shall contain at least the following:

- a) Commencement and termination of concreting of various parts of the structures,
- b) Quantities and quality of aggregates and cement provided and the storage from which they were drawn,
- c) Personnel employed during various stages of the concreting operation and name of the responsible inspector or foreman,
- d) Equipment used,
- e) Outside temperature,
- f) Directives received from the Client,
- g) Any special material or procedures employed.
- v) The Client reserves the right to require any additional information deemed necessary to be included in the submitted documents.

5.4 Constituents of Concrete

5.4.1 General

- i. Concrete shall be composed of cement, fine aggregate, coarse aggregate, water and permitted admixtures, as specified herein and as required by the Client.
- ii. Concrete and concrete constituents and all materials and operations relating to concrete shall meet the requirements of the Indian Standards Code of Practice for Plain and Reinforced Concrete IS: 456, and as required by the Client.
- iii. Concrete constituents shall be batched and mixed at site using suitable equipment to determine and control accurately the amount of each ingredient entering the mix. The amount of each ingredient shall be batched correctly with sufficient accuracy to obtain concrete of the quality specified in these specifications.
- iv. The use of a water reducing admixture to improve workability without reducing the strength or durability of the mix will be considered by the Client. If acceptable to the Client, it shall be used in strict conformance with manufacturer's instructions and will be supplied by the Contractor at no additional cost.
- v. Air content will be determined in accordance with IS: 9103.
- vi. No other admixtures shall be permitted without written acceptance of the Client.
- vii. Wherever required, from the point of view of the Client, the Contractor shall supply and use an accelerator/retarder/plasticizer, whereby the type and dosage shall be subject to the approval of the Client.
- viii. The moisture content of coarse and fine aggregate shall be checked every day and necessary corrections for water cement ratio shall be made.

5.4.2 Cement

- i. Cement shall be ordinary Portland cement or Portland Pozzolana Cement or slag cement or equivalent conforming to the requirements of IS: 269 & IS: 1489 as specified by the Client.
- ii. All bulk carriers of cement shall be clean and dry prior to filling/loading with cement. All carriers for bagged cement shall be equipped with weatherproof closures on all openings.
- iii. Cement shall be stored above ground, adequately protected against rain, sun and moisture.

Technical Specifications

- iv. Arrangements shall be made such that stocks of approved cement are adequate to meet the program of work at all times. The program shall allow time for testing and approval of each shipment before such cement is incorporated in the works.
- v. Cement shall be used in the order of lots in which it is received at site. Cement stored by the Contractor and found unfit for use shall not be allowed to be used and shall be removed from site immediately
- vi. The bidder shall price his bid on the basis of the following cement contents for various grades of concrete. However, the cement content may change when the mix design is finalized for the specified grade of the concrete but the minimum cement content as per the standard coded should always be maintained for durability consideration.

Grade of Concrete as per IS: 456	28 th day characteristic strength (MPa) as per IS: 456	Preliminary avg. strength of 3 samples (MPa) as per IS: 516	Cement content (kg / m ³)
M -7.5	7.5	10	120
M – 10	10	13.5	150
M – 15	15	20	270
M – 20	20	26	310
M – 25	25	32	400
M – 30	30	38	500

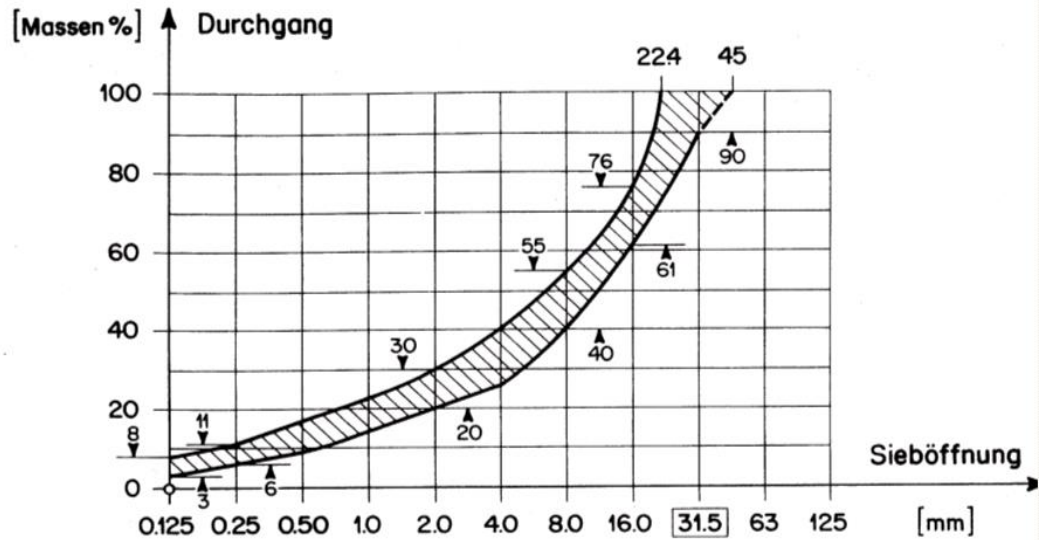
Note that the value “30” in M – 30 represents a specified 28th day characteristic strength of 30 MPa for 15 cm cubes as per Indian Standard IS: 456. In order to guarantee this strength the average of 3 samples at 28 days shall have a preliminary minimum strength of 38 MPa as per IS: 516.

5.4.3 Aggregates

i.General:

- a) Unless otherwise specified concrete aggregates shall conform to the requirements of IS: 456 and IS: 383. They shall be tested in accordance with the provisions of IS: 2386,
- b) Aggregates shall be supplied only from sources/quarries approved by the Client. Approval of a source shall not be construed as constituting acceptance of all materials to be taken from that source,
- c) The quality of all aggregates used in the work, including processing such as washing, classifying, screening, re-screening, crushing, blending petrography, cleanliness, hardness, shape and surface properties, necessary to meet the required specifications.
- d) Crushed stones have to be washed. The particle size distribution should be established through preliminary investigations by the Contractor and getting approved by the Client.
- e) Periodic tests shall be used to check the range of variability of sieve curves; variability shall be less than 10 % of the mass for a 2 mm sieve opening and less than 15% of total mass for a sieve opening of 8 m and 16 mm.
- f) The sieve curve of the particle size distribution shall lie within the “shaded” region of the following picture 1. If there are preliminary investigations to determine a sieve curve it is possible to leaf locally the shaded region of Graph1.

[Mass (%) = Percentage passing by weight Vs Sieve Size]



Graph 1: Sieve Distribution

ii. Fine Aggregates:

- a) Sand or fine aggregates shall be used for mortar in stone masonry and as fine aggregates in concrete work,
- b) It shall be either natural river sand or manufactured, sand crushed from rock/stones or mixture of both in specified proportions. The sand shall be hard, clean and gritty and of a quality approved by the Client. It shall be free from injurious amount of clay, soft and flaky particles, vegetable or organic matter, loam, mica and other deleterious substances and shall not contain any salts,
- c) The fine aggregates shall conform to the requirements of IS: 383. Varying amount of moisture in fine aggregates contributes to lack of uniformity in concrete consistency. The fine aggregates shall therefore have uniform and stable moisture contents. Dry sand shall be preferred. Hence sand stockpiles shall be protected from rainfall,
- d) The percentage of deleterious substances in the fine aggregates shall conform to relevant Standards except that the fine aggregates shall contain not more than 0.10 percent by weight of deleterious (reactive) ferrous sulfides. The total percentage of deleterious substances shall not exceed 5 percent of the weight,

Deleterious substance	Maximum permissible Limit by weight
Materials finer than IS sieve no.8	3%
Shale	1%
Coal and lignite	1%
Clay lumps	1%
Cinders and clinkers	0.50%
Alkali, mica and coated grain (deleterious)	2%

- e) Fine aggregates having a specific gravity of less than 2.50 are liable to be rejected. Fine aggregates when subjected to a soundness test with a solution of sodium sulphate, after 5 cycles of tests, shall not suffer a loss of weight in excess of 10%,
- f) The sand shall be well graded and, when tested by standard sieves, shall conform to the prescribed limits of gradation. The best gradation shall be determined by the Client, after experiments and tests and the Contractor shall follow the same,
- g) The sand, as delivered to the batching plant shall have a fineness modulus of 2.6 to 3,
- h) For improving workability of pumped concrete mixes, the Contractor may consider a combination of natural and manufactured sand. Proposed proportions shall be submitted for approval of the Client,

