CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 7. PROTECTION AND SUPPORT OF EXCAVATION

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SECTION 7. PROTECTION AND SUPPORT OF EXCAVATION

7.1 PROTECTION AND SUPPORT OF EXCAVATION – GENERAL

7.1.1 General

This section covers the requirements for the support of and protection of excavated surfaces of surface and underground excavation.

7.1.2 Surface Excavation

a. The Contractor shall protect and support surface excavations, where and when directed, by the methods shown on the Drawings or directed or approved.

b. Unless otherwise specified or directed or approved, the Contractor shall not proceed with excavation more than 3 m below a point where support for the batters has been directed until the required support has been installed.

7.1.3 Underground Excavations

The Contractor shall construct the support systems for underground excavations in accordance with the requirements of Section 4, Tunnelling, and the relevant clauses of this section.

7.1.4 Responsibility for Safety

a. Nothing contained in this Section shall relieve the Contractor from sole responsibility for the safety of the surface and underground excavations nor for liability for injuries to or deaths of persons or damage to property nor of any of his obligations under the Contract.

b. Nothing contained in this Section shall prevent the Contractor from erecting, at his own expense, such amount of protection or support as he may consider necessary or from using heavier supports than directed or approved.

7.1.5 Payment

Payment will be made only for that protection and those supports directed or approved as being necessary for satisfactorily constructing and completing the Works and which are part of the Permanent Works.

The cost of furnishing and installing surface protection and supports other than those included in the Permanent Works or for which a payment item exists in the Bill of Quantities shall be deemed to be included in rates and lump sum prices tendered in the Bill of Quantities for parts of the works where those surface protection measures or supports are used.

7.2 SHOTCRETE

7.2.1 General

a. The Contractor shall apply reinforced or unreinforced shotcrete to the excavated surfaces of surface excavations where shown on the Drawings or directed or approved.

b. For the purpose of this Specification shotcrete is concrete or mortar, with or without admixtures, pneumatically applied at high velocity to a prepared surface.

c. At approved locations in the surface works, an approved wet mix type shotcrete may be used. At all other locations in the surface works, dry mix type shotcrete as specified shall be used.

d. Where shotcrete support is required, the Contractor shall apply shotcrete to give thickness shown on the Drawings or as directed.

7.2.2 Materials

a. Cement for shotcrete shall comply with the requirements of Clause 9.3.

b. Water used in shotcrete and for curing shall comply with Clause 9.7.

c. Coarse and fine aggregate for shotcrete shall be clean, well graded and shall comply with Clause 9.5.

d. The gradation of the combined coarse and fine aggregate mixture shall conform to the following limits:

Sieve Size	Percentage Passing by Weight
25 mm	100 -
19 mm	90 - 100
12.5 mm	75 - 95
9.5 mm	65 - 88
4.75 mm	48 - 74
2.4 mm	34 - 57
1.2 mm	22 - 44
0.6 mm	12 - 31
0.3 mm	5 - 20
0.15 mm	2 - 10
0.075 mm	0 - 2

e. The combined aggregate shall have a moisture content at the time of mixing with cement of not less than 2 percent and not more than 6 percent of the oven dry weight of the aggregate.

f. The Contractor shall periodically test the aggregate held in the batch bins for moisture content.

g. Steel mesh reinforcement as specified in Sub-Clause 7.2.8 shall comply with Clause 7.5.

h. Admixture shall be in accordance with Sub-Clause 7.2.7.

7.2.3 Proportioning

a. Materials and proportions shall be chosen such that the mix contains not less than 400 kg per cubic meter of cement and so that three cast cylinders 15 cm diameter by 30 cm high made with no additives shall achieve an average minimum strength of 440 kgf/cm² at 28 days. Cylinders shall be made and tested in accordance with the appropriate standard. A minimum of three cylinder shall be made and tested for each combination of materials proposed for use on the job. The shotcrete mix design shall be developed to obtain strengths as follows:

   Compressive strength 1 day 80 kgf/cm² minimum;

   Compressive strength 3 days 160 kgf/cm² minimum;

   Compressive strength 28 days 250 kgf/cm² minimum;

b. The relative proportions of fine aggregate, coarse aggregate, cement, set accelerating admixture, and the moisture content of the ingredients when mixed shall be as approved. The fine and coarse aggregates shall be thoroughly mixed in an approved mixer and fed with the cement, and admixture if used, at the correct rate to achieve the required proportions and shall enter the shotcrete machine in such a way as to achieve proper mixing.

c. Mixed dry ingredients shall be discarded if they are not placed within 30 minutes. Payment will not be made for such discarded materials.

7.2.4 Equipment

a. Not less than 60 days before applying any shotcrete, the Contractor shall submit, for approval, drawings showing his proposed plant arrangement together with a general description of the equipment he proposes to use, the methods of operation and the mix proportions and admixtures. Mixing of ingredients by hand will not be permitted. Accelerating admixture shall be added to the mix by calibrated mechanical means at an approved dosage rate. The Contractor shall establish an onsite batch plant capable of producing the specified shotcrete mix.

b. Placing equipment shall consist of a nozzle providing for the thorough mixing of dry shotcrete materials and water, separate hoses to deliver dry shotcrete materials and water to the nozzle, a suitable dry mix shotcrete machine to introduce the dry materials to the delivery hose under air pressure, and air and water supply systems.

c. The water supply system shall consist of a positive displacement pump capable of supplying water through a regulating valve, with non-pulsating flow and accurately controllable by a nozzleman, in sufficient amount and at a pressure above the operating air pressure recommended by the

manufacturer of the shotcrete machine. A suitable water pressure and flow meter shall be fitted to the water supply system.

d. The air supply system shall be capable of supplying the delivery machine and hose with air at the pressures and volumes recommended by the manufacturer of the machine. A suitable air pressure meter shall be fitted to the air supply system adjacent to the shotcrete machine. No air supply system shall be used that delivers air contaminated by oil or that is incapable of maintaining constant pressure.

e. The delivery equipment shall have an acceptable performance record in applying coarse aggregate shotcrete as specified herein. The delivery machine shall be capable of introducing dry materials to the delivery hose at a uniform rate, with ejection from the nozzle at velocities that will afford adherence of material to the surface to be treated with a minimum rebound and maximum adherence and density.

f. The entire system shall be so arranged that the nozzleman may use air and water in any combination to prepare surfaces onto which shotcrete will be applied.

g. Equipment, including protective equipment for the nozzleman, shall be provided to allow application of shotcrete to surfaces at an approximate range of 1 meter from the nozzle.

