CHAPTER T2 EARTHWORK

T2.1 General

The work specified in this CHAPTER consists of:

- Clearing and stripping
- Open-cut excavation
- Trench excavation
- Underground excavation
- Embankment for dam
- Backfilling, bedding and surfacing
- Slope protection
- Disposal or use of excavated materials
- Removal of temporary concrete structures
- Drainage
- Other earthwork as may be directed by the PMO/Engineer

A plan specifying how the Contractor will perform excavation, embankment, backfilling and/or other earth work for each particular type of activity such as for diversion works, dam embankment, spillway, outlet works and intake work shall be submitted to the PMO/Engineer for approval at least thirty (30) days prior to such works starting.

T2.2 Clearing and Stripping

T2.2.1 General

This work shall consist of clearing and stripping the area within the limits of the Site as defined in the Drawings or directed by the PMO/Engineer. All trees, stumps, bushes, roots, down-timber, wood, rubbish, and any other vegetation or objectionable matter in the area shall be cleared of.

It shall include the removal of buildings, foundations, fences, retaining walls and other obstructions interfering with the project work, and burning or otherwise disposing of to the satisfaction of the PMO/Engineer.

The work shall also include clearing the reservoir area below Elevation EL. 193.5 m.

T2.2.2 Execution of work

The Contractor shall perform the work of clearing and stripping in accordance with statutory regulations. Such material from clearing and stripping operation shall be removed from the Site or burned or otherwise disposed of as specified or directed by the PMO/Engineer. Care shall be exercised to see that the burning of such material does not destroy or damage public or private property, and the Contractor shall be fully responsible for any destruction, damage, or nuisance. Burning shall be done at such times as approved by the PMO/Engineer.

The reservoir area below Elevation EL. 193.500 m shall be cleared of all trees, stumps, and brush 5 feet or more in height, regardless of diameter, and 2 inches or more in diameter, regardless of height.
Trees and stumps in the reservoir area shall either be uprooted or cut off so that the maximum allowable stump height shall be 6 inches as measured on the uphill side of the stump. Brush in the reservoir area shall be cut off approximately flush with the ground level. All down timber, branches, and other floatable and combustible material 5 feet or more in length, regardless of diameter, and 2 inches or more in diameter, regardless of length, shall be cleared.
No trees shall be cut outside of areas mentioned above without specific approval.
The Contractor shall, by his own investigation, determine the extent of clearing required in accordance with this section.

The Contractor may, at no cost, retain any materials of value from clearing operations for his own use or disposal by sale. Such materials shall be removed from the construction area before the date of completion of the work under the specifications. Every reasonable effort shall be made by the Contractor to channel materials of value resulting from clearing operations into beneficial use.

T2.2.3 Measurement and payment

Measurement for payment of clearing and stripping will be made based on the area to the lines as shown on the Drawings, specified in T2.2.2 of the Technical Specifications or directed by the PMO/Engineer.

Payment for clearing and stripping will be made at the unit price per square meter stated in the Bill of Quantities, which unit price shall include the cost of all labour, materials and equipment to remove the materials to the disposal area and all other items necessary to complete the work.

T2.3 Explosives and Blasting

T2.3.1 Explosives

The transportation, hauling, storage, and use of explosives shall be subject to the Law and Regulations of the Government as well as the instruction of the PMO/Engineer. The Contractor shall maintain an inventory record of storage and withdrawal of all explosives and shall make it available to the PMO/Engineer at any time. Any loss or theft of explosives shall be promptly notified to the PMO/Engineer. The Contractor shall provide such reasonable and adequate protective facilities as are necessary to prevent loss or theft of explosives. Overnight storage of explosives and detonators outside of the magazines shall not be permitted.

Caps or other exploders or fuses shall be in no cases stored, transported or kept in the same places in which dynamite or other explosives are stored, transported or kept.