- i) Maximum amount of material finer than 75 micron shall not exceed 1% by weight,
- j) The gradations shown in the following chart are indicative only. (As per IS: 515-1959)

Sieve size IS	Percentage Passing	
	Natural Sand	Manufactured Sand
480 (4.75 mm)	95 to 100	95 to 100
240 (2.36 mm)	80 to 95	75 to 90
120 (1.18 mm)	45 to 80	50 to 70
60 (600 micron)	30 to 45	30 to 50
30 (300 micron)	5 to 30	15 to 30
15 (150 micron)	1 to 5	8 to 13
8 (75 micron)	0 to 1	0 to 1

iii Coarse Aggregates:

- a) Coarse aggregate shall consist of screened natural gravel or crushed rock and shall conform to the requirements of IS: 383,
- b) The term coarse aggregate is used to designate aggregate that is reasonably well graded and ranging in size of particles from 4.75 mm to 20 mm or any size or range of sizes within such limits. The coarse aggregate shall conform to relevant specifications of IS: 515 (for natural and all manufactured aggregate), or IS: 383-1970 (for natural aggregate as revised from time to time),
- c) Coarse aggregate shall have a loss not more than 30% as determined by Los Angeles Abrasion test as specified in IS: 2386 Part IV,
- d) When subject to the sodium sulphate soundness test, coarse aggregate shall not suffer more than 10 percent loss of weight after five cycles,
- e) Natural coarse aggregates shall consist of uncoated hard, strong, dense and durable pieces and shall be free from injurious amounts of disintegrated stones, soft flaky or elongated particles, salt, alkali, vegetable matter and other deleterious substances,
- f) Coarse aggregate shall be hard, dense, durable, uncoated rock fragments. Rock having an absorption greater than 3% or specific gravity less than 2.5 shall not be used. Aggregate delivered to the batching plant shall have a uniform and stable moisture content,
- g) Manufactured coarse aggregates shall consist of “very large”, “large”, “medium”, and “small” aggregates and shall be of hard, strong, dense and durable pieces and shall be free from injurious amounts of soft or flaky particles salt, alkali, and vegetable matter and other deleterious substances (IS: 515),
- h) Permissible deleterious substances in manufactured coarse aggregates shall not exceed the following limits:

Deleterious substance	Maximum permissible Limit (by weight)
Materials finer than IS sieve no.8	1%
Coal and lignite	1%
Clay lumps	1%
Total soft, friable elongated or laminated pieces	3%
Other deleterious materials.	As per note given below

- i) Permissible deleterious substances in natural coarse aggregate: Total of all deleterious substances shall not exceed 5% by weight and the coarse aggregate shall not contain more than 0.3% by weight of deleterious (reactive) ferrous sulphide,

- j) The aggregate shall be resistant to chemical or physical change such as cracking, swelling, softening, leeching, or other chemical alteration after its incorporation in concrete.
- k) The aggregate should be crushed and the different sizes of the coarse aggregate shall be separated into nominal sizes as follows:

Designation	Nominal size range
Small	5 mm to 20 mm
Medium	20 mm to 40 mm
Large	40 mm to 75 mm
Very large	75 mm to 150 mm

- l) Coarse aggregate shall be washed at the aggregate source, however, further washing at the batching plant may be required if the aggregate is found to be unacceptable to the Client,
- m) As far as possible, coarse aggregates shall be of regular shape and free of flat or elongated particles. The volumetric coefficient C, which defines the ratio of the total volume of number of particles at random and the volume of spheres having a diameter equal to the greatest dimension of each element, shall be greater than or equal to the following values:

Aggregate Size	Ratio
6.7/26.5 mm	C = 0.15
26.5/150.0 mm	C = 0.11

iv. Aggregate Storage:

The coarse aggregate shall, if possible, be stored in a shed or covered storage and arrangements made for sprinkling of water to ensure wetting of the aggregate, great care shall be taken in screening and stacking of the coarse aggregate so as to avoid intermixture of different grade materials and inclusion of any foreign materials. The stockpile should be built in layers of uniform thickness. A hard base should be provided to prevent contamination from underlying materials in storage areas in continual use. Overlap of different materials should be prevented with suitable walls or by an ample distance between storage piles. Sufficient storage of all grades shall be maintained so as to permit continuous placing of concrete.

5.4.4 Admixtures

- i. The Contractor shall furnish suitable plasticizers and chemical admixtures for use in concrete as provided herein. The admixtures shall be of uniform consistency and quality, and shall be maintained at the job site at uniform strength of solution. Admixtures shall be batched separately in liquid form in dispensers capable of measuring at one time the full quantity of each admixture required for each batch. Admixture dispensers shall be constructed and located such that the plant operator can observe the full batch quantity of each admixture in a visual gauge. Each admixture shall be discharged into the batched mixing water so that water is being discharged into the mixer as the admixture is added.
- ii. Admixture will be accepted on manufacturer’s certifications. However, the Client reserves the right to require submission of and to perform tests on samples of any admixture either prior to shipment to the job site or after delivery.
- iii. When requested by the Client, the Contractor shall submit test data by the manufacturer confirming total compliance of the admixture to these specifications.
- iv. The Contractor shall be responsible for any difficulties arising as a result of the selection and use of admixtures, such as difficulty in concrete placing and delay in concrete finishing and form removal. The Contractor shall be entitled to no additional

- compensation by reason of such difficulties. Chemical admixtures containing calcium chloride shall not be used in concrete.
- v. Accelerating admixtures, wherever required, shall be used after prior approval of the Client.
 - vi. Water reducing, set controlling:
 - a) The Contractor shall use a water reducing, set controlling admixtures in all concrete. The admixture shall conform to IS specification or equivalent standard,
 - b) The amount of water reducing Admixtures used shall be that amount necessary to effect the requirements of Indian Standard specifications or equivalent and as directed by the Client. The Client reserves the right to adjust the quantities of water reducing Admixtures or eliminate its use and the Contractor shall be entitled to no additional compensation for such adjustments.
 - vii. The cost of the admixtures and all costs incidental to their use shall be included in the price bid in the Bill of Quantities for concrete in which the admixture are used.

5.4.5 Water

- i. A reliable water supply shall be installed and maintained for washing of aggregates and the manufacture and curing of concrete.
- ii. Water to be used in washing of aggregates and manufacturing and curing shall conform to the following specifications. Water shall be clean and free from injurious amounts of oil, acids, alkalis, sugar, salt and organic matter and shall conform to IS: 456.
- iii. Water for manufacturing of concrete shall be approved by the Client.

5.4.6 Tests during Execution of Works

i. Concrete:

- a) Concrete test cubes shall be prepared, and cured in accordance with IS: 456.
- b) The consistency of the proposed mixes will be tested by means of slump test. Specimen for slump tests will be taken from each batch of concrete used to make the test cubes.
- c) Air content will be determined in accordance with IS: 9103.
- d) Samples from the concrete shall be taken either at the batching and mixing plant or the placing point, and shall be cured and tested.

ii. Admixtures:

- a) Admixtures to be used will be tested for their suitability with the cement and materials to be used on the works and under proposed construction conditions.
- b) Admixtures will be sampled and tested as set out in IS: 9103.

5.4.7 Measuring and Tolerances

Water, cement, admixtures, fine aggregate and coarse aggregate shall be weighed separately and not cumulatively. The accuracy of the measuring devices shall be maintained so that the indicated measure does not vary by more than 1 percent from true measure throughout their range of use.

5.5 Batching and Mixing

- i. All aggregates shall be batched by weight.
- ii. All concrete shall be thoroughly mixed so as to positively ensure uniform distribution of the components throughout the mass during the mixing operations.