7.2.5 Field Trials

a. Field trials shall be made to demonstrate the capability of the equipment, workmanship and materials under field conditions at least 14 days prior to the actual application of shotcrete.

b. The field application of each mix selected for field trial shall be made on horizontal, vertical and overhead test panels to simulate construction conditions. Test panels shall be made on wood forms measuring not less than 1 meter by 1 meter by 150 mm deep. Test panels shall be cured as directed by the Engineer. One set of test panels, 1 horizontal and 1 vertical, shall be used to test each nozzlenman.

c. Six cores 60 mm diameter shall be taken from each horizontal and each vertical test panel. With the exception of cores for one day strength, all cores shall be taken one day before testing. Cores shall be soaked in lime-saturated water according to ASTM C 42 during the time the samples are in the laboratory.

d. Cores shall have a length/diameter ratio of 2.0 and shall be tested according to ASTM C 42 for their one and three day strength.

e. The average strength of all cores for each set of test panels as a minimum shall be as follows:

One day compressive strength	80 kgf/cm²
Three day compressive strength	160 kgf/cm²

The minimum strength obtained by testing of any core in a set shall be not less than 80 percent of the above mentioned values.

f. Mixes and/or nozzleman failing to meet the above requirements will be rejected. In such a case the Contractor shall repeat the field trials and tests

before applying shotcrete on any permanent surfaces. No extra payment will be made for this additional testing.

g. All phases of field trial work shall be performed in the presence of the Engineer.

h. The Engineer will inform the Contractor, in writing, of his acceptance of mixes which meet the requirements of Sub-Clause 7.2.3. No shotcrete mix shall be used in field trials if the mix has not been approved by the Engineer.

i. The actual proportions of ingredients determined on the basis of trial mixes and field trials and approved by the Engineer shall be used in the actual application of shotcrete and shall not be varied without the written approval of the Engineer.

7.2.6 Workmanship

a. The work shall be performed by individuals experienced in shotcrete application.

b. Nozzlemen shall have had previous satisfactory experience in the application of coarse aggregate shotcrete or shall work under the immediate supervision of a foreman or instructor with such experience.

c. Each nozzleman shall demonstrate, to the satisfaction of the Engineer, acceptable proficiency in the application of shotcrete of field trial qualities to vertical and horizontal test panels, in accordance with Sub-Clause 7.2.5 before the beginning of excavation.

7.2.7 Admixtures

a. Where the use of a set accelerating admixture is required in order to apply shotcrete successfully or to maintain safe conditions, the type and amount of admixture used shall be as approved in accordance with Sub-Clause 7.2.4.

b. Accelerating admixture shall not contain chlorides or material corrosive to steel nor shall they cause other detrimental effects such as cracking or spalling. The use of any particular brand or type of admixture shall be subject to approval by the Engineer.

c. Cube compressive strength tests shall be performed by the Contractor for determination of compatibility of cement and admixture in accordance with ASTM C 109. Control specimens containing no admixture and specimens containing proposed dosages of admixture shall be tested.

7.2.8 Preparations

a. Depending on the design requirement as shown in the Drawings or on the condition of the material being shotcreted the following methods of treatment may be directed or approved :

(i) shotcrete without steel mesh reinforcement

(ii) shotcrete with steel mesh reinforcement.

b. Steel mesh reinforcement shall be securely fastened with surface anchors.

c. Surface anchors are defined as devices used for fastening the reinforcement but which do not penetrate the rock to a depth greater than 600 mm and include nails, staples, and embedded wire ties and masonry anchors or other means approved by the Engineer.

d. Wherever shotcrete is required, the Contractor shall clean and prepare the surfaces to receive the coating. Loose or shattered rock, rock debris, soil or other loose material and any oil film or otherwise objectionable substances shall be removed from the surfaces. Where necessary a degreasing liquid or, if approved, high pressure steam shall be used to remove the oil film. After the loose material has been removed, the surface shall be washed where required with a strong air water jet or by other approved means.

7.2.9 Application

a. No shotcrete shall be applied to the Works until the quality of workmanship and the compressive strength of the shotcrete, as determined from the test panels, is approved.

b. Shotcrete shall only be applied in the presence of the Engineer and shall be built up in successive layers such that sagging and bleeding does not occur. Wherever practicable rock surfaces shall be rendered free of water flowing over or seeping through the surfaces to be shotcreted immediately before the shotcrete is applied. Shotcrete shall cover the mesh reinforcement to a depth not less than 30 mm. The mesh shall be adequately supported and fixed in position using concrete spacer blocks or other approved methods during all shotcrete operations.

c. The thickness of the shotcrete shall be determined by an approved means during the application.

d. After the specified interface preparation has been carried out and immediately before shotcreting, the surfaces shall, where required, be thoroughly cleaned and wetted with a strong blast of air and water. Application shall commence at the bottom of vertical and near vertical surfaces and each layer of shotcrete shall be built up by making several passes of the nozzle over the working area.

e. The distance of the nozzle from the work shall be between 600 mm and 1.50 m and the nozzle shall be held perpendicular to the application surface except that, when spraying around reinforcement, the nozzle may be held closer and at a slight angle in order to facilitate encasement. The shotcrete shall emerge from the nozzle in a steady uninterrupted flow. Should the flow become intermittent from any cause, the nozzle operator shall direct it away from the work until it again becomes uniform.

f. All rebound and other loose material shall be removed by air jets or other approved means from the surface of each layer as work proceeds.

g. During the application of shotcrete, any remaining water flowing over or seeping through the surfaces to which the shotcrete is to be applied shall be diverted by the use of panning, pipes, felt strips or other approved means. Where directed, formed holes or pipes outlets shall be provided in the shotcrete, as shown on the Drawings or directed, to relieve water pressure on the shotcrete.