T2.3.2 Planning of blasting

For all blasting operations, the depth and sizes of holes, and the sizes and characteristics of the charges shall be well planned. The explosives for each blast shall be of such quantity and power and shall be used at such locations as will neither open seams nor crack the rock outside of the limit of excavation. As an excavation approaches its final line, the depth of holes for blasting and the amount of explosives used for per hole shall be reduced progressively. As the excavation for foundation of the impervious core zone (Zone 1) and/or the concrete structures progress to 30 cm above the formation line, the excavation shall be broken off until constructing Zone 1 and/or concrete structures have become operational so as to prevent the side and bottoms of foundation rock from shattering due to overly exposing to weathering. Immediately before placing the Zone 1 material and/or concrete, the rock foundation shall be excavated completely to the required formation line by the use of hand tools or other approved method.

When blasting, the Contractor shall exercise special care to avoid damage to concrete or pressure grouting already completed. No blasting will be permitted in any case within distance less than 25m from those pertinent areas unless otherwise directed by the PMO/Engineer. Whenever, in the opinion of the PMO/Engineer, further blasting may injure the rock on or against which concrete is to be placed, the use of explosives shall be discontinued and the excavation shall be completed by wedging, barring, channeling, line drilling as directed by the PMO/Engineer. Blasting will be permitted only after adequate provision has been made for the protection of persons, the Works, and public and private properties. Approval by the PMO/Engineer of any of the Contractor's blasting operations shall not relieve the Contractor of his responsibility for safety of persons and

properties. Damages to the Works or to the public or private properties by blasting shall be repaired by and at the expense of the Contractor. Excavation by blasting shall be carried out only under personal supervision of competent persons and trained workmen. All supervisors and workmen working with blasting materials and operations shall be adequately insured by the Contractor.

T2.3.3 Pre-splitting

When blasting is required to excavate permanent side slope steeper than one (1) vertical to one (1) horizontal against which Zone 1 material or concrete is to be placed, or elsewhere as directed by the PMO/Engineer, the Contractor shall use a pre-splitting technique to ensure that a fracture plane is established along the required final excavation slope prior to excavation of the main body of rock, thus minimizing damage to the rock beyond the required final excavated surface line.

The Contractor shall submit to the PMO/Engineer for approval, at least thirty (30) days prior to starting excavation in any section of the work requiring the use of the pre-splitting technique, a detailed description of his proposed method any procedures of excavation. The spacing and diameter of pre-splitting holes and the arrangement of the explosives in each hole shall be varied to suit the rock conditions and shall be chosen to provide the best practical excavated surface line after blasting.

The Contractor shall establish by field trials in an approved area his pre-splitting blasting technique to produce a minimum of overbreak and fracturing of the rock outside the excavation lines of the areas to be pre-split. These trials shall be performed by varying the drill size and hole pattern, hole depth, explosive type and quantity. The cost of developing this technique shall be included in the unit prices stated in the Bill of Quantities for excavation in rock in the area where such pre-splitting will be required.

T2.3.4 Safety programme for handling explosives and blasting

A detailed safety programme covering all aspects of handling explosives and carrying out blasting operations shall be prepared and submitted by the Contractor to the PMO/Engineer for approval at least sixty (60) days prior to the time the Contractor brings any explosives to the Site.

This shall include but is not limited to the location and design of powder magazines, methods of transporting explosives, use of explosives, and in general precautions taken to prevent accidents relating to explosives and blasting. After being approved, the Contractor shall submit twelve (12) copies of the safety program for handling explosives and blasting to the PMO/Engineer.