Technical Specifications

- iii. Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in color and consistency. If there is segregation after unloading from the mixer, the concrete shall be remixed.
- iv. Separation of coarse aggregate from mortar shall be avoided by proper arrangement of the discharge so that the concrete falls vertically and not diagonally into whatever container is to receive it.
 - v. Should the last fraction of the batch contain an excessive amount of coarse aggregate, this portion shall be retained and mixed with the succeeding batch.
- vi. Discharge pipes of all water batches shall be of such a size and so arranged that the flow into the mixer is completed within the first 25% of the mixing time and delivered well inside the mixer where it is mixed quickly with the entire batch.
- vii. On no account shall any addition be made to any component of a concrete batch once that batch has been mixed and discharged from the mixer, whether for the purpose of re-tempering or any other reason, without the prior approval of the Client.
- viii. The mixers shall not be charged in a manner that some water will enter in advance of cement and aggregate and all materials shall continue to flow in as rapidly as possible. The construction of the mixers shall prevent loss of materials during charging.
- ix. The mixers shall not be charged beyond their rated capacities and the entire contents of the mixer shall be discharged before recharging.
- x. Unless otherwise authorized by Client for mixers of 1m³ capacity or less, the mixing of each batching shall continue for 1.5 to 2 minutes after all materials, except the full amount of water, are in the mixer. For mixers of larger capacity, the minimum mixing time will be increased by 15 seconds for each additional 0.5 m³.
- xi. The mixing time shall be increased when, in the opinion of Client the charging and mixing operations fail to result in the required uniformity of composition and consistency within the batch and from batch to batch.
- xii. Mixers shall be rotated at the rate recommended by the manufacturer of the mixer.
- xiii. The arrangement for controlling, measuring and mixing operations shall be such that the operator, or an assistant in communication with the operator, may observe the concrete discharging from the mixer.
- xiv. Each mixer shall be cleaned after each period of continuous operation and shall be maintained in such a condition that the mixing action will not be impaired.

5.6 Conveyance

- i. Concrete shall be conveyed from mixer to forms as rapidly as practicable by methods, which shall prevent segregation and/or loss of ingredients. In case such separation occurs, concrete shall be remixed before being laid in place.
- ii. The distance between the mixer and the place of concreting as also the mode of transport of concrete shall be subject to the prior approval of the Client.
- iii. Concrete shall be deposited in the final position as early as practicable but always before initial set of the concrete starts. There shall be no vertical drop greater than 1.5 m except where equipment satisfactory to the Client is used to confine and control the falling concrete.

5.7 Placing of Concrete

5.7.1 General

- i. No mortar or concrete shall be placed except in the presence of the Client.
- ii. Concrete shall be placed only in locations where authorized and no concrete or mortar shall be placed until formwork, installation of reinforcing steel, steel ribs, piping and other embedded parts, preparation of surface and necessary clean up have been done and

- checked and certified by the Client, as being in conformity with specifications and drawings.
- iii. Concrete placed without prior knowledge and approval of the Client, may be required to be removed and replaced.
 - iv. Earth foundations on which concrete are to be laid shall be firm dry soil, free from any soft mud or other objectionable material.
 - v. Whenever concrete is to be placed on earth, a layer of lean concrete shall first be placed before placing concrete of the specified grade. The thickness of such layer of lean concrete shall be as shown on the drawings or as directed by the Client.
 - vi. No concrete shall be placed in running water. Water shall, generally, not be allowed to flow over freshly poured concrete until final set has been achieved.
 - vii. Immediately, before placing concrete, all such surfaces upon which concrete is to be placed shall be thoroughly cleaned by the use of high velocity air and water jets or sand blasting, steel brooms, picks or other effective means, satisfactory to the Client.
 - viii. Any pool of water from the surface on which concrete is to be placed shall be cleaned to ensure proper bonding of fresh concrete with the rock surface or previously poured concrete surface. The method of disposal of water at the work site shall be subject to the approval of the Client.
 - ix. Sufficient mixing and placing capacity shall be provided so that the work may be kept active and free from cold joints. Formed concrete shall be placed in horizontal layers, avoiding inclined layers and construction joints.
 - x. To get a monolithic placement, it is important that each layer be shallow enough so that the previous layer is still soft and the two layers are vibrated together.
 - xi. Concrete shall not be allowed or caused to flow horizontally or on slopes in the forms.
 - xii. Concrete placing on slope shall begin at the lower end of the slope and progress upward, thereby increasing compaction of concrete.
 - xiii. In order to reduce bleeding, slump shall not be more than necessary to achieve proper placement and consolidation.
 - xiv. All care shall be taken to avoid separation of coarse aggregate from the concrete. Obvious groups and clusters of separated coarse aggregates shall not be permitted. They shall be removed before the concrete is placed over them, otherwise they may cause serious imperfections in the finished work. Hence particular attention shall be paid to the tendency for objectionable separation to occur at the points of discharge so that uniformity and homogeneity of concrete in placement and good workmanship is assured.
 - xv. The concrete shall drop vertically into the centre of whatever container receives it. To protect the rods, spacers, and embedded features from damage and to prevent displacement of reinforcement, concrete falling in forms shall be confined in a suitable drop chute.

5.7.2 Preparation for Placing of Concrete

- i. All surfaces on which or against which concrete is to be placed, including surfaces of construction joints between successive concrete placement, reinforcing steel and embedded parts, shall be thoroughly cleaned of dirt, mud, debris, grease, oil, dried mortar or grout, laitance, loose particles or other deleterious matter.
- ii. Surface seepage and other water shall be so controlled, to the satisfaction of the Client, that at no time during the placement or hardening of the concrete will it wash, mix with, or seep into the concrete.
- iii. Wind barriers shall be erected, should wind cause a too rapid evaporation of water at the concrete surface. When curing of concrete is done with water using continuous sprinkling or hoses with holes and the rate of water evaporation losses could exceed 1.0 kg/m²/hr

wind barriers should be erected. The Contractor shall submit his wind barrier scheme to the Client for approval.

5.7.3 Concrete Placement

- i. The method and equipment used for placing concrete shall be such that it will permit the delivery of concrete of the required consistency into the Work without objectionable delay, segregation, porosity or loss of workability.
- ii. All surfaces of forms and metal work, including reinforcement bars, that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such matter before the surrounding or adjacent concrete is placed.
- iii. Concrete shall be placed in lifts as shown on the drawings or as directed by the Client.
- iv. In reinforced concrete works, which have congested parts, care shall be taken to see that all the bars are properly embedded and that no voids are left. On flat, horizontal surfaces, where a congestion of steel near the forms makes placing difficult, a mortar of the same cement sand ratio as is used in the concrete shall be first deposited to cover the forms.
- v. No concrete shall be placed in running water or during rain, high winds, dust storms, excessive heat or cold and similar conditions without prior approval of the Client.
- vi. In all cases, concrete shall be deposited as nearly as practicable directly in its final position.
- vii. The maximum time interval between placing successive layers within a lift shall not exceed 30 minutes. However, depending upon job requirements and climatic conditions, the Client can allow an increase of this time interval using appropriate methods of vibration/agitation or the use of retardants.
- viii. Concrete shall not be piled up in the forms in a manner that causes movement of the unconsolidated concrete, or permits mortar to escape from the coarse aggregate.

5.7.4 Rate of Placing Concrete

- i. Concreting shall be done as a continuous operation until the structure or section is completed or until a satisfactory construction joint can be made. The Contractor shall make all arrangements necessary to maintain continuity of concrete placing in any particular pour during meal periods, shift changes, or any other such interruptions.
- ii. Concrete shall not be placed faster than the placing crew can compact it properly.
- iii. In placing thin members and columns, precaution shall be taken against a too rapid placement, which may result in movement or failure of the form due to excessive lateral pressure. An interval of at least 24 hours, unless otherwise approved or directed by the Client, shall elapse between the completion of columns and walls and the placing of slabs, beams or girders supported by them.
- iv. The rate of placing shall be such as to have no objectionable effect on placement of concrete, particularly near the forms and in and around embedded equipment where the rate shall not exceed the limit placed by the Client.

