

CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 9. CONCRETE PRODUCTION AND CONCRETE CONSTRUCTION

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SECTION 9. CONCRETE PRODUCTION AND CONCRETE CONSTRUCTION

9.1 CONTRACTOR'S EQUIPMENT AND CONSTRUCTION FACILITIES

9.1.1 General

- a. The Contractor shall manufacture concrete at the Site in accordance with the Contractor's proposals approved in principle in the Letter of Acceptance.

All concrete work shall be performed as established on the Drawings or directed by the Engineer and carried out in the presence of an inspector of the Engineer. Unless specifically provided for otherwise in the Specification, concrete shall be produced, placed, cured, finished and tested in accordance with the applicable provisions of the Standard Specification of JCEA and the Manual of Standard Practice of ACI.

- b. Not less than 60 days before for processing, the installation of Contractor's Equipment for Concrete Works to be used for handling, transporting, storing, proportioning and cooling concrete ingredients, and for mixing, transporting and placing concrete, mortar and shotcrete, the Contractor shall submit flow charts, drawings, and written descriptions to allow for the full and proper assessment of his proposals for the production of aggregates and the production and placing of concrete, mortar and shotcrete in the Works.

All aggregate shall be produced using plant capable of supplying aggregate at a rate which is adequate to meet the requirements of the Construction Programme.

After completion of installation, the operation of the Contractor's Equipment for concrete works and storage facilities shall be at all times subject to the approval of the Engineer.

Approval of Contractor's Equipment for concrete works or its operation, or of any construction procedure, shall not operate to waive or modify any provisions or requirements contained in this Specification governing the quality of the materials or the finished work.

- c. Unless otherwise approved by the Engineer, the Contractor shall provide and maintain a cooling plant capable of supplying cooling water for all concrete at the temperature and in the quantities required to meet the needs of this Specification. In assessing the capacity of the plant the Contractor shall take into account the programme requirements, the size of the placements, the heat generating capacity of the mixes he proposes to use, the ambient temperatures, the solar loading and the temperature of the available river water.

- d. The Contractor shall install, maintain and operate at his own expense a loud ringing telephone system linking the points of placing concrete with the concrete batching.

9.1.2 Transporting and Handling Equipment

The use of transporting and handling equipment including buckets, chutes, hoppers, agitators trucks or pumps which cannot readily handle and place concrete of the slumps specified in Clause 9.2 will not be approved.

9.1.3 Alternative Types of Equipment

Where this Specification requires specific types of equipment to be used or specific procedures to be followed, such requirements are not to be construed as prohibiting use by the Contractor of alternative types of equipment or procedures if it can be demonstrated that equal results will be obtained by the use of such alternatives.

9.1.4 Pollution

All proper precautions shall be taken by the Contractor to minimise discharge into the Kreo River and local streams and water courses of water containing visible suspended matter. In locations where such discharge appears to the Engineer likely to take place, the Contractor shall construct, maintain and operate suitable settling ponds, separating plants or other effective means that may be necessary to prevent such discharge. The measures taken shall be in accordance with the Contractor's proposals as approved in the Letter of Acceptance and as otherwise modified from time to time by the Engineer in accordance with this Specification.

9.1.5 Payment

- a. The Contractor shall not be entitled to any additional payment over the rates and lump sums tendered in the Bill of Quantities for concrete by reason of any limitations in the batching, mixing, transporting and placing of concrete required under the provisions of this Specification.
- b. Separate payment will be made for complying with the provisions of Sub-Clause 9.1.4. and all costs shall be deemed to be included in the rates and lump sum prices tendered in the Bill of Quantities.

9.2 COMPOSITION

9.2.1 General

- a. Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, water and admixture as specified, all well mixed and brought to the proper consistency.
- b. The source and type of ingredients used in the concrete shall not be varied without approval.
- c. All concrete and its constituent materials and all methods and procedures shall conform to applicable Standards specified in Clause 1.6.

9.2.2 Maximum Size Aggregate

- a. Unless otherwise approved or directed, the nominal maximum size aggregate used in concrete shall be as follows:
 - (i) 40 mm – for concrete in walls, slabs and sections of medium thickness and not heavily reinforced.

- (ii) 20 mm – for heavily reinforced sections, precast concrete units and thin walls or sections.

9.2.3 Responsibility for Mix Design

The Contractor shall be responsible for the design of concrete mixes and for ensuring that all concrete placed in the Works meets the requirements of the Specification.

9.2.4 Criteria for Designing Mixes

All mixes shall be designed so that :

- a. The amount of cement and fine aggregate are the minimum necessary to obtain concrete having workability, density, impermeability, resistance to abrasion, durability, low shrinkage and meeting the requirements of Sub-Clause 6.
- b. The mean strength complies with the requirements of Clause TS8.14. During the course of the project, the Engineer may approve variations to the mix design to take account of the coefficient of variation achieved.

9.2.5 Approval of Mix Design

- a. At least 60 days before placing any concrete in the Works the Contractor shall submit, for approval, details of his proposed mixes for the various classes/types of concrete specified.
- b. Before approving the proposed mixes the Engineer shall require the Contractor to prepare, in the Engineer's presence, trial mixes of the proposed mixes which will then be sampled and tested in accordance with Clause 9.14 to verify their compliance with the Specification. The Engineer may require trial mixes to be laboratory sized batches and/or full production size batches using the Contractor's batching plant.

9.2.6 Required Properties of Concrete

- a. Concrete shall be liable to rejection if :
 - (i) The characteristic strength of the concrete is less than specified, or
 - (ii) The total air content is outside the range $4 \pm 1\%$
 - (iii) After the concrete has been discharged at the placing point and before it has been consolidated, the slump is not within the range 80 ± 20 mm.
- b. The Engineer may direct the use of a lesser slump whenever concrete of such lesser slump can be consolidated into place by means of the vibration specified in Clause 9.12.

9.2.7 Required Properties of Hardened Concrete

- a. Hardened concrete shall be liable to rejection if it does not comply with the requirements of Clause 9.14.
- b. The grade of concrete, and maximum water/cement ration applicable to the concrete in various structures shall be as specified in Table 9.2.7.a. The Contractor shall design mix proportions of concrete so as to satisfy the properties specified in this table. The mix design shall be subject to approval in accordance with Sub-Clause 9.2.5 of this Clause.

TABLE 9.2.7.a – STANDARD TYPES OF MIX

Type of Mix	Maximum Water-Cement Ratio	Characteristic Strength (kgf/cm ²)
A	0.60	270
B	0.60	225
C	0.60	225
D	0.60	180
E	0.60	150

- c. The various types of mix shall be placed in the location specified in Table 9.2.7.b and elsewhere as directed :

TABLE 9.2.7.b – TYPE OF MIX TO BE USED IN STRUCTURES

Type of Mix	Location
A	Diversion tunnel lining
B	Reinforced concrete for gallery, hydropower station, inclined intake structure, etc.
C	Concrete in blockouts
D	Reinforced concrete for spillway, outlet tunnel, concrete plug in diversion tunnel, backfilling concrete in adit, other structures.
E	Plain concrete, levelling concrete, backfill concrete in defects and faults in dam foundation.