T2.4 Open-Cut Excavation

T2.4.1 General

All open-cut excavation for structures shall be executed as specified in this Clause and to the lines, slopes and dimensions as shown on the Drawings or as directed by the PMO/Engineer. Such excavation shall include but not be limited to, main dam, spillway, intake and ditches. During the progress of the work, it may be found necessary or desirable to alter the depth, the slopes or the dimensions from those shown on the Drawings. Any increase or decrease of quantities excavated as a result of such alteration or causes beyond the control of the Contractor will be included in the measurement for payment, provided that the unit prices stated in the Bill of Quantities for excavation shall not be adjusted. Any other excavation performed at the option of the Contractor to secure access to the required work, for disposal of excavated material or for any other purpose shall be within the limits approved by the PMO/Engineer and shall be at the Contractor's expense.

All necessary precautions shall be taken to preserve the material below and beyond the established lines of all excavation in the soundest possible condition. Unless otherwise determined by the PMO/Engineer, any and all over-excavation performed by the Contractor except as may be ordered in writing by the PMO Engineer, is unauthorized excavation and shall be at the expense of the Contractor.

All unauthorized excavation including over-excavation shall be backfilled with Class "E" concrete or other materials, as directed by the PMO/Engineer, at the expense of and by the Contractor: however, the Employer will pay the Contractor for such backfill to refill any over-excavation in overbreak due to the specific nature of the rock, and not due to the Contractor's action or fault, as determined by the PMO/Engineer. Payment for such backfill will be made at the applicable unit prices stated in the Bill of Quantities.

All excavations for structure foundations shall be performed in the dry. No additional allowance above the unit prices stated in the Bill of Quantities for excavation will be made an account of any of the materials being wet.

All blasting and handling of explosive shall conform to the Specifications listed in Clause T2.3 of this CHAPTER.

Excavation shall be made to the full dimensions required and shall be finished to the prescribed lines and grades, except that individual sharp points of undisturbed ledge rock will be permitted to remain within the prescribed lines not more than twenty (20) centimeters where the surface to not to

be covered with concrete. If the surface is to be covered by concrete, it must be generally level as determined by the PMO/Engineer.

Except as specifically shown on the Drawings or as otherwise directed by the PMO/Engineer, required open-cut excavation will be measured, for payment, to the slopes defined below:

	Material	Permanent Coasted	Permanent Exposed	Temporary cut
1)	Fresh rock	1:0.5	-	1:0.15 - 1:0.3
2)	Weathered rock	1:0.8	-	1:0.5
3)	Earth, talus	1:1.0 - 1.3	-	1:0.8 ; H ≤ 15m
	Earth, talus	1:1.0 - 1.3	-	1:1.0 ; H > 15m

The exposed slopes of the required excavation shall be protected by the Contractor. A berm one point five (1.5) m wide without ditch or two (2) m wide with ditch shall be provided at every seven point five (7.5) m high interval in cut slope.

Where required and when directed by the PMO/Engineer, the Contractor shall excavate open, unlined drains to direct surface water away from open cuts. The entire cost of this work shall be at expense of the Contractor except where such drains form part of the permanent works, in which case payment for excavation will be made at the applicable unit prices stated in the Bill of Quantities.

In all work related to open cut excavation, the Contractor shall carry out soil conservation measures to the satisfaction of the PMO/Engineer and the costs for such work shall be included in the unit prices of excavation stated in the Bill of Quantities.

T2.4.2 Classification of excavation material

Except as otherwise specified in these Specifications, open-cut excavation will be classified for measurement and payment as follows:

(1) Rock

Rock is sound and intact rock in place that cannot be excavated without drilling and blasting as determined by the PMO/Engineer.

(2) Weathered rock

Weathered rock is disintegrated rock by weathering that can be excavated efficiently after loosening by ripping or the use of power tools without drilling and blasting as determined by the PMO/Engineer.

(3) Common

Common is all material other than rock and weathered rock including, but not limited to, clay, silt, sand, solid rock/gravel not exceeding 1.0 m^3 in volume, and mixtures thereof with gravel and boulders as determined by the PMO/Engineer. Solid rock exceeding 1.0 m^3 in volume is classified as rock. The Contractor shall prepare survey maps of the stripped area, and submit them to the PMO/Engineer for his approval, before commencing excavation.