h. Layer thickness shall mainly be governed by the requirements that the material shall not slump or sag and is dependent on factors such as position of reinforcement, plane of application, mix design constituents and use of admixture. Where thick layers are applied it is important that the leading edge be maintained at a slope. Where necessary to achieve greater overall thickness, a layer of shotcrete may be covered by a succeeding layer but it shall first be allowed to stiffen, all laitance and loose material removed and the surface wetted using a strong blast of air and water.

i. Construction joints shall be tapered at approximately 30° or cut back square to the reinforcement and then tapered at 30° unless other wise directed. The entire joint shall be thoroughly cleaned and wetted before placing adjacent shotcrete. Reinforcement shall be cleaned of any previously deposited hardened material which might prevent a proper bond or encasement.

j. A proportion of shotcrete will rebound. Such rebound shotcrete shall not be reused but shall be removed to disposal at the expense of the Contractor. All rebound shotcrete shall be removed from the Works and disposed of by the Contractor as part of the work under this Clause.

k. The Contractor shall ensure that the shotcrete application operation is adequately lit by floodlight if carried out during hours of darkness or underground in accordance with Sub-Clause 1.10.2.4 and he shall take all measures as are necessary for the safety of his workmen including provision of face protection for the nozzleman.

l. Blasting in excavation shall not be carried out within 2 hours after the application of shotcrete or within 30 m of the area sprayed.

7.2.10 Curing

All shotcrete shall be kept continuously wet for at least 7 days immediately following placement. Natural curing may be approved if atmospheric conditions surrounding the shotcrete are satisfactory, such as when the relative humidity is at or above 85 percent.

7.2.11 Safety of Works

The application of shotcrete as temporary or permanent support shall not be considered as relieving the Contractor of his responsibility to maintain all portions of the Works in a safe condition.

7.2.12 Testing and Repairs

a. The Contractor shall take 60 mm diameter test cores from in-place shotcrete at locations and at times directed. Core shall be drilled normal to the surface through the full thickness of shotcrete and at least 50 mm into the substrate at the rate of 6 suitable cores from every 100 m² of completed shotcrete or as directed by the Engineer. The drilled cores for inspection by the Engineer to evaluate the quality of bonding to the rock surface and the interface of shotcrete layers if more than one layer is applied. The cores shall have, where practicable, a length/diameter ratio of 2.0 and shall be stored, cured and tested in accordance with ASTM C 42 by the Contractor. Three cores shall be compression tested at 24 hours and three cores at 28 days.

b. The compressive strength requirement for each set of cores shall be satisfied if:

   (i) Each core has a compressive strength equal to or greater than that specified; or

   (ii) The average compressive strength is equal to or greater than that specified and the difference between the strengths is less than 40 percent of the average.

c. The average compressive strength of samples taken during routine quality control must equal or exceed the following strength requirements :

Compressive strength at 24 hours	80 kgf/cm²
Compressive strength at 28 days	250 kgf/cm²

   No single core strength shall be less than 75 percent of the required strength.

d. The thickness of the shotcrete support shall be tested when directed by drilling 5 randomly located holes in a rectangular area 1.0 m by 1.50 m. The locations of the holes shall be as directed. The holes shall be approximately 40 mm in diameter and shall be drilled normal to the surface. The thickness of the shotcrete at any location shall not be less than 95 percent of the specified thickness.

e. All drilling for testing, backfilling of drill holes with dry-pack mortar shall be carried out by the Contractor. The cost of drilling for testing, of testing samples and of backfilling drill holes shall be included in the rates for shotcrete.

f. Shotcrete which fails to meet the minimum strength requirements as specified, lacks uniformity, exhibits segregation, honeycombing, lamination, shows cracking, or is "drummy" shall be regarded as defective shotcrete. The Engineer may order removal of defective shotcrete and order its replacement with acceptable shotcrete, or other remedial without additional cost to the Employer.

   One shotcrete layer shall not be placed over another defective shotcrete layer until the required remedial measures have been taken. The Engineer may withold payment for defective shotcrete layer until remedial measures have been taken. Any remedial measure ordered by the Engineer to correct defective shotcrete shall be at the expense of the Contractor.

7.2.13 Drain Pipes

For shotcrete used for protection of surface excavation, drain pipes (also referred to as relief or weep holes) shall be provided through the shotcrete protection in accordance with Clause 9.22.

7.2.14 Measurement

a. Measurement, for payment, of shotcrete in surface excavations shall be made of the area of shotcrete applied in square metres calculated from the payment lines for excavation and dimension shown on the Drawings or directed.

b. No allowance shall be made in the measurement for additional shotcrete applied due to over excavation beyond the payment lines for excavation, for local thickening required in recesses to achieve a smooth profile, for thickening required for achieving the specified shotcrete thickness because of irregularities in the excavated surface as a result of geological conditions and/or methods of excavation, for material wastage, for rebound losses and for defective shotcrete.

c. Measurement for payment of shotcrete concrete lining in tunnels shall be made of the volume of shotcrete applied.

No allowance shall be made in the measurement for additional shotcrete applied beyond the maximum overbreak line shown on the Drawings, for thickening required for achieving the specified shotcrete thickness because of irregularities in the excavated surface as a result of geological conditions and/or methods of excavation, for material wastage, for rebound losses and for defective shotcrete.

7.2.15 Payment

a. Payment for applying shotcrete 100 mm thick in surface excavations will be made at the applicable rate per square meter tendered therefor in the Bill of Quantities (Item G.5). The rate per square meter for shotcrete shall allow for the cost of all cement, additives, aggregate, transportation, preparation, storage, cleaning of the application, field trials, testing, curing and all and any other contingencies and requirements specified in this Clause for the production and application of shotcrete.

b. Separate payment will not be made for PVC pipe drains and gravel fill and excavation of pockets for gravel fill where required as shown on the Drawings or directed and all costs thereof shall be deemed to be included in the unit rates for the applicable shotcrete items in paragraph 7.2.15.a. Pipe drains are not required for shotcrete in tunnels.

c. Payment for applying shotcrete in tunnel linings will be made at the applicable rates per cubic metre tendered therefor in the Bill of Quantities (Items D.3.1 and D.3.2). The rate per square metre for shotcrete shall allow for the cost of all cement, additives, aggregate, transportation, preparation, storage, cleaning of the application, field trials, testing, curing and all and any other contingencies and requirements specified in this Clause for the production and application of shotcrete. The rates shall also include allowance for the cost of extra shotcrete applied to overbreak.

d. Payment for steel mesh reinforcement will be made in accordance with Clause 7.5.