5.7.5 Consolidation of Concrete

- i. Consolidation of newly placed concrete shall ordinarily be done with internal vibrator of an approved design. The equipment for vibration shall have adequate power and shall be of high frequency, rugged and reliable.
- ii. Operators of vibrators shall be experienced and competent in handling these devices.
- iii. Ample stand-by-units and parts, as well as, systematic servicing shall be provided.
- iv. Vibrators shall not be used to cause concrete to move more than a short distance laterally, otherwise fine wet material may run ahead and separate from the coarse aggregate.

Technical Specifications

- v. Inadvertent or unintended re-vibration of concrete may be beneficial provided the concrete become momentarily plastic again during re-vibration. Re-vibration shall be resorted to only after specific instructions are given by the Client.
- vi. Where vibration is used to full advantage for consolidation of newly placed concrete, no supplementary rodding or other working of the concrete is necessary.
- vii. Concrete shall be compacted and worked into all corners and angles of forms, obstructions, block-outs, locations with congested reinforcement, and around embedded items. Special care shall be taken to attend to these places with ample, properly applied additional vibration or rodding as the case may be, without permitting the concrete materials to segregate.
- viii. External, i.e. form vibrators of an approved type shall be used only in inaccessible locations and where it is impracticable to use immersion type vibrators; and only after their use has been specifically authorized by the Client. The form vibrators shall be designed to receive vibrations without losing shape and causing leakage of mortar.
- ix. The immersion type mechanical vibrators, complying with IS: 2505, electric, air driven or diesel, shall generally be inserted vertically and the vibrating head shall be allowed to penetrate under the action of its own weight. In very shallow concrete, some consolidation can be obtained by using vibrators in horizontal position.
- x. Internal vibrators, when used, shall be inserted at regular intervals and vibration, with the vibrator fully into the layer being compacted, shall be continued until an acceptable degree of compaction has been achieved, and by taking care to avoid excessive vibration which may result in the top containing excessive paste and laitance.
- xi. The entire depth of a new layer of concrete shall be vibrated and ordinarily the vibrators should penetrate the layer below (which has not yet become rigid) for approximately 10 cm to ensure thorough bond between the layers.
- xii. Under ordinary job conditions, there is little likelihood of damage from direct re-vibration of lower layer as long as the lower layer is still plastic and not reached its final set. Vibrators shall not, however, be inserted into lower courses that have commenced final set nor shall they be directly applied to or allowed to disturb reinforcement extending into hardened or partially hardened concrete. Vibration shall not be transmitted by means of the embedded steel.
- xiii. Systematic spacing of points of vibrators shall be established to ensure that no portions of the concrete are missed. It shall be ensured that zones of influence overlap and the concrete is properly consolidated.
- xiv. In compacting the surface of a concrete lift, the coarser particles of the aggregate in the surface shall be embedded while the concrete is being vibrated, but the surface left with the desired degree of roughness.
- xv. Disturbance of the surface concrete at construction joints during early stage of hardening shall be avoided. Necessary traffic on new concrete shall be on timber walkways constructed so as not to cause injury to the concrete.
- xvi. When smooth surfaces are required, for all surfaces that shall be permanently exposed to the weather and for all surfaces next to embedded metal work around which it is desired to prevent leakage, the adjacent concrete shall be properly vibrated, spaded or tamped.
- xvii. To ensure even and dense surfaces which are free from aggregate pockets, honey combing, or air holes, it may be necessary to supplement internal vibration with hand spading or tamping all along the boundaries of the concrete and around embedded parts, while the concrete is plastic under vibrating action.
- xviii. Equipment and methods for the production, transportation placing, consolidating, curing and finishing of concrete shall be subject to acceptance by Client.

5.7.6 Chipping and Roughening of Concrete Surfaces

- i) Surface upon or against which additional concrete is to be placed shall be chipped and roughened to a depth of not greater than 40% of the maximum aggregate size nor greater than 25 mm, whichever is smaller.
- ii) The roughening shall be performed by chipping, sand blasting or other satisfactory methods and in such manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface.
- iii) After being roughened, the surface of the concrete shall be cleaned thoroughly of the loose fragments, dirt and other objectionable substances and shall be sound and hard and in such a condition as to assure good mechanical bond between old and new concrete.
- iv) Concrete that is not hard, dense and durable shall be removed to the depth required to secure a satisfactory surface.

5.8 Finishing of Concrete

5.8.1 Finishing of Formed Surfaces

- i. Any damage to finished concrete resulting from the action of removing formwork or from any other cause shall be repaired to the satisfaction of the Client. Immediately on removal of the form, the surface shall be examined and all porous honeycombed or defective concrete removed and repaired as specified herein.
- ii. All imperfections or ridges due to joints in the formwork, shall be removed by light chipping or grinding down if necessary, to produce a smooth surface.
- iii. When the treatment of a surface has been completed, the surface shall be cured.
- iv. All patches and mortar filled pits on exposed surfaces shall be neat and have the same color and texture as the adjoining concrete.
- v. The finished surfaces of concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and other defective concrete and surface irregularities and shall be in accordance with the requirements for the particular class of finish specified herein or as shown on the drawings.
- vi. Finishing work shall be done only by skilled workman in the presence of the Client or his mandated representative and shall be performed as soon as possible and within one day after formwork removal.
- vii. Before final acceptance of the Work, Contractor shall clean all exposed concrete surfaces of all encrustations of cement, mortar or grout, to the satisfaction of the Client. Concrete shall not be considered finished until all required repair work and finishing have been completed.

5.8.2 Finishing of Unformed Surfaces

- i) Unformed surfaces shall be finished by one or more methods of screeding, floating and trowelling and working of the surfaces shall be done at the proper time, employing experienced men and shall be just sufficient to produce the desired finish.
- ii) Screeding: It gives the surface its approximate shape by striking off surplus concrete immediately after completion and shall be accomplished by moving a straight edge or template with a swing motion across wood or metal strips that have been established as guides. Where the surface is curved, a special screed shall be used.
- iii) Floating: Shortly after the concrete is screeded, the surfaces shall be brought true to form and grade by working it sparingly with a wooden float. If a coarse textured finish is specified or if the surface is to be steel trowelled, a second or final floating shall be performed after some stiffening has occurred and the surface moisture film or shine has disappeared.

- iv) Trowelling: If a smooth dense finish is desired, floating shall be followed by steel trowelling sometime after the moisture film or shine has disappeared from the floated surfaces and when the concrete has hardened sufficiently to prevent fine material and water from being brought up to the surface. Excessive trowelling at an early stage as would tend to produce cracking or result in a surface that is too hard to finish properly shall be avoided. Trowelling shall, therefore, be done at the appropriate time and shall have the surface smooth, even and free of trowel marks and ripples. A fine textured surface that is not slick shall be obtained by trowelling lightly over the surface with a circular motion keeping the trowel flat on the surface of the concrete. Where a hard steel trowelled finish is required, trowelling shall be continued until it no longer produces noticeable compaction and the surface has a glossy appearance, trowelling pressure being increased gradually as the operation progresses.
- v) The use of any finishing tool in areas where water has accumulated shall be prohibited. Operation on such areas shall be delayed until the water has been absorbed or has evaporated or has been removed by draining, mopping or other means.
- vi) All joints and edges on unformed surfaces, that shall be exposed to view, shall be finished with suitable moulding tools with rounded, bevelled or filleted edge, as directed by the Client. Unless the use of other slopes or level surface is indicated on the drawings as directed, narrow surfaces such as top of walls or tunnel portals shall sloped approximately 9 mm per 300 mm of width. Broader surfaces as walls, roadways, platforms and decks shall be sloped approximately 6 mm per 300 mm.
- vii) Where separate concrete finish for floors or for 2nd stage concreting in gate grooves is specified or directed, the concrete shall be struck off sufficiently below grade to allow for the subsequent placing concrete. The surface of such concrete shall be left rough, by applying air jet or any other means as specified by the Client.
- viii) As soon as the condition of the base permits and before it has hardened fully, all dirt, laitance and loose aggregate shall be removed from the surface, by means of water jets and wire brooms leaving the coarse aggregate slightly exposed and the surface made suitable for taking further concrete.