When the Contractor observes the boundary lines between weathered rock and common, and rock and weathered rock, as defined above during the excavation work, the Contractor shall prepare and submit the survey maps to the PMO/Engineer for his approval in advance of weathered rock excavation and rock excavation, respectively. The Contractor shall also prepare and submit to the PMO/Engineer for his approval the survey maps for the original ground lines the final excavation lines actually excavated. These surveys shall be performed in the presence of the PMO/Engineer, and be the basis of quantities for claim for payment. The Contractor shall notify the PMO/Engineer of his intention to undertake such surveys.

T2.4.3 Seams and other defects

The exploratory investigations of the foundations and excavation slopes cannot possibly disclose all seams and other defects which may exist. It is anticipated that there may be depressions, faults, seams, and bands of soft rock including disintegrating rock running in various directions in the foundations and excavation slopes.

Where such defects occur below the general surface of excavation, they shall be corrected by local excavation to the lines, depths and dimensions as directed by the PMO/Engineer. These local excavations shall be solidly backfilled with class "E" concrete or other materials as directed by the PMO/Engineer. Payment for such excavations and backfill will be made at the applicable unit prices stated in the Bill of Quantities for excavation in open-cut, concrete, etc.

T2.4.4 Execution of work

(1) General

Working schedule with explanatory reports for open-cut excavation shall be submitted prior to the commencement of the work for the approval of the PMO/Engineer. The schedule shall include the quantity, type and capacity of the equipment, working method envisaged, transportation and distribution of excavated material, location of temporarily stockpile or disposal area as well as labour deployment, etc. The schedule and any amendment thereto shall be subject to the PMO/Engineer's approval.

(2) Safety measures

The Contractor shall be responsible for all necessary safety measures and follow the safety regulations.

Proper strutting, sheeting and bracing including rearrangement of the installations, protection of slopes and appropriate measures to ensure the safety during the work shall be provided by the Contractor. The cost thereof shall be included in the unit prices stated in the Bill of Quantities to which the work is incidental.

(3) Over-excavation

All necessary precaution shall be taken to preserve the material below and beyond the establish lines of all excavation in the soundest possible condition. Unless otherwise ordered in writing by the PMO/Engineer, any and all over-excavation performed by the Contractor for any purpose or reason is unauthorized excavation and shall be at the expense of the Contractor.

Where required to complete the work, all unauthorized excavation shall be backfilled, as directed by the PMO/Engineer, at the expense of the Contractor. Slopes shattered or loosened by blasting shall be removed at the expense of the Contractor.

(4) Protection of excavated surfaces

The excavated surfaces on or against which concrete is to be placed shall be protected by leaving a temporary cover of 30 cm of unexcavated material, if it is deemed necessary in the opinion of the PMO/Engineer. The final 30 cm excavation shall be made by continuous operation within a specified time to be determined by the PMO/Engineer. Such excavation

shall be followed without delay by backfilling of fill material, by application of protective coatings, or by placement of structural or backfill concrete as shown on the Drawings or as directed by the PMO/Engineer. No additional allowance above the unit prices stated in the Bill of Quantities for excavation shall be made on account of leaving the temporary cover of unexcavated material.

Where and when directed by the PMO/Engineer, the Contractor shall place protective coatings of shotcrete on excavated surfaces on which concrete is to be placed. The Contractor shall not perform excavation, when directed by the PMO/Engineer, within the final 30 cm of finished surfaces in areas which will require protective coatings until all equipment and facilities required for immediate application of protective coatings are available and in working condition. Coatings shall be as provided in Clause T4.2.

Planking and strutting necessary to retain the sides of the excavations shall be provided, erected and maintained in a safe condition by the Contractor. No separate payment will be made for planking and strutting.

(5) Excavation for structure foundation

The bottom and side slopes of excavation for foundations upon or against which concrete is to be placed shall be excavated to the required grades, lines and dimensions as shown on the Drawings or directed by the PMO/Engineer. No material will be permitted to extend within the neat lines of the structure.