7.3 ROCK BOLTS

7.3.1 General

a. The Contractor shall furnish and install grouted rock bolts in the underground works, in accordance with the requirements of this Clause, the Drawings or as directed or approved.

b. For the purpose of this Clause a rock bolt is a length of deformed steel bar installed and grouted into a drilled hole, anchored to the rock at the far end

and tensioned through a nut and steel plate bearing against the surface of the rock or shotcrete. The anchorage may be by either an approved chemical anchor or an approved cement grout.

c. The installation of rock bolts shall be under the direct supervision of a skilled person having at least two years experience in the installation of grouted rock bolts in tunnels.

7.3.2 Materials

a. Rock bolts shall be SD-35 deformed bar complying with JIS G 3112 having diameters of 22 mm and 25 mm for the outlet tunnel and diversion tunnel respectively and be of the type shown on the Drawings or an approved equivalent. The tensioning end shall have a thread of not less than 180 mm in length and the anchorage end shall be cut to a 45 degree bevel.

b. The Contractor shall furnish with each rock bolt all accessories including or cement anchor, plastic or metal centering rings, a steel bearing plate, a ball-washer, a machine washer a hexagonal nut and, where grouting is required, the grout and accessories for grouting. For the purposes of payment all such accessories will be deemed to be an integral part of the rock bolt.

7.3.3 Patterns of Installation

The required patterns in which rock bolts shall be installed is as shown on the Drawings or as directed or approved.

7.3.4 Method of Installation

a. General

The method of installation of rock bolts shall be in accordance with this Sub-Clause, the Drawings and the direction of the Engineer.

Generally the method shall consist of drilling a hole to the required diameter and depth, cleaning out the hole, placing the rock bolt in the hole and anchoring it, tensioning, grouting and testing.

The Contractor shall keep on Site, ready for immediate use, a sufficient stock of rock bolts and accessories to avoid delays to the work.

Specific methods for chemically anchored and cement anchored rock bolts are as follows.

b. Chemically Anchored Rock Bolts

(i) Individual resin cartridges shall be carefully inserted in the hole to avoid rupture and shall be placed in position with tamping rods. A shaped plastic cap shall be placed after every third cartridge in holes rising more than 30 degrees above horizontal to maintain cartridges in position. The number of cartridges per hole shall be as recommended by the manufacturer for the hole and steel bar size combination used to insure complete encapsulation of the rock bolt.

(ii) Anchorage cartridges shall be of the fast gel type with a set time of not more than two minutes at 20°C. The anchorage cartridges shall be inserted to design depths followed by slower setting encapsulation cartridges.

(iii) Once the anchorage and encapsulation cartridges are in place, the steel bar shall be inserted and rotated through the cartridges at the rate and for the period of time recommended by the manufacturer to provide thorough mixing of the resin components. The steel bar shall then be held in placed until the resin has gelled and hardened sufficiently to hold the rock bolt in place. Care shall be taken not to damage threads on the end of the rock bolt during installation.

(iv) Resin anchored rock bolts shall be tensioned to 30 kN or as directed. Tensioning shall not begin until the fast gelling anchorage cartridges have reached working strength as determined from certified tests by the manufacturer for the approximate temperature at which installation occurs. Tensioning shall be completed before gelling of the remaining cartridges begins, also as determined by certified tests by the manufacturer.

c. Cement Anchored Rock Bolts

(i) Hole for rockbolts shall be filled with a plastic cement grout by means of a compressed air mortar feeder, from the back of the hole to the front. The consistency of the grout shall be such that it does not flow out of the hole even if the hole is directed vertically upwards. The rock bolt shall then be pushed into the grout- filled borehole in a continuous procedure.

(ii) Where necessary, due to seepage or other reasons, a cartridge filled with hardening accelerator shall be placed at the rear of the drill hole prior to placing cement grout.

(iii) The rock bolts shall be tensioned to 30 kN or as directed not later than two hours after installation.

(iv) The grout shall consist of one to two parts fine sand, one part cement or neat cement and enough water such that the grout has a stiff, plastic consistency. Test shall be carried out to determine optimum proportioning. Sand and cement shall be premixed and this premix delivered in bags to the construction site. The compressive strength of the grout shall, as a minimum, reach 200 kgf/cm² in 24 hours. Additionally, the anchorage shall attain sufficient strength within two hours of installation to allow prestressing. Test results shall be submitted to the Engineer for approval.

7.3.5 Testing

The Engineer will select rock bolts for pull out test using a hollow ram hydraulic jack. Test loads up to 80 percent of the breaking load may by used. The Contractor shall provide and maintain the tools, equipment and labour to perform these tests. As an average, four percent of the rock bolts installed shall be tested and all tests will be witnessed by the Engineer. The decision whether to replace defective rock bolts will be made by the Engineer.

7.3.6 Records

The Contractor shall submit records of the rock bolt installation to the Engineer within 24 hours of their installation. The records shall include but not be limited to the type of rock bolt anchorage, length, borehole diameter, number of resin

cartridges, problems during installation, time of installation, time of prestressing and prestressing load.

7.3.7 Measurement and Payment

a. Measurement, for payment, for furnishing and installing rock bolts in underground excavation will be made of the length of bolt actually installed as directed or approved.

b. Payment for furnishing and installing rock bolts for the diversion tunnel and for the outlet tunnel will be made at the respective rates per linear meter tendered therefor in the Bill of Quantities (Items D.5.1 and D.5.2).

c. Separate payment will not be made for testing or for drilling holes for drilling holes for the rock bolts.

d. Separate payment will not be made for using hardening acceleration when required.