9.2.8 Regulation of Water Content

- During batching, the Contractor shall periodically measure the moisture content of the fine aggregate held in the batch bins. Such testing shall be by an approved drying-out and weighing procedure or other approved procedure. The cost of all equipment for testing and the testing shall be included in the rates tendered in the Bill of Quantities for the various items of concrete construction in which the aggregate is used.
- The amount of water used in the concrete shall be regulated to adjust for any variation of the moisture content or grading of the aggregate as they enter the mixer.
Addition of water to overcome stiffening of the concrete before placing will not be permitted.
Concrete shall have uniform consistency from batch to batch.
- Aggregate shall not be batched for concrete or mortar when free water is dripping from the aggregate.

9.3 CEMENT

9.3.1 General

The cement to be used throughout the Works shall be obtained from manufacturers approved by the Engineer.

The cement shall be the low alkali Portland cement conforming to the requirements of JIS R 5210 or ASTM C 150 Type I or approved equivalent and shall be dry and free from lumps and caking.

For surfaces exposed to public view, where colour of the finished concrete is important, all cement shall be of the same type and colour and from the one plant.

9.3.2 Testing Cement

The Contractor shall submit a complete test report prepared by the cement factory on every 100 tonne lot of the respective cement, taking samples in such a manner as to represent the average quality of the lot. Testing of cement shall be in accordance with the appropriate ACI or JIS standard.

9.3.3 Maximum Storage Period

Cement that has not been used within 3 months from the date of initial sampling shall not be used in the Works unless it has been re-tested and approved. Such re-testing shall be at the expense of the Contractor.

9.3.4 Cement Containers

The Contractor shall deliver cement to the Works in bulk except that cement for pressure grouting shall be delivered in bags.

9.3.5 Delivery of Bulk Cement

Where cement is supplied in bulk containers, the following requirements shall apply:

- a. All containers shall be completely weatherproof and maintained in good order and condition.
- b. All apertures in the containers shall be fitted with completely watertight closures and shall be sealed after filling. Depending on the transportation methods adopted, the Engineer may require to be present when these seals are broken at any subsequent transfer or delivery point.
- c. All containers shall be filled as completely as possible.
- d. All containers shall be completely cleaned out at each transfer or delivery point after each and every use and before being returned for refilling.

- e. Each and every container dispatched from the manufacturer's works or any intermediate transfer point shall be accompanied by a delivery docket signed by a responsible person which shall clearly show the brand and type of cement, the identification number or numbers relating to the testing and certification of the cement, the date of filling the container and the net mass of the cement in the container. This docket shall be carried in a suitable fashion inside the sealed container and shall be handed over to the Engineer at any subsequent transfer or delivery point.
- f. Cement supplied in bulk shall not be re-bagged for use in the Works without approval.

9.3.6 Delivery of Bagged Cement

Where cement is supplied in bags the following requirements shall apply:

- a. Cement shall be delivered in sound undamaged bags uncontaminated by moisture, oil or any other substance.
- b. The nominal mass of a bag of cement shall be 40 kg. Where cement is batched by bag, individual bags which vary by more than 5 percent from the nominal mass shall be rejected. Where the average mass of 50 bags taken at random from any one consignment is less than the nominal mass, the whole consignment shall be rejected. The Contractor shall provide weighing equipment, calibrated by an approved authority, and shall check each consignment in the presence of the Engineer.
- c. Every bag shall be marked with the manufacturer's brand, the type of cement, identification number or numbers relating to the testing and certification of the cement and the date the bag was filled.
- d. The contents of broken or damaged bags shall not be re-bagged.

9.3.7 Storage and Handling of Cement

The following requirements shall apply to the storage and handling of cement at the Site or at any intermediate transfer or storage point :

- a. All methods for transporting, handling and storing bulk and bagged cement shall be designed, constructed and arranged so as to ensure the use or transfer of cement in the approximately chronological order of manufacture.
- b. All storage bins and cement handling equipment shall be completely weatherproof and substantially dust-free to the satisfaction of the Engineer and shall be designed and constructed so as to ensure that there will be no dead storage of cement.
- c. The Contractor shall not set up cement handling facilities where cement dust may come in contact with the electrical and mechanical plant stored in the vicinity and to which cement dust will be deleterious.
- d. All loading and unloading facilities for cement shall be under cover and weatherproof to the satisfaction of the Engineer.
- e. All storage bins and silos shall be drawn down so as to be substantially empty at least once every 3 months.

- f. Where cement is handled by pneumatic means which involve contact of compressed air with the cement, the temperature of air in contact with the cement shall not at any time exceed 38°C. Where necessary, after-coolers or other means shall be provided to cool the compressed air. All compressed air supplies where the air may come in contact with the cement shall be fitted with filters for the removal of moisture, oil or any other contaminating substances. Such filters shall be regularly inspected and maintained by the Contractor.
- g. All bagged cement shall be stored at all times, up to its use in the Works, in completely weatherproof structures, which shall include an approved raised floor and be adequately ventilated to prevent the accumulation of moisture.
- h. All storage of bagged cements shall be arranged so as to permit easy access for inspection and definite identification of all cement in the storage.
- i. Bagged cement shall be used in the Works in the same order in which it was delivered to the Site Store.

9.3.8 Temperature of Cement

The temperature of the cement as delivered to the Site shall not exceed 60°C.

9.3.9 Rejection

Cement not conforming to the requirements of this Clause 9.3 shall not be used in the Works.

9.3.10 Payment

Direct payment will not be made for cement used in concrete, mortar, shotcrete, dry-pack or grout other than cement in grouting works specified in Section 5.

9.4 ADMIXTURES

9.4.1 General

- a. The Contractor shall furnish and use concrete admixtures so as to improve workability and finishability of concrete or mortar.
- b. Admixture will be accepted to the manufacturer's certification that the admixture complies with the Specifications provided herein. The Engineer reserves the right to reject any admixture proposed by the Contractor when the admixture does not produce concrete with a high degree of uniformity throughout the course of the work. The Engineer may direct the Contractor to sample and test the admixtures after delivery at the Site to check their compliance with the Specification.

9.4.2 Air-Entraining Agent

- a. The Contractor shall use an approved air-entraining agent in all concrete unless otherwise directed. The agent used shall conform to ASTM C 260, JIS A 6204, or approved equivalent. The agent shall be of uniform consistency and quality within each container and from shipment to shipment.