5.9 Tolerance for Concrete Construction

5.9.1 General

- i. Permissible surface irregularities for various classes of concrete surface finish as specified above are to be distinguished from tolerances as described herein.
- ii. Deviations from the established lines, grades and dimensions will be permitted to the extent set forth herein. DoR reserves the right to diminish the tolerances set forth herein if such tolerances impair the structural action or operational function of a structure or portion thereof. Where specific tolerances are not stated in these specifications, or if not shown on the drawings for a structure or portion of a structure, permissible deviations will be interpreted as conforming to the tolerances stated in this Chapter.
- iii. The Contractor shall be responsible for setting and maintaining concrete forms within the tolerance limits necessary to ensure that the completed work will be within the tolerances specified. Concrete work that exceeds the tolerance limits specified in these specifications or shown on the drawings shall be remedied or removed and replaced at the Contractor's expense.

5.9.2 Tolerances for Concrete Structural Components

Following table shows the different tolerance limits for the concrete structural components.

SN	Description	Tolerance
a	Departure from established alignment	- 25 mm, + 10 mm
b	Departure from established grade	- 25mm, + 10 mm
c	Variation from plumb from the specified batter for lines and surfaces of walls and for arises: Exposed in any length of 3.0m Backfilled. in any length of 3.0m In any height < 30 m In any height ≥ 30 m	±10 mm ±20 mm 1:1000 but not exceeding ±25 mm 1:1000 but not exceeding ±75 mm
d	Variation from level or from grades indicated on the drawings for slabs: Exposed in any length of 3.0m Backfilled in any length of 3.0m In any length < 30 m In any length ≥ 30 m	±8 mm ±15 mm 1:1000 but not exceeding ± 25 mm 1:1000 but not exceeding ± 75 mm
e	Variation in cross-sectional dimensions of slabs, walls and similar parts of the structures.	- 5 mm, +10 mm
f	Tolerance for placing reinforcing steel -	With member size < 60 mm, -5 mm With member size ≥ 60 mm, 10 mm
g	Variation from indicated bar spacing	± 25 mm, but number of bars per meter is maintained
h	Variation of protective cover	when member size is < 300 mm, - 8 mm when member size is ≥ 300 mm, -8 mm

5.9.3 Defective & Damaged Concrete

Concrete which is damaged from any cause and is not manufactured, placed and compacted in accordance with the scheduled specifications and is found to have lower strength, density etc. than specified, as determined from test samples or core samples, shall be removed and replaced by the Contractor. The Contractor shall seek the approval of the Engineer-Charge for the method and timing of the removal.

5.10 Curing & Protection of Concrete

5.10.1 Curing with Water

- i) Plant and materials required for curing and protection of concrete shall be available at the location of each concrete placement before concrete placement is started and the water used for curing shall meet the requirements set out as specified in this specifications.
- ii) All concrete shall be protected against damage until final acceptance.
- iii) Exposed finished surfaces of concrete shall be protected from the direct rays of the sun for at least 72 hours after placement.
- iv) Fresh exposed concrete shall also be protected from the action of the rains, flowing water and mechanical injury.
- v) Curing water temperature shall not exceed 25°C or above the expected average ambient temperature (in the shade) of the 28-day curing period. Note that curing water should not be much cooler than the concrete; otherwise, it may cause cracking from thermal stresses. Average anticipated ambient temperature (in the shade) shall be based on climatic records and forecasts approved by the Client.
- vi) No fire shall be permitted in direct contact with concrete at any time.

Technical Specifications

- vii) Concrete in which Portland cement is used shall be kept continuously wet for not less than 14 days, for normal concrete and 21 days for concrete containing Pozzolana or fly ash, by covering with water saturated materials such as jute bags wet burlaps, or a system of perforated pipes, mechanical sprinklers or porous hole or by any other approved method. Curing period where special cement may be used shall be specified by the Client.
- viii) Construction joints shall be cured in the same manner as the other concrete and shall also, if practicable, be kept moist until the placing of additional concrete upon the joint or for at least for 72 hours.
- ix) Horizontal surfaces shall be cured preferably by the use of wet quilts or mats and/or by sprinkling water or by covering with damp sand all of which shall have a satisfactorily supply of the required curing water. If damp sand or quilt is used for curing, it shall later be completely removed. The time of applying damp sand shall be specified by the Client before which curing shall be carried out by other approved methods.
- x) The method of keeping formed vertical concrete surface moist shall be by covering with a water saturated material and continuous sprinkling or spraying of water as may be necessary to prevent any portion of the surface from drying during the specified period.
- xi) The unformed top surface shall be moistened by covering with a water saturated material such as jute bags, or by other effective means as soon as the concrete has hardened sufficiently to prevent damage by water.
- xii) The water and other methods of curing shall be so handled as not to stain concrete surfaces, which shall be exposed.
- xiii) The actual method of curing adopted shall be subject to the approval of the Client.

5.10.2 Protection of Concrete

- i. Care shall be taken not to disturb the steel reinforcement projecting from any placement for at least 24 hours after the completion of such placement.
- ii. Finished concrete surface shall be protected from stains or abrasion and surface or edges likely to be injured during the construction period shall be kept properly protected by leaving forms in place or erecting protective covering satisfactory to the Client.
- iii. In case, the curing operations are inadequate or unsatisfactory, the Client shall be entitled to take such steps as he may deem necessary to make good the deficiencies and defects.
- iv. Traffic and other construction operations shall be such as to avoid damage to coatings of curing compound for a period of not less than 28 days after application of the curing compound. Where it is impossible because of construction operations to avoid traffic over surfaces coated with curing compound, the membrane shall be protected by a covering of wooden planks at least 25 mm thick or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. Any sealing membrane that is damaged or the peels from concrete surfaces within 28 days after application shall be repaired without delay.

5.11 Repair of Concrete

- i) Repair of concrete shall be performed by skilled workmen and in the presence of the Client.
- ii) No repair work shall be carried out until the Client has inspected the location of the proposed repair and accepted the method of repair.
- iii) The Contractor shall correct all imperfections on the concrete surfaces as necessary to produce surface that shall conform to the required standards.
- iv) Stains and discolorations of exposed concrete surfaces shall be repaired. The procedure method shall be submitted by the Contractor and is subject to the approval of the Client.
- v) All materials, procedures and operations used in the repair of concrete shall be subject to approval by the Client.

Technical Specifications

- vi) Surfaces of concrete finished against forms shall be smooth and free from projections. Immediately upon the removal of forms and within 24 hours thereof, wherever practicable, all unsightly ridges or fins shall be removed and any local bulging on exposed surfaces shall be removed and remedied by tooling and rubbing. All holes left by the removal of fasteners and tie rods shall, after being reamed with a toothed reamer, be neatly filled with dry pack mortar.
- vii) All honeycombed, porous, fractured, or otherwise defective concrete and surface concrete in which, in the opinion of the Client, additions are required to bring it to the prescribed lines, shall be removed by chipping concrete.
- viii) The chipped openings shall be sharp edged and keyed, and shall be filled to the required lines with fresh concrete or as found suitable. Where concrete is used for filling, the chipped openings shall be not less than 100 mm in depth and the fresh concrete shall be reinforced and dowelled to the surface of the openings as directed by the Client.
- ix) Dry pack mortar shall consist of one part of cement to two parts of sand by volume and just enough water so that the mortar as used sticks together on being moulded into a ball by slight pressure of the hands and does not free water when so pressed but leaves the hands damp. The mortar shall be fresh when placed and any mortar that is not used within 30 minutes, after preparation shall be wasted with all consequences to the Contractor.
- x) The mortar shall be placed in layers not more than 25 mm thickness after being compacted and each layer shall be thoroughly tamped to the satisfaction of the Client. Each layer except the last shall be roughened thoroughly to provide effective bond with the succeeding layers. The last or finishing layer shall be smoothed to form a surface continuous with the surrounding concrete. Dry pack mortar shall be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.
- xi) All patches shall be bonded thoroughly to the surface of the chipped holes and shall be sound and free from shrinkage cracks and shoddy areas.

5.12 Concrete Pouring Quantity

The Contractor has to put into account, that there will be concrete pouring up to 50 m³ per day. The Contractor shall manage all necessary materials, equipment and personnel to fulfill this task.