7.4 GROUTED ANCHOR BARS

7.4.1 General

The Contractor shall drill holes for and shall furnish and install grouted anchor bars for strengthening surfaces of surface excavation as shown on the Drawings or directed.

7.4.2 Materials

a. Anchor bars shall be deformed bars complying with the applicable provisions of Clause 9.24.

b. Grout shall consist of a mixture fine aggregate complying with Sub-Clause 5.6.3 and Portland cement mixed in the ratio 1:1 and water complying with Sub-Clause 5.6.3. The water cement ratio shall be not greater than 0.35 or as directed by the Engineer.

7.4.3 Installation

a. The dimensions of the anchor bars and the locations, diameters and depths of the drilled holes shall be as shown on the Drawings or directed.

b. The diameter of each drilled hole shall not less than 1.5 times the diameter of the anchor specified for that hole.

c. The hole shall be cleaned thoroughly and shall be completely filled with grout. If the hole cannot be kept dry during the filling operation, the grout shall be introduced into the bottom of the hole by means of a pipe which shall subsequently be withdrawn.

d. The anchor shall be forced into place before the grout takes its initial set and, where praticable, shall be vibrated or rapped. Thereafter, the Contractor shall ensure that movement of the placed anchor does not occur and concrete shall not be placed anchor around anchors until 24 hours after the anchors have been grouted.

7.4.4 Testing

Load testing is not required to be carried out.

7.4.5 Measurement

Measurement, for payment, of Furnishing and Installing Grouted Anchor Bars shall be made of the length of anchor bar installed as shown on the Drawings or directed.

7.4.6 Payment

Payment for Furnishing and Installing Grouted Anchor bars will be made at the rate per linear metre tendered therefor in the Bill of Quantities (Item G.8). This rate shall include the cost of drilling the holes, furnishing anchor bars cement, fine aggregate and additives for the grout and all associated costs.

7.5 STEEL MESH REINFORCEMENT

7.5.1 General

The Contractor shall furnish and install steel mesh reinforcement, where directed and approved, in conjunction with shotcrete, in accordance with Clause 7.2 in connection with surface protection for surface excavation and tunnelling .

7.5.2 Materials

Steel mesh reinforcement shall comply with the material requirements specified in AASHTO M SS (ASTM A 185) Welded Steel Wire Fabric for Concrete Reinforcement. Wire diameters and pitches of mesh shall be as shown on the Drawings, directed or approved.

7.5.3 Measurement

Measurement, for payment, of steel mesh reinforcement of the various types shall be made of the mass of steel mesh reinforcement installed as directed or approved and shall include the mass of all surface anchors required for fastening the steel mesh reinforcement.

7.5.4 Payment

Payment for furnishing and installing steel mesh reinforcement in surface excavations and in the diversion tunnel and outlet tunnel will be at the rates per kilogram tendered therefor in the Bill of Quantities (Items G.6, D.4.1, D.4.2). Such rates shall include the cost of all labour materials and equipment necessary for furnishing and installing steel mesh reinforcement in accordance with this Clause.

7.6 MAT GABIONS

7.6.1 General

The Contractor shall furnish and install mat gabions and at the locations shown on the Drawings or directed.

7.6.2 Materials

a. Mat gabions shall be fabricated from galvanized iron wire 6mm in diameter for the framework and 5 mm in diameter for wire mesh and shall conform to JIS A 5513 or other appropriate standards. The mesh opening shall be 130 to 150 mm.

b. The mat gabions shall be of rectangular section to the dimensions shown on the Drawings.

c. Stone used for filling the mat gabions shall be hard and durable with a least dimension not smaller than the size of the mesh opening of the gabion.

7.6.3 Installation

a. The foundation of the mat gabion shall be prepared as shown on the Drawings before placement.

b. Mat gabions shall be connected together with galvanized iron wire 6 mm in diameter.

c. In filling the gabions, the larger size of stone shall be placed in the outside of the gabion and smaller stone in the centre. The stone shall be compacted sufficiently to lessen voids between stones as much as practicable. Smaller stone shall be placed in the voids between larger stones. The top of the mat gabion shall be overfilled slightly prior to closing the top of the mat gabion with a net of galvanized iron wire.

7.6.4 Measurement

Measurement, for payment, of mat gabions will be made of the volume of the mat gabion in place to the lines as shown on the Drawings or directed by the Engineer.

7.6.5 Payment

Payment for mat gabions will be made at the applicable rate per cubic meter tendered therefor in the Bill of Quantities (Item G.4) which rate shall include all costs of furnishing and transporting the materials, preparing and placing the gabions, foundation preparation and supply and installation of wooden anchor pegs.

7.7 STEEL RIBS

7.7.1 General

a. The Contractor shall furnish and install steel rib supports in underground excavations where directed or approved. Steel rib supports shall include crown and base plates, tie rods, nuts, bolts and all other fasteners.

b. The design and fabrication of steel rib supports including size, mass, accessories and methods of initialling the supports in all parts of the underground excavation shall comply with BS 449 : Part 2 and shall be subject to approval.

7.7.2 Supply

At all times during underground excavation, the Contractor shall have available on the Site ready for immediate use, at least 8 steel ribs and support accessories suitable for installation and replenish the stock ahead of time in the particular section of the underground excavation under construction.

7.7.3 Installation

a. Steel rib supports shall be installed true to the lines and grades shown on the Drawings or as approved and shall be maintained by the Contractor in proper condition and alignment. Any steel rib supports placed improperly shall be adjusted by the Contractor within 48 hours after the improper placement of the steel rib supports is called to his attention by the Engineer. Any repair to, or replacement of, steel rib supports necessitated by the Contractor's operations shall be made by and at the expenses of the Contractor.

b. The use of timber support accessories, except timber spreaders which are removed before concreting, will not be approved between the outer face of the steel rib support and the rock face or shotcrete surface as the case may be.

7.7.4 Accessories

a. Steel support accessories include foot plates, tie bars, steel pipe, jointing plates, wedging and footblocks, which shall be steel plates or steel sections of approved dimensions and nuts, bolts and washers.

b. Once steel support accessories have been placed firmly into position they shall be securely tried together to prevent subsequent movement. Steel accessories shall be left in place during placement of the concrete lining.