- b. The amount of air-entraining agent used in each concrete mix shall be such as will effect the entrainment of the percentage of air specified in Sub-Clause 9.2.6 in the concrete at the point of delivery and discharge from the mixer.
- c. The agent in solution shall be maintained at uniform strength and shall be added to the batch as a portion of the mixing water.

9.4.3 Expanding Agent

- a. The Contractor may be directed to use an approved expanding agent in a small amount of concrete and mortar used in the works.
- b. The amount of expanding agent used in the concrete or mortar shall be as approved.

9.4.4 Water-Reducing, Set-Controlling Admixture

- a. The Contractor may use an approved water-reducing, set controlling admixture, referred to herein as WRA, in all concrete unless otherwise directed. The WRA used shall conform to ASTM C 494, JIS A 6204, or approved equivalent. WRA set retarding type (ASTM 464 Type D), such that the temperature of the concrete would exceed 30°C, as determined by the Engineer.
- b. The WRA shall be of uniform consistency and quality within each container and from shipment. The quantity of WRA to be used in each concrete batch shall be as approved by the Engineer.
- c. The Contractor shall be responsible for any difficulty arising or damage occurring as a result of the selection and use of a WRA, such as a delay or difficulty in concrete placing or damage to the concrete during form removal. The Contractor shall not be entitled to additional compensation to the unit rates tendered in the Bill of Quantities for concrete by reason of such difficulties.
- d. The use of WRA will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placement operations.

9.4.5 Accelerator

Admixtures for accelerating the strength development of concrete at early ages may be used as approved by the Engineer.

9.4.6 Calcium Chloride

Calcium chloride shall not be used as an admixture in any concrete or grout.

9.4.7 Payment

Air entraining agent, expanding agent and water-reducing set-controlling admixture shall be furnished by the Contractor and the cost of these materials and all costs incidental to their use shall be included in the rates tendered in the Bill of Quantities for the various items of concrete construction.

9.5 AGGREGATES

9.5.1 General

- a. Fine and coarse aggregates shall conform to the requirements of this Specification.
- b. The term 'fine aggregate' is used to designate aggregate in which the maximum size of particles is 5 mm. Fine aggregate for concrete, mortar, shotcrete and grout shall be furnished by the Contractor and shall be a sand manufactured in accordance with Clause 9.6.

The term 'coarse aggregate' is used to designate aggregate in which the minimum nominal size is 5 mm and which is reasonably well graded from 5 mm to the largest size required in the work in which the material is being used. Coarse aggregate for concrete shall be furnished by the Contractor and shall consist of aggregate manufactured in accordance with Clause 9.6.

- c. At least 90 days before placing any concrete the Contractor shall submit, for approval, representative samples of the proposed aggregates.

9.5.2 Tests

Aggregate when sampled and tested in accordance with Clause 9.14 shall comply with the requirements of this Clause.

9.5.3 Fine Aggregate

- a. Fine aggregate shall be clean, hard, durable and of proper grading, and shall be free from objectionable quantities of dirt, silt, organic matter or other deleterious materials. The moisture content of fine aggregate as delivered to the batching unit shall vary not more than 1.0 percent within any one hour and not more than 3.0 percent within the working time of one shift.
- b. Fine aggregate, as batched, shall be well graded and shall conform to the following limits:

Screen Mean Opening		Individual Percent, by Weight, Retained on Screen
US Standard	JIS (mm)	
3/8 inch	10	0
No. 4	5	0 to 5
No. 8	2.5	5 to 15
No. 16	1.2	10 to 25
No. 30	0.6	10 to 30
No. 50	0.3	15 to 35
No. 100	0.15	12 to 20
Pan	Pan	3 to 7

- c. The grading of the fine aggregate shall be so controlled that any time the fineness modulus of at least 9 out of 10 consecutive test samples of finished fine aggregate will not vary more than 0.2 from the average of fineness modulus of the 10 test samples. The fineness modulus of fine aggregate shall range between 2.4 and 3.2.
- d. The minimum specific gravity for fine aggregate shall be not less than 2.56 (dry basis).

- e. The amount of deleterious substances in fine aggregate shall not exceed the following prescribed limits.

Substance	Percentage by weight
Clay lump	1.0
Material passing No.200 sieve	3.0
Material retained on No.50 sieve and floating on a liquid having a specific gravity of 2.0	0.5

- f. Fine aggregate producing a colour darker than the standard in the colorimetric test (ASTM C 131, JIS 1105) for organic impurities may be rejected.

Where fine aggregate from different sources are being used at the batching plant at the same time they shall be so blended to ensure uniform grading and colour in successive batches.

- g. Loss of mass of fine aggregate when subjected to five cycles of the sodium sulphate soundness test (ASTM C 88, JIS A 1122) shall not exceed 10 percent.

9.5.4 Coarse Aggregate

- a. Coarse aggregate shall be clean, hard and durable, and shall be free from objectionable quantities of flat or elongated particles, organic matter or other deleterious material.

- b. Grading of coarse aggregate shall be as follows:

Max. Size of Coarse Aggregate, (mm)	Grading (% by weight)			
	80-40 mm	40-20 mm	20-10 mm	10-5 mm
40	—	55 – 40	35 – 30	25 – 15
20	—	—	70 – 30	45 – 20

- c. The amount of deleterious substance in coarse aggregate shall not exceed the following prescribed limits:

Substance	Percentage by weight
Clay lump	0.25
Soft Particles	5.0
Material passing No.200 sieve	1.0 *
Material retained on No.50 sieve and floating on a liquid having a specific gravity of 2.0	1.0

* In the case of crushed aggregate, if the material finer than No. 200 sieve consists of rock dust free from clay or shale, this percentage may be increased to 1.5.

- d. Loss of aggregate subjected to Los Angeles abrasion test (ASTM C 131, JIS A 1121) shall not exceed 40 percent by weight.
- e. Loss of mass of aggregate when subjected to five cycles of the sodium sulphate soundness test (ASTM C 88, JIS A 1122) shall not exceed 12 percent by weight.
- f. The minimum specific gravity (dry basis) of coarse aggregate shall not be less than 2.56.

9.5.5 Payment

Direct payment will not be made for fine and coarse aggregate used in concrete, mortar or grout except that payment will be made for fine aggregate used in grouting works as specified in Section 5.

9.6 PRODUCTION OF COARSE AND FINE AGGREGATE

9.6.1 Source

- a. Material for the production of coarse and fine aggregate may be obtained from the rock quarry designated on the Drawings or other approved sources.
- b. Within 60 days of the Commencement Date, the Contractor shall submit to the Engineer information pertaining to the sources of materials to a laboratory approved by the Engineer in sufficient quantities for testing. The costs of material investigation, sampling, transportation and testing shall be borne by the Contractor and included in the rates for various types of concrete in the Bill of Quantities.