5.13 Measurements & Payments

5.13.1 General

The rates have to include all works, materials and efforts necessary to complete the task. No additional payments will be made for further handling, loading, offloading, transport, water keeping, pumps, or any activities and costs. These notes apply to all items, serial no. works, and descriptions in the tender documents. This specifications are valid for every item and rate the documents and for any part and any kind of works necessary to construct the bridge. These conditions are an integral part of these tender documents.

5.13.2 Structural Concrete

- i. Measurement of each grade of concrete, unless specified otherwise hereafter, shall be made of the volume, in cubic meters, as shown on the drawings or as required or determined by Client.
- ii. Payment will be made at the Unit Rate in cubic meters for different grades and types of concrete entered in the Bill of Quantities, which shall include, but not be limited to, the following:
 - a.) Excavation, loading, transportation, crushing, screening, washing, blending and storage,

- b.) Batching, supply of mixing water, mixing, transportation, placing and compacting the concrete,
- c.) Labour, tools and equipment for cleaning and preparing surfaces prior to concreting,
- d.) Forming and treatment of construction joints including furnishing and spreading of mortar layers before concrete placing,
- e.) Surface finishing,
- f.) Attaining the concrete temperature as specified, and following hot and/or cold weather precautions,
- g.) Protection and curing of concrete,
- h.) Repair of defective concrete,
- i.) Furnishing samples of materials i.e. cement, coarse and fine aggregates, water, admixtures as also the samples of concrete, mortar and providing assistance for sampling required in connection with the tests to be performed by the Corporation as and when required,
- j.) Chipping and roughening of concrete surface,
- k.) All laboratory tests to be performed by the Contractor as stipulated in this specification.

5.13.3 Cement

- i) The Unit Rates for various grades of concrete shall include the cost of the cement content specified therein.
- ii) The cement contents of the original mix (mixes) on which the bid has been priced and the mix (mixes) finalized after trial mix stage may differ. However, no separate payment will be made to the Contractor for such increase or decrease in the cement content.
- iii) **According to Circular No. MoF/Central Proc/2010/1246 dated 15/11/2010 of Ministry of Finance regarding Central Procurement of Cement; Contractor has to use cement manufactured by PCAL for government budgeted works amounting to Nu. 10 million and above. The cement has to be lifted from the nearest PCAL sales Depot at Phuentsholing, Samdrup Jongkhar or Gelephu. The contractor has to arrange and pay for the transportation and make direct payment to PCAL at the price notified to the public, including the taxes, which may change from time to time. This rate should be applied in the rate analysis for all items of cement work.**

Vide circular No. MoF/Central Proc/2010/1948 dated 19/01/2011, cement manufactured by Lhaki Cement, Gomtu is also accepted for government works of Nu. 10 million and above. In case of Lhaki Cement, the agencies can lift the cement from any of their agents, where available.

The conditions and procurement procedures remain same as specified in the circular No. MoF/Central Proc/2010/1246.

5.13.4 Admixtures

No separate payment will be made for supplying & adding admixtures to concrete, which shall be the Contractor's liability.

5.13.5 Exclusions

No extra measurement or payment will be made for the following:

- a. Any rounded or bevelled edges, fillets, scoring, chamfers, or any deduction made for voids or embedded items, which are either less than 0.10 m³ in volume. No allowance will be made for approved temporary openings, drains, embedded pipes, or recesses created by the Contractor for his own convenience during construction provided they are filled as directed,
- b. Any defective and wasted concrete, which has to be removed and replaced due to Contractor's non-compliance with the Specifications or Client's dissatisfaction.
- c. Any concrete which the Contractor places or uses for his own installations or for his own convenience.
- d. Making stockpiles for coarse and fine aggregates.
- e. Removal and replacement of any concrete placed without the prior knowledge and agreement of the Client.
- f. Removal and replacement of concrete not manufactured, placed and compacted in accordance with these Specifications,
- g. Curing compound and all operations involved in its use,
- h. Forming expansion and contraction joints including making drainage and other holes where such joints occur,
- i. Filling of holes left by the removal of concrete samples with the concrete of the same grade.

5.14 Formwork

5.14.1 Scope of Work

The work under this Chapter shall comprise supply of all labour, plant and material and the performance of all work necessary for the design, fabrication, supply, erection, maintenance and removal of formwork and false work to form concrete structures as shown on the Construction Drawings or as otherwise directed by the Client.

5.14.2 Definitions

- i) FORMS or FORMWORK shall mean the moulds into which concrete is placed.
- ii) FALSE WORK or SHORING shall mean the structural supports and bracings for forms used in any part of the Works.
- iii) CURVED FORMS shall mean any form not composed of plain surface and limits of curved forms shall not extend beyond the lines of tangency or intersections with flat surfaces.

5.14.3 Standards

The formwork material, design, fabrication, erection, maintenance and removal of formwork shall conform to the latest revisions of the following Indian Standards or, where not covered by these standards, to the equivalent International Standards:

IS: 456 Code of practice for plain and reinforced concrete.

5.14.4 Materials

5.14.4.1 Formwork

- i) Material used for form sheathing and lining shall be of wood, steel, plywood, or fibre glass. All materials used in formwork construction shall be of adequate strength and quality for their intended purpose.
- ii) Timber shall be sound, straight, free from warp, decay and loose knots and shall be dressed smooth. Except as expressly approved by the Client, all
- iii) Timber brought to the Site for use as forms, shoring or bracing shall be new material.
- iv) Plywood for use as form shall be mill-oiled and edge-sealed. Plywood shall be non-warping, non-wrinkling and manufactured with special waterproof glues. Plywood sheets shall be of uniform width and length.
- v) The surface of steel of steel lined forms shall be smooth. Forms with dents, buckled areas or other surface irregularities shall not be used.
- vi) Rough sawn boards may be used only for underground concreting works.
- vii) Re-use of forms will be allowed only if they are thoroughly cleaned and repaired and capable of producing the finish required for the concrete. Timber or plywood forms repaired with metal patches shall not be used.
- viii) Damaged forms that have deteriorated through use shall not be used.
- ix) Where required, expanded metal fixed to the formwork shall be used in vertical construction joints.

5.14.4.2 Form Ties

- i) The type, number and positions of internal formwork supports and ties shall be to the approval of the Client. Form inserts or other similar permanently embedded items shall be accurately located and securely fastened in place. The number and location of form ties and bolts shall be such as to ensure that forms fit tightly against the concrete previously placed and remain in tight contact during operations.
- ii) The whole or part of such formwork supports and ties shall be removed without damage to the concrete so as to leave no part embedded nearer the surface of the concrete than the designed cover of the reinforcement or 50 mm in the case of unreinforced concrete. Only metal portions of formwork supports and ties shall be allowed to remain in place.

5.14.4.3 Design

- i) The Contractor shall be solely responsible for the adequate design, construction and maintenance of any and all formwork and false work required in the Works. Forms shall be designed to permit the concrete to be deposited as nearly as is practicable directly in its final position, and to allow inspection, checking the cleanup of the formwork and reinforcement to be completed without delay.
- ii) Formwork and false work shall be designed, fabricated, erected and removed in accordance with the applicable provisions of the recommended practice for concrete form of IS: 456.
- iii) All false work shall be designed to withstand safely all live and dead loads that might be applied to the false work during all stages of construction, service and removal.
- iv) For the purpose of formwork and false work design, the Contractor shall assume a value of 25 kN/m^3 for the density of concrete. Further, construction loads shall also be applied and assumed to act simultaneously with the self-weight of concrete. Such construction loads shall be of at least 1.5 kN/m^2 .