7.7.5 Removal of Timber Before Concreting

All loose timber shall be removed as completely as practicable before lining is placed. All timber spreaders shall be removed before placing concrete lining. The Contractor shall securely brace the supports with the minimum practicable amount of blocking and wedging.

7.7.6 Measurement

Measurement, for payment, of furnishing and installing steel ribs supports and accessories in the underground works will be made of the mass of steel installed as approved or directed and shall include not more than ten (10) steel ribs and accessories for each tunnel which may be furnished but not installed.

7.7.7 Payment

Payment for Furnishing and Installing Steel Rib Supports and Accessories will be made at the applicable rates per tonne tendered therefor in the Bill of Quantities (Items D.2.1 and D.2.2). This payment will be made for all steel ribs furnished and installed as approved or directed. Payment for steel rib supports and accessories furnished but not installed, will be made at the rate of 80 per cent of the rate per tonne tendered in the priced Bill of Quantities for furnishing

and installing steel ribs supports.

7.8 COBBLE STONE FOUNDATIONS

7.8.1 General

The Contractor shall furnish and install cobbles for cobblestone foundations for culverts, buildings, facilities, and elsewhere to the lines, grades and dimensions as shown on the Drawings or as directed.

7.8.2 Materials

a. Cobbles used in foundations shall be regular field, river or quarry stone of approved quality, free from seams and other defected, approximately uniform in size to ensure no large voids between stones. The thickness of the cobbles shall be as shown on the Drawings.

b. Cobbles shall be placed by hand and shall be sufficiently compacted in such manner as to lessen voids between stones as much as practicable. The voids between stones shall then be filled with well graded gravel or crushed stones and compacted to the satisfaction of the Engineer.

7.8.3 Measurement and Payment

Measurement, for payment, of cobblestone foundation shall be made of the volume compacted in place to the lines, grades and dimensions shown on the Drawings or directed.

Payment of cobblestone foundation will be made at the rate per cubic meter tendered therefor in the Bill of Quantities (Item G.3) which shall include the cost of all labour, materials, equipment and incidentals required for furnishing, handling and placing cobbles including infill gravel or crushed stones and any other necessary works connected therewith.

Separate payment will not be made of cobblestone foundations for stone masonry and stone pitching and all costs shall be deemed to be included in the items in the priced Bill of Quantities for which payment of the relevant items is made.

7.9 STONE MASONRY

7.9.1 General

Wet stone masonry and stone pitching shall be used in various structures as specified below or as directed by the Engineer.

(i) Stone Masonry

Used as retaining walls for access road embankment.

(ii) Stone Pitching

Used as slope protection for the access road embankment.

c. The term "masonry" used hereinafter in the Specifications shall be deemed to mean both stone masonry and stone pitching but excludes stone pitching used for lining surface drains in accordance with Clause 8.3.

d. The Contractor shall furnish and install stone masonry and stone pitching on the surfaces of slopes and batters and in retaining walls as shown in the Drawing or directed.

7.9.2 Materials

e. Stone used in masonry shall be regular field, river or quarry stone of approved quality, free from seams and outer defects. The stone shall have a specific gravity of not less than 2.5.

f. All masonry stones stockpiled at the Site shall be kept in such manner that they will be slightly moist at the time of use. Stone used in the work or any part of the work shall be approximately uniform in size to ensure no large voids between stones.

g. The stone shall be not less than 350 mm thick and the exposed surface of each stone shall be approximately flat and of an area not less than 0.10 m^2.

h. Concrete shall be Type E in accordance with Sub-Clause 9.2.7.

7.9.3 Placement

a. Prior to constructing masonry, a cobblestone foundation and a concrete foundation shall be complete as shown on the Drawings or as directed by the Engineer.

b. Before placing stone, the stone shall be cleaned and be sufficiently moistened. The masonry stone shall be so placed by hand that each stone is completely surrounded by concrete. Concrete shall be used for jointing in such a manner that the concrete is continuous throughout the concrete joints. The stones shall be tamped and thoroughly consolidated and those stones broken during tamping shall be removed and replaced with sound stone.

c. Backfill concrete and backfill gravel shall be placed simultaneously with the placing of masonry so as to keep the masonry, concrete and gravel at the same level.

d. Stone shall not be placed during rain periods sufficiently heavy or prolonged as to wash the concrete from the masonry.

7.9.4 Pointing

Joints on the face of all stone masonry exposed to view shall be neatly finished. The concrete in the joints of the stone masonry shall first be removed to a depth of 30 mm. The joint shall then be cleaned thoroughly with a wire brush of all loose materials and filled with cement mortar with a mix proportion of one part of Portland cement and three parts of sand by volume. The surface of the stone shall be cleaned of all mortar upon completion of the finishing operation.

7.9.5 Plastering

The top of stone masonry construction shall be finished neatly by placing a concrete slab 10 cm thick as shown on the Drawing. Before placing the concrete topping slab, concrete in the joints of the stone masonry beneath the slab shall be removed to a depth of 30 mm and the joint and top portion of the

masonry wall shall be cleaned thoroughly of all loose materials with a wire brush.

7.9.6 Contraction Joints and Wall Drains

a. Masonry walls and stone pitching slope protection shall be provided with construction joints at 20 m intervals except as otherwise designated on the Drawings or as directed by the Engineer. The contraction joint shall be a vertical line perpendicular to the plane of wall.

b. Except as otherwise shown on the Drawings or as directed by the Engineer, vertical or sloped portions of masonry walls and stone pitching slope protection shall be provided with wall drains for every 2 m² of surface area of the wall as specified in Clause 9.22.

7.9.7 Measurement

Measurement, for payment, of furnishing and placing stone for wet stone masonry retaining walls and stone pitching slope protection shall be made of the actual volume of stone masonry and stone pitching in place to the lines, grades and dimensions shown on the Drawings or directed.