9.6.2 Clearing

- a. Before excavating materials for the production of concrete aggregate, the Contractor shall clear trees, roots, brush, sods, clay, unsuitable sand and gravel, weathered and unsound rock and other objectionable matter from all of those portions of the surface deposits from which aggregates are to be produced.
- b. The areas from which aggregates are to be obtained shall be located and operated so as not to detract from the usefulness of the deposits or any other property and so as to preserve, insofar as is practicable, the future usefulness or value of the deposits. Materials, including stripping, removed from the deposits and not used in carrying out the Works shall be disposed of as specified in Sub-Clause 3.4.2 or as directed.

9.6.3 Processing

- a. Processing of the raw materials may include crushing, screening and washing, milling and blending to produce fine and coarse aggregates meeting the requirements of Clause 9.5 and shall be done at an approved location and in an approved manner.
- b. Water used for washing aggregate shall comply with Clause 9.7.
- c. After washing, fine aggregate shall be stored in stockpiles with a free draining base for at least 72 hours and shall be subsequently handled to ensure that fine aggregate delivered to the batching plant has a uniform and stable moisture content.
- d. Where the surface of stockpiles from which fine aggregate is being delivered directly to the batching plant is substantially drier or wetter than the bulk of fine aggregate in the pile, handling shall be such as to exclude this surface material from the batching plant.

9.6.4 Payment

- a. The cost of producing or furnishing aggregates required under this Specification will be deemed to be included in the rates and lump sums tendered in the Bill of Quantities for the various items of concrete construction in which the aggregate is used. Such rates and lump sums shall also include all expenses of the Contractor in clearing, stripping, handling, processing, transporting, purchasing from approved sources and storing the materials.
- b. The Contractor will not be entitled to any additional payment for materials wasted from deposits, including crusher fines, excess material of any of the sizes into which the aggregates are required to be separated by the Contractor, and materials which have been discarded by reason of being above the maximum sizes specified for use.

9.7 WATER

The water used in concrete, in grout, in mortar, for washing aggregate and for curing concrete shall be clean and free from objectionable quantities of silt, organic matter, alkali, salts, acids and other impurities.

9.8 BATCHING AND MIXING

9.8.1 General

Prior to the installation of the Contractor's Equipment for concrete works, the Contractor shall submit to the Engineer for approval drawings showing the proposed general plant arrangement, together with the general description of the equipment he proposes to use. This equipment shall be capable of producing the concrete comprising the cement, admixtures, aggregates and water into a uniform mixture and of discharging the mixture without segregation. It shall also be capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the weights of the materials being batched.

9.8.2 Measuring and Tolerances

Cement shall be weighed separately on an individual scale. Water shall be weighed separately on an individual scale or may be measured by volume. All other ingredients shall be measured by mass except that liquid admixtures may be measured by mass or volume. If water is measured by volume, two (2) flow meters shall be installed in parallel so that no delay shall result from faulty operation of the meters.

9.8.3 Calibration

- a. The construction and accuracy of the weighing and measuring equipment will be such that the equipment will maintain an accuracy within 0.4 percent of the scale capacity. Batching equipment shall be maintained and operated so that the combined inaccuracies in feeding and measuring the materials will not exceed 1.0 percent for water, air-entraining agent and cement and 2 percent for each size of aggregate.
- b. The Contractor shall provide standard certified test weights and any other auxiliary equipment required for checking the accuracy of each measuring device.

- c. The Contractor shall calibrate each measuring device in the presence of the Engineer when and as directed. Such tests shall be made at least once every month in the case of equipment for measuring aggregates and at least once every 2 weeks in the case of equipment for measuring cement, water and admixtures.
- d. The Contractor shall furnish copies of the complete results of all calibrations to the Engineer and shall adjust, repair or replace any measuring device which does not meet the requirements of paragraph a. of this Sub-Clause for accuracy.

9.8.4 Batching and Weighing Equipment

- a. Materials shall be weighed individually and each weighing device shall be equipped with a visible springless dial which shall register the scale load at any stage of the weighing operation.
- b. The Contractor shall provide all necessary facilities for obtaining representative samples of aggregate and cement from the discharge streams between the bin and weigh-hoppers or between weigh-hoppers and the mixers.
- c. All gates and closing devices shall be positive in action and shall prevent leakage of materials when in the closed position.
- d. Batching equipment shall be interlocked so that :
 - (i) a new weighing cycle cannot be started until all weigh-hoppers are completely emptied and the discharge gates closed;
 - (ii) the discharge-gates of the weigh-hoppers cannot be opened until the correct masses of materials are in and the scales in balance;
 - (iii) the discharge-gates cannot be closed until all materials are entirely discharged and the scales are back in balance;
 - (iv) the discharge-valve of the water-measuring device cannot be opened until the filling-valve is closed; and
 - (v) accidental overbatching of admixtures is prevented.
- e. The batch bins will be constructed so as to be self-cleaning during draw-down and the bins shall be drawn down until they are practically empty at least three times per week. Materials shall be deposited in the batch bins directly over the discharge gates. The coarse aggregate shall be deposited in the batch bins through effective rock ladders when the distance through which the aggregate would fall is greater than 1.0 meter. Equipment for conveying batched materials from the batchers or hoppers to and into the mixer shall be so constructed, maintained and operated that there will be no spillage or contamination of the batched materials or overlap of batches. Equipment that fails to conform to this requirement shall be effectively repaired, modified or replaced to the satisfaction of the Engineer.

9.8.5 Records

The batching equipment shall include an accurate automatic recorder for making a continuous, visible record, combined on a single chart, of the measurement of each separate concrete ingredient including all mixing water and admixtures. The recording equipment shall include facilities for automatically registering on the chart the time of day at intervals of not more than 15 minutes. The recorder shall be so constructed that the Engineer can

view the recorder chart and make notes on the chart without interfering with the plant operations. The recording equipment shall be subject to approval and all graphic records shall be furnished to the Engineer at the completion of each day's production. The records shall become the property of the Employer. Communication facilities between the batching plant and the point of concrete placing shall be furnished by the Contractor where necessary or desirable as determined by the Engineer.

9.8.6 Mixer

- a. The batched ingredients of concrete shall be so mixed in a mechanical batch mixer as to produce a homogenous mass of uniform consistency. Hand-mixing shall not be used for permanent structures and, when used for temporary structures, it shall be subject to the approval of the Engineer.
- b. Unless otherwise directed or approved, the mixing time of each batch shall continue to not less than the number of minutes stated in the following table after all ingredients are in the mixer.