The PMO/Engineer will have the right to decide whether the foundation excavation indicated in the Drawings is sufficient, or whether deeper foundations are necessary. This decision will be final and binding on the Contractor. If, at any point in the excavation, upon written orders of the PMO/Engineer, material is excavated beyond the limits required to receive the structure, the additional excavation shall be filled solidly with concrete, or as directed by the PMO/Engineer. Payment for concrete placed in such additional excavation will be made at the appropriate unit price stated in the Bill of Quantities for concrete. Excess excavation and over-excavation performed by the Contractor for any purpose or reason without written orders of the PMO/Engineer shall be refilled with concrete by the Contractor at his own expense.

T2.4.5 Stockpiling and disposal

Suitable material from excavation, as decided by the PMO/Engineer, shall be used for the Works. These material shall be directly transported and placed at the designated final location if practicable, or shall be placed in temporary stockpiles upon the PMO/Engineer's approval. Location of stock pile will be as approved by the PMO/Engineer. Such material actually placed in the completed construction will be included for payment under appropriate items in the Bill of Quantities covering such construction.

The Contractor shall protect all temporary stockpiles against erosion or slide of slope by the construction of drains, drop structures, revetments or any other structure. The Contractor shall not be entitled to additional allowance above the unit prices stated in the Bill of Quantities on account of the requirement to control erosion or slide of the slope.

Excavated material which are unsuitable or not required for permanent construction shall be disposed in the disposal area as approved by the PMO/Engineer. Such material shall be disposed in a horizontal layer not exceeding 0.5 m in thickness to receive appropriate compaction. Unless otherwise approved by the PMO/Engineer, the finished outer slopes of the disposed material shall not be steeper than 1 vertical to 3 horizontal and shall be covered with strip sodding or other approved means.

The Contractor shall grade the top surface of all material placed within the disposal area and shall construct permanent drains and other protective works sufficient to ensure that surface runoff will not erode the slopes of all material placed therein.

The cost of disposing excavated material and the cost to form disposal areas to the satisfaction of the PMO/Engineer shall be included in the unit prices stated in the Bill of Quantities for the various items of work for excavation.

Location changes or additions of disposal areas for the Contractor's own convenience shall be subject to the approval of the PMO/Engineer and relevant authorities, and made at the expense of the Contractor.

T2.4.6 Measurement and payment

Measurement for payment of open-cut excavation of each class of materials shall be made to the lines, grades and dimensions shown on the Drawings or as directed by the PMO/Engineer.

Quantities shall be calculated from the survey maps mentioned in sub-clause T2.4.2 (3) by the following standard procedures approved by the PMO/Engineer.

Payment for open-cut excavation will be made at the unit price per cubic meters stated in the Bill of Quantities, which unit prices shall include the cost of all labour, equipment, and materials for excavation, slide prevention, erosion control and other work necessary to maintain the excavation in good order during construction. For payment, no distinction will be made as to whether the material excavated is dry, moist, or wet.

These unit prices shall also include the entire cost of transporting the materials from the excavation to the point of final use, and where stockpiles are used, the unit prices shall include the entire cost of transporting the materials to the stockpiles, rehandling and transporting such material to the point of final use; and the entire cost of cleaning up excavated surfaces and the areas where excavated materials had been stored before re-use by the Contractor.

The unit prices shall also include the cost of hauling unsuitable excavated materials, as per sub-clause T2.4.5, up to the top of gorge from the place of excavation. The cost of transporting unsuitable excavated materials from the top of gorge to the disposal area shall not be included in the unit prices. The above transportation cost will be payable for the actual distance in accordance with the rate quoted in Schedule 7 of the Schedule of Particulars.