7.9.8 Payment

a. Payment for wet stone masonry and stone pitching slope protection will be made at the applicable rate per cubic meter tendered therefor in the Bill of Quantities (Items G.1 and G.2).

b. The rates for stone masonry and stone pitching shall include the cost of all labour, materials and equipment for execution of stone masonry works, including cobble foundation, concrete foundation, placing stones, jointing, pointing, plastering, backfilling concrete, filling concrete, backfilling gravel, providing contraction joint except as specified elsewhere, wall drains and all other necessary works connected therewith.

7.10 SOIL CONSERVATION MEASURES

7.10.1 General

a. The Contractor shall carry out soil conservation measures using the methods shown on the Drawings or directed in the following locations

(i) where directed, in accordance with Clause 1.12.8;

(ii) on the batters of embankments for roads;

(iii) on erodable batters of excavations;

(iv) in disposal areas where required;

(v) in the quarry;

(vi) in borrow areas; and

(vii) elsewhere as directed.

b. The Engineer may direct the Contractor to carry out soil conservation measures in successive stages at any time during the execution of the Works when weather conditions are suitable for the establishment of grass.

c. The Contractor shall carry out soil conservation measures as early as practicable and to the programme established by the Engineer at the time of directing the work or to an approved modification of the programme such that the measures are in place and firmly established before completion of the Works.

7.10.2 Methods

a. Soil conservation measures shall be carried out in accordance with any of the following methods or combinations of methods:

(i) By topsoil placement, which consists of distributing topsoil to depth of 100 mm on areas of common and highly weathered rock excavation and embankment.

All areas where topsoil is to be placed on common excavation or embankment fill shall be scarified or embankment fill shall be scarified to a depth of 150 mm wherever practicable as determined by the Engineer, just prior to the application of topsoil. The finished surface should be uniform and level and any large stones are to be removed. The topsoil shall be spread evenly to the required thickness and harrowed to break up lumps and clods and finished to a uniform surface free from humps and depressions.

(ii) By seeding and fertilising areas where topsoil has been placed or into other areas as directed. These areas shall be sown with an approved grass seed mixture at a rate of not less than 25 kg/ha and fertilised with an approved fertiliser at a rate of not less than 60 kg/ha. The seed mixture and fertiliser shall each be applied in 2 approximately equal applications at times of sowing as directed. The areas covered with topsoil shall be lightly scarified at the time of initial sowing, followed by initial watering.

(iii) By establishing a protective cover of grass over erodible surfaces by full face sodding or strip sodding using sods of dense, well-rooted grass cut to a depth of not less than 4 cm. The sods shall be well bedded in topsoil, pegged to the ground where necessary and kept watered until the sods have rooted. The Contractor shall replace any sods which die or fail to take root.

Where full face sodding is required or directed, the Contractor shall cover the complete surface with sods. The sods shall be tightly butted together in a staggered pattern so joints are not continuous.

b. Where strip sodding is required or directed the sods shall be bedded in strips not more than 30 cm apart so as to cover not less than 30 percent of the required surface with sods.

c. On completion of full face sodding or strip sodding the Contractor shall maintain and water the sodded areas.

7.10.3 Maintenance Watering

a. On completion of the seeding specified in Sub-Clause 7.10.2., the Contractor shall maintain and water seeded areas as necessary to ensure germination occurs and the grass develops to a uniform sward with healthy growth. Areas that fail to germinate shall be reseeded and re-fertilised until a uniform grass over develops. Maintenance including removal of all weeds

and other undesirable growth and regular watering shall continue until the completion of the Works. Any areas subsequently killed or damages before completion of the Works shall be immediately restored, re-grassed, fertilised and watered by the Contractor at his expense.

On completion of the grassing specified in Sub-Clause 7.10.2, the Contractor shall maintain including removal of weeds and other undesirable growth and water the grassed areas as necessary to create and maintain a good healthy cover of grass and good growth from strip sodding. Any areas subsequently killed or damage before completion of the Works shall be immediately restored, re-grassed and watered by the Contractor at his expense.

b. After initial watering, the Contractor shall water the grassed areas regularly and when necessary, to the equivalent of at least 25 mm of rain per week. The method of watering shall be subject to approval and shall be carried out during normal working hours. The watering system shall include provision for measurement of the quantity of water applied.

7.10.4 Measurement

a. Measurement, for payment, for application, of full face sodding or strip sodding shall be made of the actual surface area of Permanent Works, including sodding of designated soil disposal areas, covered with grass sods or strips as shown on the Drawings or directed.

b. No measurement, for payment, of soil conservation measures taken in accordance with the Contractor obligations under the Contract, will be made.

7.10.5 Payment

a. Payment for supply and placement of full face sodding or strip sodding will be made at the rate per square meter tendered therefor in the Bill of Quantities (Item G.7). Such rates shall include the cost of all labour, materials and equipment necessary for furnishing and laying the sods, fertilising and watering as needed any other works connected therewith in accordance with this Clause.

b. Separate payment will not be made for topsoil replacement, establishing grassing and any other soil conservation measures for reinstatement and restoration of Temporary Works, borrow areas, and quarry carried out by the Contractor at the direction of the Engineer in accordance with Sub-Clause 1.12.8 and all costs shall be deemed to be included in the rates and lump sum prices tendered in the priced Bill of Quantities for the items for which the work is required.

CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 8. DRAINAGE

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SECTION 8. DRAINAGE

8.1 GENERAL

The Contractor shall construct drains for collection and discharge of surface water in accordance with the Drawings, this Section of the Specification and as directed.

Drains and associated structures to be constructed are summarised as follows:

Designation	Description	General Application
Type 1-1	Wet stone masonry-lined ditch	Side ditch along permanent access road and toe of cut adjacent spillway and in designated disposal areas
Type 1-2	Wet stone masonry-lined ditch	Side ditch along permanent access road and toe of cut adjacent spillway and in designated disposal areas
Type 2-1	Wet stone masonry drain with concrete slab cover	Left bank access road near Dam Management Complex
Type 2-2	Wet stone masonry drain with steel grating cover	Left bank access road near Dam Management Complex
Type 3-1	Open reinforced concrete drain	Roadside drain for reservoir permanent access road
Type 3-2	Reinforced concrete drain with steel grating cover	Used where drain is to cross permanent access road in lieu of culvert.
Catch Basin	Wet stone masonry catch basin	Used at drain junctions

8.2 EXCAVATION FOR DRAINS

8.2.1 General

The Contractor shall carry out all excavation for drainage in accordance with the requirements of Clause 3.4

8.2.2 Measurement and Payment

Excavation for drainage shall be measured and paid for in accordance with Sub-Clause 3.4.12.4. and included in payment item J.1 with the exception of excavation for drains at the toe of cut near the spillway which shall be included for payment in item C.4.4.