Capacity of mixer (m ³)	Minimum Time of Mixing (minutes)
3 to 2	2.5
2 to 1.5	2
1.5 or less	1.5

- c. The minimum mixing periods specified are conditional on the materials being fed into the mixer in a manner which will facilitate efficient mixing and on operation of the mixer at its designed speed.

The central plant mixer or truck-mounted mixer shall not be loaded in excess of its rated capacity.

- d. Approval of the mixer may be withheld if
 - (i) from 3 tests of any batch of concrete, a range in slump exceeding 25 mm or a range in air content exceeding 1.0 percent is given between representative samples taken at different portions of the mixer discharge; or
 - (ii) for any batch of concrete, the difference between unit masses of air-free mortar in samples taken from the first and last portions of the batch as discharged from the mixer exceeds 1.0 percent of the mean value; or
 - (iii) the weight of coarse aggregate per cubic meter in samples, each of 50 litres in volume, taken from the first and last portion of the batch as discharged from the mixer vary more than 8 percent from the average weight of the two coarse aggregate samples.

9.8.7 Truck-Mounted Mixer and Agitator Units

- a. Where the use of truck-mounted mixer and agitator units is approved, the Contractor shall maintain at the Site an up-to-date list of the approved truck-mounted mixer and agitator units and shall ensure that only approved units are allowed to enter the Site.

- b. Truck-mounted mixer and agitator units and the mixing and transporting of concrete in such units shall be in accordance with the requirements of the appropriate JIS or ASTM standard. Each unit shall be fitted with an approved mixer drum revolution recording counter which can be manually reset to zero but shall not be capable of being advanced.
- c. Truck-mounted mixer and agitator units will be approved for use only when the units and their operations are such that they conform to the requirements of this Clause over the full range of slump and aggregate size of the concrete mixes for which they are used.
- d. The volume of mixed concrete in the drums of agitator units shall not exceed the manufacturer's rating nor exceed 70 percent of the gross volume of the drum.

9.8.8 Charging Sequence

- a. The Engineer reserves the right to vary the mixing time or to limit the batch size when the charging and mixing operations fail to produce a batch of concrete that conforms with the foregoing requirements with respect to adequacy of mixing. The concrete of a given composition, as discharged from the mixer, shall be uniform in composition and consistency within batches and from batch to batch.
- b. Water shall be added before, during and following the mixer-charging operations. Excessive over-mixing requiring addition of water to preserve the required concrete consistency will not be permitted.

9.8.9 Discharging Period

Unless otherwise approved, concrete shall be completely discharged from the truck-mounted mixers or agitator drums within 90 minutes after the mixing water has been added to the dry ingredients. During weather not conducive to quick stiffening of concrete, this period may, if approved by the Engineer, be extended to 120 minutes. Any concrete which requires additional water to be added to permit satisfactory discharge or placing will not be accepted regardless of the time which has elapsed since the mixing water has been added. Such rejected concrete shall be removed from the Works with the least possible delay.

9.8.10 Mixer Performance

Any mixer that at any time does not meet the requirements of this Clause shall be repaired promptly and effectively or shall be replaced. Mixers shall be loaded to their rated capacity or to such batch sizes as determined in accordance with the provisions of Sub-Clause 9.8.8 except where mixing mortar or concrete for the concluding phase of concrete placement. Mixers shall not be loaded in excess of their rated capacity unless otherwise approved, but in no case shall mixers be overload by more than 10 percent of their rated capacity. Each stationery mixer shall be equipped with a mechanically operated timing and signalling device which will indicate and ensure the completion of the required mixing period and will count the batches.

9.8.11 Delivery Docket

At the point of delivery or placing, the Contractor shall furnish the Engineer with a delivery docket, in a form acceptable to the Engineer, stating the batch number, the item of batching, type of concrete and volume of concrete

delivered.

9.8.12 Payment

Separate payment will not be made for complying with the requirements of this Clause and all costs shall be deemed to be included in the rates and lump sums tendered in the priced Bill of Quantities for concrete construction.

9.9 PREPARATION FOR PLACING

9.9.1 General

a. Concrete shall not be placed until all construction of formwork and falsework, installation of reinforcement and parts to be embedded, preparation of surfaces, methods and equipment for transporting, handling, placing and finishing concrete, the number of vibrators and method of consolidating the concrete, and the method of curing the concrete have been approved for concrete in a nominated section of work.

b. Concrete shall not be placed in water unless the method of depositing the concrete has been approved.

Concrete shall not be placed in running water and shall not be subject to the action of running water until after the concrete has hardened.

c. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.

9.9.2 Cleaning Foundations

a. Immediately before concrete is placed, all surfaces of rock foundation upon or against which concrete is to be placed shall be cleaned of free standing water, oil, mud, organic matter, wooden pieces, objectionable coatings, debris, loose rock fragments, or other perishable materials by the use of high-velocity air-water jets or other effective means approved by the Engineer.

b. The surfaces of absorptive rock foundations shall be moistened thoroughly before placing concrete and standing water shall be removed.

c. The surfaces of soil foundation upon which concrete is to be placed shall be free from standing or running water, wooden pieces or other objectionable materials. For soil foundation, if specified, the foundation shall be in damp condition before placing concrete.

9.9.3 Cleaning Previously-Placed Concrete Surfaces

a. The surfaces of construction joints, as defined in Clause 9.19, upon or against which new concrete or mortar is to be placed shall be cleaned and kept moist by means approved by the Engineer. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coatings, sand, curing compounds and foreign materials.

The joint surface shall be kept moist for a period of 48 hours prior to placing fresh concrete.

- b. The surfaces of all construction joints, including surfaces of blockouts, shall be washed thoroughly with air-water jets immediately before placing adjacent concrete. All pools of water shall be removed from the surfaces of construction joints before new concrete is placed.
- c. Formed and unformed construction joints shall be prepared in accordance with Clause 9.19.
- d. Where special bonding treatment is required between old and new concrete, the bonding surface of the old concrete shall be cleaned with 5 percent solution of caustic soda or with dilute hydrochloric acid (diluted to 10-15 times). The surface shall then be roughened with wire brushes and washed with clean water as directed by the Engineer. All portions showing disintegration of the surface shall be removed completely beforehand. As soon as the washed surface has dried, a mixture of approved bonding agent shall be applied to the prepared surface and the new concrete shall be placed on the prepared surface within the period of time when the bonding agent is effective. In the event of delay in placing the new concrete so as to render the bonding agent ineffective, a fresh coat of bonding agent shall be applied by and at the expense of the Contractor.
- e. The surfaces of all contraction and expansions joints, as defined in Clause 9.19, shall be cleaned thoroughly of accretions of concrete or other foreign materials by spacing, chipping or other means satisfactory to the Engineer. Contraction joints shall be given a coat of curing compound approved by the Engineer to prevent bond.