5.14.4.4 Erection of Formwork

- i) Formwork and false work shall be constructed only after the formwork drawings have been accepted by the Client.
- ii) Formwork shall be erected and maintained such as to confine the concrete without loss of mortar and to produce required finished surfaces. Forms shall be set and maintained within the specified tolerance limit such that the complete concrete surfaces are within these limits.
- iii) Forms for concrete against which backfill is to be placed or which will not be exposed to view may be constructed of smooth tight boards not less than 25 mm nominal thickness.
- iv) Forms for concrete exposed to view shall be constructed of steel or plywood, which is smooth and free from defects, with matched and sanded joints to give a symmetrical pattern over the entire area. Chamfer strips, 25 mm by 25 mm shall be used on all exposed corners, unless otherwise directed by the Client.
- v) Any forms, which in the opinion of the Client are unsafe or inadequate in any respect, may, at any time, be rejected and the Contractor shall promptly remove the rejected forms from the works and replace them.
- vi) When a second lift is placed on hardened concrete, the number, location and tightening of ties at the top of the old lift and bottom of the new shall be such as to prevent any damage to concrete. The form of a new lift shall overlap the hardened concrete by at least 100 mm, to prevent abrupt irregularities.
- vii) Forms for sloping concrete surfaces shall permit their placing board-by-board or panel-by-panel immediately ahead of concrete placement so as to enable access for placement, vibration, and inspection of the concrete.
- viii) All form surfaces shall be thoroughly cleaned before erection and shall be lubricated with a non-staining mineral oil. Excess oil shall be wiped off from the forms prior to placement of concrete. Oil shall not be allowed to come into contact with reinforcement steel or other embedded items.
- ix) Immediately before the concrete is placed, all forms shall be inspected to ensure that they are properly placed, sufficiently rigid, clean, tight, properly surface treated and free from excess of oil or other foreign materials. No concrete shall be placed until the formwork has been inspected and accepted by the Client.

5.14.4.5 Removal of Formwork

- i) Removal of forms shall be performed with care so as to avoid injury to the concrete and as soon as permissible in order to avoid delay in curing and repair of surface imperfections. Forms shall not be removed without the consent of the Client.
- ii) Forms shall not be removed until the concrete has attained sufficient strength to prevent damage to concrete. Damaged concrete shall be repaired or treated by the Contractor as soon as possible, but not before the Client has inspected such damage and agreed to the remedial works.
- iii) The elapsed time between the completion of concrete placing and the removal of forms shall generally be in accordance with IS: 456-2000.
- iv) The governing rule to be observed is the 28-day compressive strength, which shall be determined by the cube test. When fixing the minimum period for formwork removal, the shrinkage and creep of the concrete shall be taken in to consideration.
- v) False work removal shall be progressive so that no sudden loads are imposed on large areas of concrete. In removing the false work the Contractor shall place props, which shall be maintained until the concrete has attained sufficient strength to prevent damage to the concrete, but not before the following unless the Client can approve an earlier removal based on the comparison of strength of the concrete to its 28-day compressive

Technical Specifications

- strength. a) Props to slabs 14 days or 85% strength b) Soffit formwork to beams 21 days or 80% strength c) Props to beams 28 days or 90% strength
- vi) Considering the weather conditions and type of pour, the Client may modify the minimum elapsed time required before formwork can be removed from individual pours, and in case of formwork for beams and deck slabs it shall remain in place until concrete has developed the specified design strength.
 - vii) Notwithstanding the above or any approval given by Client, Contractor shall be fully responsible for ensuring that sufficient time has elapsed for the concrete to attain adequate strength before removal of formwork.
 - viii) Forms shall be removed carefully so as to avoid cracking, spalling, peeling, breaking of edges or surfaces, or other damage to concrete. If it is necessary to use wedges, only wooden wedges shall be used against the concrete. Damaged concrete shall be repaired or treated by the Contractor as soon as possible, but not before the Client has inspected such damage and agreed to the remedial works.

5.14.5 Measurement and Payment

5.14.5.1 General

- i) Measurement for formwork will be of the formed area for the class of finish shown on the Construction Drawings.
- ii) Payment will be made at the Unit Prices per square meter entered in the Bill of Quantities for various classes of flat and curved formwork, which shall include the entire cost of design, maintenance, oiling, erection, all necessary ties and fixings, supply and erection of all material, labour, access scaffoldings, forming of chamfers up to 1000 mm² either internal or external and edges up to 100 mm width.
- iii) Openings in the forms for block outs, niches, etc., for the areas which are smaller than 0.5 m² will not be deducted from the area measured for payment.
- iv) Measurement for formwork used to form contraction and expansion joints will be made of the flat area in square meters of joints shown on the Construction Drawings.

5.14.5.2 Exclusions

No extra measurement or payment will be made for the following:

- i) Any kind of construction joints and key boxes,
- ii) Formwork used for manufacturing of precast concrete units,
- iii) Unformed surfaces,
- iv) Any forms rejected by the Client and the replacement thereof,
- v) Any damage caused by Contractor's negligence during forms removal.

5.15 Steel Reinforcement

5.15.1 Scope of Work

- i) The Specifications described herein relate to the work, which includes all labour, materials, equipment and services required for the supply, handling, storing, cutting, bending, binding, welding, cleaning, placing and fastening into position all reinforcing steel, as shown on the drawings, to be carried out by the Contractor under this Contract.
- ii) The Contractor shall produce the detailed bending schedules and placing drawings. These drawings shall be based on the outline reinforcement plans provided in the drawings.

5.15.2 Standards

- i) The cutting, welding, placement and binding of reinforcing steel shall conform to following Indian Standards or, where not covered by these Standards, to their equivalent International Standards, subject to the approval by the Client.

Code No	Description
IS: 280	Mild steel wire for General Engineering purposes.
IS: 432	Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS: 456	Code of practice for plain and reinforced concrete.
IS: 814	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.
IS: 1566	Hard-drawn steel wire fabric for concrete reinforcement.
IS: 1608	Mechanical testing of metals – tensile testing.
IS: 1786	High strength deformed-steel bars and wires for concrete reinforcement.
IS: 2062	Steel for general structural purposes.
IS: 2502	Code of practice for bending and fixing of bars for concrete reinforcement..
IS: 2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
IS: 5525	Recommendations for detailing of reinforcement in reinforced concrete works.
IS: 9417	Recommendations for welding cold worked bars for reinforced concrete construction.

- ii) In case of conflict between the above Standards and the Specifications given herein, the decision of the Client should prevail.

5.15.3 Material

The reinforcing bars shall meet the requirements high yield strength deformed bars conforming to IS: 1786 (latest revision) and other relevant Indian Standards. (latest revision).

Minimum yield strength = 500 MPa
 Minimum tensile strength = 545 MPa
 Minimum elongation = 12.0 %

The following diameters may be used but shall follow the drawings unless otherwise approved by the Client:

8, 10, 12, 16, 20, 25, 28, 32 mm.

The maximal length of the individual steel bars can be obtained from the reinforcement lists. The lists are shown on the drawings and are also an integral part of the bill of quantities (tender documents). The Contractor has to optimize his cutting of the steel by himself. There will be no payment made for any wastage of steel whatsoever, as this has to be included into the calculation and price of the rates.

The rates for the reinforcement steel have to include all efforts and costs for the supply, wastage, cutting, wasting, bending, placing and fixation in the indicated positions as per the drawings and all works necessary to fulfill the task.

5.15.4 Fabrication

- i) All bars shall be cut and bent in accordance with the bar bending schedules made by the Contractor which have been previously approved by the Client.

- ii) Reinforcing steel bars shall be cut and bent on the Site of the Works or at a fabricator's plant.
- iii) Reinforcing steel shall not be straightened or rebent in a manner that will damage the materials. Bars with kinks or bends other than those indicated on the drawings and schedules shall not be used.
- iv) Shorter lengths of steel shall not be used in places where continuous lengths are required as per the drawings without the approval of the Client. Shorter bars, if approved for use, shall be lapped or spliced to achieve continuity in accordance with the requirements of relevant Indian Standards or as approved by the Client.
- v) Bars shall be bent cold to the shape and dimensions shown on the drawings using a bar bender operated by hand or power to attain the proper radii of bends.
- vi) A standard 180 degree hook at the end of a reinforcement bar, if used, shall have an inner diameter not less than six times the diameter of the bar, up to a bar or 25 mm diameter, and shall have length of straight part beyond the curve of at least four times the diameter of the bar. Hooks shall be used only where shown on drawings or as required by the Client. The radii of bends for stirrups and ties shall be less than four times the diameter of the bar for up to bars 16 mm in diameter, and six times the diameter for bars up to 25 mm diameter and should follow the drawing.
- vii) Heating of reinforcement bars to facilitate bending shall not be permitted.
- viii) The reinforcement available from rejected reinforced concrete shall not be used without prior approval of the Client.