T2.4.7 Trench excavation

The item in the Bill of Quantities for the trench excavation in various classes of material shall include excavation for all types of trenches as shown on the Drawings or as directed by the PMO/Engineer consisting of the following items but not limited to:

a) Trenches for concrete pipe, cross drains, drain pits and side drain ditch for permanent access road
b) Trench for foundation for the inspection gallery in the dam embankment
c) Trenches for pipe drains beneath the chuteway of the spillway
d) Trenches for cut-offs under the spillway overflow weir
e) Trenches for drain ditches around the control houses including cable trough and pit around the control houses
f) Trenches as may be shown elsewhere on the Drawings or as directed by the PMO/Engineer

Trench excavation shall be performed by the use of hand tools and/or approved mechanical equipment, in such a manner as to prevent shattering of the sides and bottom of the excavation. At the option and risk of the Contractor, with the approval of the PMO/Engineer, line drilled holes and light blasting may be employed in approved locations, in which case the Specifications listed in Clause T2.3 shall be complied with.

All planking, strutting and supports necessary to retain the sides of the trench excavation shall be provided, erected and maintained in a safe condition by the Contractor.

Trench excavation shall conform to the applicable stipulations of Clause T2.4.

Measurement for payment of each class of material of trench excavation will be made to the prescribed dimensions and to the depth of excavation, as shown on the Drawings or as directed by the PMO/Engineer.

Payment for the various classes of trench excavation shall be made at the unit prices per cubic meter stated in the Bill of Quantities, in accordance with the provisions of sub-clause T2.4.6.

T2.5 Underground Excavation

T2.5.1 General

Relevant portions from Clause T2.4 shall apply to underground excavation also, except as to otherwise specified hereunder. The term "underground excavation" means all required excavation performed by methods for shafts and other underground structures other than open-cut excavation.

Prior to underground excavation, the Contractor shall outline the arrangement of machines, equipment and facilities, the system of excavation and hauling, and the progress schedule, in due consideration of the condition of geology, climate and prescribed construction period, and the plan so laid down shall be subject to the approval of the PMO/Engineer.

T2.5.2 Design section

Underground excavation shall be made to the lines shown on the Drawings or established by the PMO/Engineer.

The A-lines shown on the sections on the Drawings are lines within which no material of any kind and no support other than permanent steel support will be permitted to remain. In the use of

permanent steel support, the inside face of the support will be allowed to project from the A-line equal to or less than 7.5 cm.

The B-lines are the outside limits to which measurement for payment of excavation and concrete will be made, and measurement for payment will in all cases be made to the B-lines regardless of whether the limits of the actual excavation fall inside or outside of the B-lines.

The application of each type of section shown on the Drawings for underground excavation is only indicative, and will be determined by the PMO/Engineer according to the geological condition at the Site during the progress of the work.

The PMO/Engineer will determine to increase or decrease the distance between the A-line and the interior finish surface of concrete lining for certain stretches of underground structure, if he thinks necessary to do so. In such event the position of the B-line shall be moved in such a manner that at every point the distance between the A and B-lines will remain unchanged. Such change of quantities resulting from increasing or decreasing of the distance between the A-line and the interior finish surface of concrete lining will be included in the measurement for payment, provided that the unit prices stated in the Bill of Quantities for excavation and concrete shall not be adjusted.

T2.5.3 Excavation procedure

Proper excavation procedures shall be adopted to suit the design section to be accommodated, the material to be excavated and the conditions to be encountered.

During the excavation work, the Contractor shall, at his full responsibility, maintain the lines shown on the Drawings by accurate surveying as approved by the PMO/Engineer.

All drilling and blasting shall be carefully performed so that the finished excavated surface will not be loosened or shattered. Unless otherwise determined by the PMO/Engineer, all excavation beyond the B-lines shall be completely filled with concrete entirely at the Contractor's expense.

The drill holes shall be exactly located by scaling the design section on the heading face by surveying, showing accurately the direction and figure of excavation.