9.9.4 Temperature of Concrete

- a. Temperature of concrete when it is being placed shall not exceed 32°C. The Contractor shall, where necessary, employ effective means such as pre-cooling the aggregates, refrigerating the mixing water, adding chipped or flaked ice to the mixing water, placing at night or a combination of these or other approved methods to ensure that the concrete does not exceed the temperatures specified. The method of cooling shall be in accordance with methods approved in the Letter of Acceptance.
- b. If the concrete is placed when the weather is such that the temperature of the concrete would exceed 30°C, as determined by the Engineer, the Contractor shall use WRA (water-reducing admixture), set-retarding type, to mitigate unfavourable effects on concrete caused by the high temperature.

9.9.5 Payment

Separate payment will not be made for complying with the requirements of this Clause and all costs shall be deemed to be included in the rates and lump sums tendered in the Bill of Quantities for concrete construction.

9.10 TRANSPORTING AND CONVEYING PLASTIC CONCRETE

9.10.1 General

- a. The method and equipment used for transporting concrete shall be such that concrete shall be delivered to the point of placing without objectionable segregation or loss of slump.

- b. Addition of water to concrete after it has been discharged from the mixer or "re-tempering" will not be permitted.

9.10.2 Truck-Mounted Mixers and Agitator Trucks

Plastic concrete shall be transported to the site of the placement in truck-mounted mixers and agitator trucks complying with Clause 9.8.

9.10.3 Chutes

In general, conveyance of concrete by the use of chutes will not be permitted unless approved by the Engineer. If approved for use chutes shall have a section with interior rounded corners and shall have a proper fixed slope so as to allow the concrete to flow easily and without segregation. The lower end of the chute shall be provided with a drop chute not greater than 1.5 m in height to avoid segregation of falling concrete. Chutes shall be protected from the direct rays of the sun.

9.10.4 Concrete Pump or Placer

Conveyance of concrete using a concrete pump or placer shall be as approved by the Engineer. Delivery pipes shall be so installed as to permit easy removal. Before starting pump or placer operation, about 1.0 m³ of mortar as specified in Clause 9.11 shall be pumped through the pipe. The pipe shall be set as straight as possible with the minimum number of bends and changes in direction. Air boosters shall not be used except in conditions where the outlet of pipes is completely embedded at least 2.0 meters in fresh concrete.

9.11 PLACING CONCRETE

9.11.1 General

The Contractor shall place all concrete in structure as shown on the Drawings or directed by the Engineer in accordance with this Clause 9.11 or as approved by the Engineer. The Contractor shall advise the Engineer when concrete will be placed and concrete shall only be placed in the presence of the Engineer.

9.11.2 Concreting during Hot Weather

The Contractor's attention is drawn to the recommendation contained in Manual of Concrete Practice Part 2-1980, 'Hot Weather Concreting - American Concrete Institute 305R-77'. The Contractor shall adopt any or all of these recommendations as necessary to manufacture and place concrete in accordance with this Specification.

9.11.3 Joint Concrete

Unless otherwise directed or approved, concrete placements shall be started with an approved over-sanded mix containing 20 mm maximum size aggregate, maximum water/cement ratio 0.47 by mass, having a maximum slump of 100 mm, and shall be placed about 40 mm deep on the joint at the bottom of the placement.

9.11.4 Depositing Concrete

- a. Where two different types of concrete are shown on the Drawings adjacent to one another without an intervening movement joint, the two types shall be placed at the same time. Where the surface of division between the two types is vertical or inclined the two types of concrete shall be placed together using a separator which shall be withdrawn as the concrete is placed. Alternatively, the concrete may be placed in alternated batches of one type and then other without a separator, provided approved measures are taken to prevent excessive intermixing of the two types.
- b. Whenever practicable, concrete shall be deposited directed in its final position and shall not be dropped, chuted or caused to flow in a manner to permit or cause segregation. Methods and equipment employed in depositing concrete in forms shall be such as will not result in clusters or groups of coarse aggregate being separated from the mass. The Contractor shall provide approved chutes and baffles to confine and control the falling concrete. The vertical free drop of concrete shall not exceed 1.5 m. The movement of concrete within the forms by use of vibrators will not be permitted.
- c. In the event of continuous placing being interrupted for any reason, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic and any concrete which is unconsolidated and no longer plastic shall be removed by the Contractor at his own expense. The Contractor at the surface of such cold joints shall be clean and damp when covered with fresh concrete.

9.11.5 Concrete Placed in Horizontal Layers

Except as intercepted by joints, all formed concrete shall be placed in continuous approximately horizontal layers the depths of which generally shall not exceed 500 mm. The Engineer may direct thinner layers where concrete in 500 mm layers cannot be placed in accordance with the requirements of this Specification.

9.11.6 Placing Unformed Concrete on Slopes

In placing unformed concrete on slopes so steep to make internal vibration of the concrete impracticable, the concrete shall be placed ahead of an unvibrated slip-form screed extending approximately 800 mm back from its leading edge. Concrete ahead of the slip-form screed shall be consolidated by internal vibrators so as to ensure completed filling under the slip-form screed. Vibrators shall conform to the requirements of Clause 9.12.

9.11.7 Placing Concrete Monolithically Around Openings

If concrete is placed monolithically around openings having vertical dimensions greater than 600 mm, or if concrete in decks, floor slabs, beams, girders or other similar parts of structures is placed monolithically with supporting concrete, the following instructions shall be strictly observed:

- a. Placing of concrete shall be delayed not less than 30 minutes nor more than 1 hour at the top of openings and at the bottom of bevels under decks, floor slab, beams, girders or other similar parts of structures when bevels are specified and at the bottom of such structural members when bevels are not specified, but in no case shall the placing be delayed such that the vibrating unit will not of its own weight readily penetrate concrete placed before the delay. When consolidating concrete placed after the delay, the vibrating unit shall penetrate and re-vibrate the concrete placed before the delay.
- b. The last 600 mm or more of concrete placed immediately before the delay shall be placed with as low a slump as practicable, as determined by the Engineer, and shall be thoroughly consolidated.
- c. The surfaces of concrete where delays occur shall be clean and free from loose and foreign material when concrete placing is started after the delay.
- d. Concrete placed over openings and in decks, floors, beams, girders and other similar parts of structures shall be placed with as low a slump as practicable and the Contractor shall ensure that thorough consolidation of the concrete is effected.

9.11.8 Placing Mass Concrete

- a. In placing mass concrete the Contractor shall, when directed, maintain the exposed area of fresh concrete at the practical minimum, by first building up the concrete in successive approximately horizontal layers to the full width of the block and to full height of the lift over a restricted area at one end in similar progressive stages to the full area of the block.
- b. Clusters of large aggregate shall be scattered before new concrete is placed over them. Each deposit of concrete shall be vibrated completely before another deposit of concrete is placed over it.
- c. Once placement of mass concrete has commenced, placement shall not be interrupted by diverting the placing equipment to other uses.
- d. Concrete buckets shall be capable of promptly discharging the low slump, mass concrete mixes specified, and the dumping mechanism shall be designed to permit the discharge of as little as 0.5 m³ portion of the load in one place. Buckets shall be suitable for the attachment and use of drop chutes where required in confined locations.