5.15.5 Splicing of Reinforcement Bars

- i) Wherever it is necessary to splice reinforcement, the splices shall be made by lapping, or by mechanical means.
- ii) The steel bars shall be joined by providing lap joints in accordance with the requirements of the relevant Indian Standards or as approved by the Client. Splices at points of maximum stress shall however, be avoided. Splices in adjacent bars shall be staggered as directed by the Client. Lap length of bars shall be as shown on the drawings and as per Indian Standards. This length may be changed by the Client in special locations.
- iii) If the contractor proposes to use welded splices in the reinforcing bars, the equipment, the materials and all welding and testing procedures shall be subject to the approval of the Client. The contractor shall carry out test welds as required by Client.
- iv) For welded splices for reinforcing bars, welding shall be done in accordance with relevant Indian Standard Codes. Electrodes for welding shall conform to relevant Indian Standards. But welding shall be done only to reinforcement bars of weldable grade.
- v) If the Contractor proposes to use mechanical couplings for reinforcing bars, he shall submit samples of the proposed coupling to the Client for approval prior to their proposed use.
- vi) Lap splices shall not be used for bars larger than 36 mm diameter, which may be welded with the approval of the Client. In cases where welding is not practicable, lapping of bars larger than 36 mm may be permitted, in which case, additional spirals shall be provided around the lapped bars. Where welding is approved, the Contractor shall prepare at least three samples of butt welds as directed by the Client. These specimens shall undergo tests by the Contractor in a recognized laboratory. If the results are satisfactory, the Client may allow welding instead of lap joints. The decision of the Client in this regard shall be final. The joint shall be butt welded by the electric-arc-method. The ends of the bars shall be cleaned of all loose scale, rust, grease, or other foreign materials and all welding shall conform to the relevant Standard Specifications for welding of reinforcement bars used in reinforced concrete construction or as directed by the Client.

- vii) A weld shall be considered unsatisfactory if it fails to sustain a tensile stress of at least 90% of the tensile strength of the bar in which the weld has been made.

5.15.6 Execution

5.15.6.1.1 *Placing*

- i) Before being placed in position, the reinforcing steel shall be thoroughly cleaned of loose mill scale and rust, grease, paint, or other coatings that would reduce bond. All splashed concrete, which has dried on the reinforcing steel, shall be removed.
- ii) Reinforcing steel to be incorporated in the Works shall be placed accurately in positions as shown on the drawings and shall be held firmly in place during the placing and setting of the concrete.
- iii) Reinforcing steel shall be so placed that there will be a clear distance of at least 50 mm between the reinforcing steel and anchor bolts or embedded metal Work.
- iv) Reinforcing steel shall be maintained in position by the use of small concrete blocks, steel chairs, steel spacers, steel hangers and other steel supports and ties, acceptable to the Client at sufficiently close intervals so that they do not either sag between supports or be displaced during placing of concrete or by any operation on the Work. Wood supports or spreaders shall not be used. All intersections shall be securely tied except that where the bar spacing is less than 300 mm in each direction, only alternate intersections need be tied.
- v) Binding wire and steel chairs shall not be carried to permanently exposed surfaces and shall be subject to the same requirements with regard to concrete cover as for the reinforcing steel.
- vi) Special care shall be exercised to prevent any disturbances of the reinforcement in concrete that has already been placed. The reinforcement after being placed in position shall be maintained in a clean condition until it is completely embedded in concrete.
- vii) The longitudinal bars shall be straight and fixed parallel to each other and to the sides of the form as shown on the drawings. The ties, links and stirrups connected to the bars shall be tightly fixed so that the bars are properly braced. The inside of their curved part shall be in actual contact with the bars around which they are fixed and their position shall be exact as shown on the drawings.
- viii) Wire for tying reinforcement shall be black annealed iron wire. The diameter of wire shall not be less than 1.6 mm and shall have an ultimate strength of 5.63 tonnes per cm² and yield point of not less than 3.87 tonnes per cm².
- ix) “Bar-Grip” type joints shall be adopted by the Contractor for deformed bars of 25 mm diameter and above, subject to the approval of the Client. Splices at points of maximum stress shall however, be avoided. Splices in adjacent bars shall be staggered as directed by the Client. Lap length of bars shall be as shown on the drawings and in accordance with IS standards. This length may be changed by the Client in special locations.
- x) Sufficient concrete cover, as indicated on the drawings shall be provided to protect reinforcement from corrosion. All protruding bars from concrete to which other bars are to be attached and which shall be exposed to action of the weather for long period shall be protected from rusting by a thin coat of neat cement grout. Accurate record shall be kept at all the times of the number, sizes, lengths and weights of bars placed in position for different parts of the Work.
- xi) The Contractor shall avoid the use of two different grades of steel for one construction object.

5.15.6.2 Tolerance for Placing Reinforcing Steel

- i) Unless otherwise required by the Client, reinforcement shall be placed within the following tolerances:
 - a) For effective depth of members of 300 mm or less, the variation shall be limited for spacing of rebars +25 mm, for cover –5 mm, +2 mm,
 - b) For effective depth of members of more than 300 mm, the variation shall be limited for spacing of rebars +25 mm, for cover –8 mm, +2 mm.
- ii) The cover shall, in no case, be reduced by more than one-third of specified cover or varied beyond the above tolerances whichever is less, unless approved by the Client.

5.15.6.3 Care of Placed Reinforcement and Concrete

Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care shall be taken to ensure that at no time the radius of the bend is less than 8 diameters for deformed bars and 6 diameters for plain mild steel bars. Care shall also be taken, when bending back bars, to ensure that the concrete around the bar is not damaged.

5.15.7 Measurements and Payments

5.15.7.1 General

- i) Measurement for payment for reinforcing bars will be of the weight of reinforcement steel including hooks, bends and splices actually installed and approved by the Client. Actual lengths of reinforcement bars including permissible hooks, bends and splices will be measured. The weight of reinforcing bars will then be calculated for each size of bar from the Unit weight as stated on the Certified copies of manufacturer's reports or by actual weighing at site, which the Contractor shall submit to the Client.
- ii) Before starting concreting, the Contractor shall make sure that the measurements of reinforcing bars placed in position have been recorded and that the Client, or his mandated representative has certified the correctness of the reinforcement used.
- iii) For the purpose of payment, a welded joint, or mechanical splicing will be considered as equivalent to a length of bar 30 times the diameter of the bar in which the weld or the mechanical splicing is made.
- iv) Payment will be made at the Unit Rate per metric tonne entered in the Bill of Quantities, which shall include the entire cost of supplying, handling, storage, cutting, bending, binding, welding, cleaning, placing, wire clips, ties, separators, mechanical connectors, and any other fastening devices.

5.15.7.2 Exclusions

No extra measurement for payment or payment will be made for the following:

- a) Wire for tying reinforcement,
- b) Any additional reinforcement or splices required when Contractors casting sequences differ from construction joints shown on the drawings,
- c) Any reinforcing steel placed by the Contractor for his own convenience in addition to those shown on the drawings,
- d) Devices like steel chairs, hangers, spacers, small concrete blocks, other supports, ties and anchor rods etc. used to maintain reinforcing steel in position,
- e) Any reinforcing steel delivered for testing,
- f) Carrying out tests for checking butt welds to replace lapping/splicing of reinforcing bars,
- g) Any Mechanical/Welded splicing provided by the contractor due to his fault in not

maintaining the required concrete cover for overlap or due to any other reason of poor workmanship as decided by the Client.

5.16 Reinforced Concrete (RC) Bill of Quantities (BOQ)

It is understood that, for the complete bills of quantities, the supply, providing, transportation, loading and offloading, handling, and all efforts and required materials have to be included in the rates. The building site itself is considered as an area within a range of 5 km.

6 Structural Steel Works

6.1 Launching of Bailey Bridge

The launching of the superstructure Bailey bridge shall be carried out under the supervision of a competent engineer. Prior to start of the work, the contractor shall submit a detail plan of the launching procedures and equipment/machinery proposed to be used. Care should be taken during launching to not to damage the paints on the steel elements.