8.3 OPEN WET MASONRY-LINED DRAINS

8.3.1 General

The Contractor shall furnish and wet stone masonry-lined drains where shown on the Drawings or directed.

8.3.2 Materials

Rock used for stone pitched lining shall be sound durable rock selected from the harder rock from the required excavations or other approved sources.

8.3.3 Bedding and Placement

a. The final excavated surface in natural ground or fill shall be firm ground or compacted to the requirement for road subgrade material as specified in Section 10.

b. The rock shall not less than 150 mm thick and shall be properly bedded to a uniform surface on an approved bedding mortar. The exposed surface of each stone shall be approximately flat and of an area not less than 0.03 m².

c. The surfaces to be lined with wet stone masonry shall be trimmed and shaped where necessary and the stones set in a mortar consisting of 3 parts of clean fine aggregate to 1 part of cement by volume so that all voids between the stones are completely filled to the general level of the top surface of the stones.

d. The final surfaces of the inner faces of the lined drains shall be true to line and level within a tolerance of + or – 20 mm. Any section of drain in which water ponds shall be reconstructed to ensure that all water drains to catch basins, outlets or road crossings as the case may be.

8.3.4 Measurement

Measurement, for payment, of furnishing and constructing wet stone masonry-lined drains (Type 1-1 and Type 1-2) shall be made of the length of each type of drain in place to the lines, grades and dimensions shown on the Drawings or directed.

8.3.5 Payment

Payment for furnishing and constructing wet stone masonry-lined drains (Type 1-1 and Type 1-2) will be made at the rates per metre tendered therefor in the Bill of Quantities (Items H.1.1 and H.1.2).

8.4 COVERED WET STONE MASONRY DRAINS

8.4.1 General

The Contractor shall construct covered wet stone masonry drains to the lines and levels as shown on the Drawings or as directed by the Engineer.

8.4.2 Materials

a. Stone masonry materials shall be in accordance with Clause 7.9.

b. Concrete shall be concrete class D in accordance with Section 9.

c. Reinforcement shall be deformed bars as specified in Section 9.

d. Steel grating shall be in accordance with the requirements for steel bar and galvanising as specified in Section 11.

8.4.3 Construction

a. Excavation for drains shall be carried out in accordance with Clause 3.4.

b. Stone masonry shall be constructed in accordance with Clause 7.9. The surfaces of the drains shall be screeded with mortar consisting of 3 parts of clean fine aggregate to 1 part of cement by volume so that all voids between the stones are completely filled to the general level of the top surface of the stones.

c. Where precast concrete slabs shall be set in a bed of 1:3 sand cement mortar to ensure uniform seating on the underlying wet stone masonry.

d. Steel grating shall be fabricated as shown on the Drawings and shall be hot dip galvanised after fabrication. The grating panels shall have edge bars on all sides and shall be free of warp or distortion. Grating panels shall be place in the drain structures as shown on the Drawings. Panels shall be firm and shall not rock or tilt under traffic.

8.4.4 Measurement

Measurement, for payment, of furnishing and Surface Drains (Type 2-1 and Type 2-2) shall be made of the length of each type of drain in place to the lines, grades and dimensions shown on the Drawings or directed.

8.4.5 Payment

Payment for furnishing and constructing Surface Drains (Type 2-1 and Type 2-2) (Type 2-1 and Type 2-2) will be made at the rates per metre tendered therefor in the Bill of Quantities (Items H.1.3 and H.1.4).

8.5 CONCRETE DRAINS

8.5.1 General

The Contractor shall construct reinforced concrete drains to the lines and levels as shown on the Drawings or as directed by the Engineer.

8.5.2 Materials

a. Concrete shall be concrete class C in accordance with Section 9.

b. Reinforcement shall be deformed bars as specified in Section 9.

c. Steel grating shall be in accordance with the requirements for steel bar and galvanising as specified in Section 11.

8.5.3 Construction

a. Construction of reinforced concrete drains shall be in accordance with the requirements of Section 9.

b. Steel grating shall be fabricated as shown on the Drawings and shall be hot dip galvanised after fabrication. The grating panels shall have edge bars on all sides and shall be free of warp or distortion. Grating panels shall be place in the drain structures as shown on the Drawings. Panels shall be firm and shall not rock or tilt under traffic.

8.5.4 Measurement

Measurement, for payment, of furnishing and constructing reinforced concrete drains (Type 3-1 and Type 3-2) shall be made of the length of each type of drain in place to the lines, grades and dimensions shown on the Drawings or directed.

8.5.5 Payment

Payment for furnishing and constructing Surface Drains will be made at the rates per metre tendered therefor in the Bill of Quantities (Items H.1.5 and H.1.6).

8.6 CATCH BASINS

8.6.1 General

The Contractor shall construct wet stone masonry catch basins to the lines and levels as shown on the Drawings or as directed by the Engineer.

8.6.2 Materials

Stone masonry materials shall be in accordance with Clause 7.9.

8.6.3 Construction

Stone masonry shall be constructed in accordance with Clause 7.9. The interior surfaces of the catch pits shall be screeded with mortar consisting of 3 parts of clean fine aggregate to 1 part of cement by volume so that all voids between the stones are completely filled to the general level of the top surface of the stones.
Plastering shall be in accordance with Sub-Clause 7.9.5

8.6.4 Measurement

Measurement, for payment, shall be made of the volume in cubic metres, of wet stone masonry in the catch basins constructed to the approved lines and livels. Measurement of wet stone masonry outside the approved lines shall not be measured.

8.6.5 Payment

Payment for furnishing and constructing catch basins shall be made at the rate per cubic metre tendered therefor in the Bill of Quantities (Item H.2).