9.11.9 Placing Concrete in Tunnels – General

Concrete in tunnels shall be placed by a displacement type pump or by pneumatic placing equipment or by any other approved method. The equipment used in placing the concrete, and the method of its operation, shall be such as will permit introduction of the concrete into the forms without high velocity discharge and resultant segregation. After the concrete has been built up to the crown of the tunnel lining at the start of a placement, the end of the discharge line shall be kept buried at least 2 m in the concrete during placement of the top placement to ensure complete filling. The discharge line shall be marked so as to indicate the depth of burial at any time. Concrete shall be forced into the top placement to fill completely the crown at the tunnel. Placing equipment shall be operated by experienced operators only. Cold joints in tunnel placements shall be avoided where practicable.

9.11.10 Preparations for Concreting in Tunnels and Around Steel Conduit

- a. Where water flows or seeps to the area against which the concrete is to be placed, it shall be excluded from the space to be filled with concrete by caulking, diverting by pipes, pans and other means, and pumping from sumps, until the concrete has set sufficiently to be unaffected by action of the water through percolation, hydrostatic pressure or abrasion.
- b. The Contractor shall clean up and prepare the concrete surfaces of the tunnel lining against which concrete is to be placed in accordance with Clause 9.9. Such joints shall be treated as construction joints in accordance with Clause 9.19 and shall be prepared in accordance with Sub-Clause 9.19.1.e, para. 2.
- c. Before concreting behind steel conduit, all objectionable material shall be removed from the outside surface which shall be maintained clean until concrete is placed. Field welding of any joint shall be completed and approved before concreting. All temporary timber struts, loose material and debris shall be removed from outside the steel conduit before concreting.
- d. The Contractor shall adequately support and anchor the steel conduit with approved steel or concrete cradles or other approved steel or concrete supports. Site welding of supports to the outside of the pipe shell will not be allowed. Temporary internal stiffeners of the steel conduit, if required, shall not be removed for at least 24 hours after placing concrete surround.
- e. The Contractor shall adequately support and anchor forms in the tunnel by an approved method.

9.11.11 Placing Concrete in Diversion Tunnels Plugs

- a. Cooling of the concrete in the diversion tunnel plugs will be required as shown on the Drawings or directed by the Engineer. The cooling system shall consist of black steel pipes embedded shall commence at the time of placing the concrete in the plug and shall continue until the concrete temperature of the last concrete placement has been reduced to 26°C or as directed by the Engineer.
- b. The concrete in the diversion tunnel plug shall be constructed in lifts as shown on the Drawings or directed with a minimum of 72 hours between successive lifts. The temperature of the concrete deposited in the forms shall be less than 32°C.
- c. The Contractor shall cool the concrete in the diversion tunnel plug by furnishing and installing a system of black steel cooling pipes as shown on the Drawings or directed and circulating water through the pipes in accordance with this Sub-Clause or as directed.
 - (i) The system of pipes shall be made up of separate circuits of hooped pipework with a horizontal spacing of 1,500 mm and a vertical spacing of 2,000 mm approximately or as directed.
 - (ii) The pipe or tubing shall be installed on the tunnel invert and on the surface of each lift of concrete so as to form grid-like cooling coils covering the full area of the tunnel invert or lift.
 - (iii) The cooling pipe or tubing shall be 25 mm outside diameter plain end metal pipe or tubing in accordance with JIS C 8305 Light

Gauge Conduit Tubing or approved equivalent. The lengths of pipe or tubing shall be joined together with expansion type couplings. Pipe nipples used for surface connections shall be galvanised. All pipe, tubing, and fittings for the cooling systems to be embedded in the concrete of the diversion tunnel plugs shall be furnished by the Contractor, and shall be cut, bent, fabricated and coupled by the Contractor. All pipe and tubing shall be clean and free from scale, inside and outside, and shall be so maintained until it is embedded in the concrete.

- (iv) All pipe or tubing shall be supported and securely held in place by metal ties in a manner approved by the Engineer. All materials required to support and secure the cooling systems in place shall be furnished by the Contractor.
- (v) All cooling systems shall be washed clean and shall be tested for leakage in the presence of the Engineer at a pressure of 3.5 kgf/cm² or 1.5 times the working pressure, whichever is greater, and shall be watertight at the pressure before being embedded in concrete. The Contractor shall protect the cooling systems from displacement or damage during the placing of concrete and other work following the placing and testing of the cooling systems.
- (vi) Removable nipples shall be placed where the inlet and outlet ends the cooling coils extend through the formed surfaces of the concrete. The Contractor shall cap and otherwise suitably protect the end of coils from damage until the cooling operations are completed and the tubing filled with grout.

- d. Cooling shall commence at the time of placing the concrete in the plug and shall continue until the concrete temperature has been reduced to and maintained at 26°C or as directed by the Engineer.

The arrangement, housing, location, and capacity of the pumping plant and equipment, pipe headers, connections to the embedded tubing, and outlet piping shall be such as to insure dependable and continuous operation and shall be subject at all times to the approval of the Engineer. The connection to the individual embedded coils shall be such that the flow of water through each coil may be controlled positively at any time without interfering with the flow through the other coils of the system. Provision shall be made in the layout of the pipe connections for reversing the direction of flow of water through the embedded coils. The direction of flow through the cooling coils shall be reversed not more than once each 24 hours. The intake for the cooling water shall be screened and shall be kept clear of mud and debris, and all necessary precautions shall be taken to prevent any part of the cooling system from becoming clogged or otherwise inoperative.

The Contractor shall provide all necessary facilities, such as catwalks, ladders, and platform, for easy and convenient access for observing the cooling operations, unless otherwise directed by the Engineer, the foregoing facilities shall be left in place until all grouting operations have been completed.

- e. The Contractor's cooling system shall be capable for providing a flow rate of up to 20 litres/minute continuously in each cooling coil system.

The Contractor shall use cool river water, or chilled or iced water as approved to control the temperature of the plug concrete placements.

The Contractor shall ensure that the circulation is controlled such that maximum temperature of the concrete such that maximum temperature

of the concrete does not exceed 50°C and the final cooled concrete is reduced to 26°C or as directed by the Engineer. The maximum rates of cooling shall not exceed those specified in the following table:

MAXIMUM COOLING RATES

Days After Placing Concrete	Maximum Rate of Cooling (°C/Day)
2 – 5	2.0
5 – 10	0.8
10 – 20	0.6
20 – 30	0.3
30 – 40	0.2
Greater than 40	0.1

The Contractor shall furnish, install and test nickle resistance thermometers in the concrete placements in accordance with Clause 13.9 as shown on the Drawings or directed for the purpose of monitoring and controlling the concrete temperature and cooling operations.

The Contractor shall read the thermometers in the presence of the Engineer at a frequency directed by the Engineer and submit records to the Engineer.

On completion of the cooling of the tunnel plug concrete and the grouting of the joints of the tunnel plugs in accordance with Clause 5.10, and the cooling pipes and thermometers have served their purpose, then the embedded pipes shall be filled with grout in accordance with Clause 5.6. The grout shall be forced into the pipes with only sufficient pressure to ensure that the pipes are completely and solidly filled. All pipes or nipples shall be removed to at least 30 mm below the surface of the concrete and the holes left shall be completely filled with dry pack in accordance with Clause 9.17.

f. Payment

- (i) Payment for furnishing and installing the cooling system will be made at the rate per tonne tendered therefor in the Bill of Quantities in accordance with Sub-Clause 11.3.4.
- (ii) Payment for thermometers shall be in accordance with Clause 13.9.
- (iii) Payment will not be made for circulating water through the systems and the cost of circulating water through the system shall be included in the rate for the concrete for diversion tunnel plugs in accordance with Sub-Clause 9.30.3 para. b.. Such costs shall include all works in relation to provision and disposal of cooling water, pumping, cooling the water, as required, reading thermometers and recording temperatures and all other works associated therewith.
- (iv) The entire cost of injecting grout and repairing concrete surfaces required by this Sub-Clause 9.11.11 shall be included in the rate per cubic meter tendered in the Bill of Quantities for concrete plug in diversion tunnel in which cooling water and thermometer pipes are embedded.

9.11.12 Placing Concrete in Adits

- a. This Sub-Clause refers to the concreting of 4 abandoned inspection adits in the vicinity of the dam axis.
- b. Preparations
 - (i) Where water flows or seeps to the surfaces against which concrete is to be placed it shall be excluded by caulking, directing by pipes, pans, pumping from sumps or other means until the concrete has set sufficiently to be unaffected by the action of the water through percolation, hydrostatic pressure or abrasion
 - (ii) Adit surfaces against which concrete is to be placed shall be swept free of dust and loose particles
 - (iii) Grout tubing for the grouting to be carried out in accordance with Clause 5.11 shall be installed
- c. Placement
 - (i) concrete in adits shall be constructed in lifts as shown on the Drawings or directed with a minimum of 22 hours between successive lifts.
 - (ii) On completion of connecting grouting shall be carried out in accordance with Clause 5.11.

9.11.13 Embedding Steel Conduit

The Contractor shall furnish and install the steel conduit in the outlet tunnel and secure it in the positions specified in Section 12 of the Technical Specification and as shown on the Drawings.

Should voids remain between the embedded metalwork and the concrete, they shall be filled with grout at a pressure determined by the Engineer but not exceeding 2 kg/cm². Grouting shall be carried out by the Contractor through holes provided for the purpose or drilled and tapped in locations directed by the Engineer through the steel conduit or through pipes embedded for the purpose in the concrete. Grouting shall be performed in accordance with the requirements of Section 5 of this Specification. Holes provided in the steel conduit and holes drilled and tapped at the direction of the Engineer in accordance with the requirements of this Sub-Clause and Clause 5.11 shall be made good by the Contractor at his own expense.

9.11.14 Placing Concrete in Blockouts and under Baseplates

- a. The Contractor shall place blockout concrete in blockouts, constructed as shown on the Drawings or directed, after the installation and adjustment of Water Control Plant and other metalwork has been completed and approved. Blockout concrete includes concrete designated on the Drawings as second stage concrete for Plant or metalwork embedment.
- b. Before concrete is placed in the blockouts, the concrete surfaces of the blockouts shall be roughened by chipping or other approved methods and in such a manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface.

After being roughened, the surface of the concrete shall be cleaned in accordance with Clause 9.9 and shall be sound and hard and in such a condition as to ensure a good mechanical bond between the existing and the new concrete.

All concrete which is not hard, dense and durable, as determined by the Engineer, shall be removed to the depth required to secure a surface satisfactory to the Engineer.

The Contractor shall place the concrete in blockouts in such a way as to ensure satisfactory bond with the existing concrete, to secure complete contact with metalwork to be embedded in the blockout concrete and to avoid displacement of the Plant or metalwork being embedded. Where directed, concrete placed in blockouts shall contain an approved expanding agent in accordance with Clause 9.4 or the placing of concrete shall be delayed after the concrete has been mixed to reduce subsequent shrinkage.

- c. The Contractor shall place dry-pack, or non-shrink mortar or grout under metalwork, baseplates, plant and equipment bases after the baseplates have been levelled and aligned correctly and the baseplates rigidly secured in place by the anchor bolts and nuts. All spaces under the baseplates shall be completely filled with dry-pack, or non-shrink mortar or grout.

9.12 CONSOLIDATION

- a. Each layer of concrete shall be immediately consolidated with the suitable appliances so that the concrete is compacted to the maximum practicable density and closes snugly around all surfaces of forms and embedded materials. Subsequent layers of concrete shall not be placed until the layers previously placed have been consolidated as specified.
- b. In general, concrete shall be consolidated with electric or pneumatic power driven internal-type vibrators operating at a speed of at least 7,000 revolutions per minute when immersed in concrete. The vibrating head shall be vertically inserted in concrete and at least 50 mm into the underlying layer. Where it is difficult to use internal vibrators concrete may be consolidated with an external-type vibrator. The external-type vibrator shall be operated at a speed of 8,000 revolutions per minute and be large enough to effect consolidation.
- c. In consolidating each layer of concrete, the immersion type vibrator shall be operated in a near vertical position and the vibrating head shall be allowed to penetrate and re-vibrate the concrete in the upper portion of the underlying layer. In the area where newly placed concrete in each layer joins previously placed concrete in the same layer, more than usual vibration shall be performed, the vibrator penetrating deeply at close intervals over the areas of contact of these layers. Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contact of the vibrating head with surfaces of the forms shall be avoided. Direct vibration of the reinforcement will not be permitted.
- d. The total consolidating capacity, in cubic meters of concrete per hour, of all vibrators in effective operating condition and employed on concrete compaction in the Works, shall be based on a rated capacity of 70 percent of the manufacturer's recommendation of each type of vibrator in operation and the total compacting capacity so computed shall be not less than the maximum rate at which concrete is placed in the Works. For every 3 vibrators in use on a concrete placement, the Contractor shall provide one additional standby vibrator of similar compacting capacity in good working order.