With proper drainage, ventilation and lighting system, the Contractor shall perform the work efficiently and safely, taking into consideration the method and sequence of supports and concrete lining.

Complete sections of excavation shall be subject to the inspection of the PMO/Engineer before lining concrete is placed.

Stockpiling and disposal of excavated material shall conform to the requirements of sub-clause of T2.4.5.

T2.5.4 Steel support

(1) General

Permanent steel support shall be used to support the roof and sides of the underground excavation as required or determined by the PMO/Engineer.

Permanent steel supports completed with all bolts, tie rods, foot plates and other accessories required for assembling the supports and supporting them in place until the lining concrete is placed shall be furnished by the Contractor.

Temporary steel supports that are not required to be in place as the permanent work shall be removed unless such removal is judged impracticable by the PMO/Engineer.

Type and size of steel support for permanent or temporary shall be as shown on the Drawings. However, the Contractor may propose alternation for them. In that case, type and size of the steel supports, of alternation, its miscellaneous details, location and spacing shall be submitted to the PMO/Engineer for approval. The clear distance between the flanges of the installed supports shall not be less than 30 cm unless otherwise approved by the PMO/Engineer.

(2) Installation

The steel supports shall be installed to the proper lines and grades and shall be maintained by the Contractor in the proper condition and alignment until the lining concrete is placed about them. The Contractor shall securely brace the supports with tie rods and collar braces and the minimum practicable amount of blocking and wedges. Any steel support installed improperly or damaged by the Contractor's operation shall be adjusted or repaired or replaced to the satisfaction of the PMO/Engineer within 24 hours after notification of the PMO/Engineer.

The Contractor may, to facilitate his operation, place permanent steel support at a greater distance from the inside finishing surface of concrete lining than shown on the Drawings or prescribed by the PMO/Engineer, provided that any increase in quantity of steel supports and any excavation and concrete lining outside the B-lines required thereby shall be at the expense of the Contractor.

Permanent steel supports required for the sections not shown on the Drawings shall be in accordance with designs submitted by the Contractor and approved by the PMO/Engineer

Temporary timber collar braces shall be furnished and installed by the Contractor where required and shall be removed before placement of lining concrete unless such removal is judged impracticable by the PMO/Engineer.

T2.5.5 Temporary support

Temporary support including bracing shall be provided for excavations where necessary until permanent support is installed, for temporary excavations such as tunnel drifts, and as may be otherwise required for construction purposes. Supports that are not required to remain in place and can be removed, in the opinion of the PMO/Engineer, shall be removed. Supports in good condition may be reused. Suitable temporary timber may be used to support the roof and sides of the tunnels and shaft. Such temporary timbering shall be removed by the Contractor before concrete lining is placed and every precautions shall be exercised as to timing and extent of removal to prevent an accident.

Temporary steel supports shall conform to the requirements specified hereinbefore for permanent supports or other requirements approved by the PMO/Engineer. When the Contractor's measure for removal of such temporary timbering are unsuitable by the PMO/Engineer, the PMO/Engineer may order the Contractor to suspend the work and the Contractor shall be subject to the direction of the PMO/Engineer. The material for temporary timbering shall be always stocked enough to meet the emergency demand.

T2.5.6 Measurement and payment

(1) Underground excavation

Measurement for payment of underground excavation will be made of the volume determined by the specified sectional dimensions within the B-lines as prescribed in sub-clause T2.5.2.

Payment for underground excavation will be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all labour, equipment and materials for excavation, including the cost of drainage, ventilation, lighting, transportation and disposal of excavated material, and maintaining the excavation in satisfactory condition until the lining concrete is placed. Relevant portions of sub-clause T2.4.6 shall apply for transportation of unsuitable excavated material.

(2) Permanent steel support

Measurement for payment of permanent steel support will be made of the weight of main steel supports actually installed excluding all accessories.

Payment for permanent steel support will be made at the unit prices per ton stated in the Bill of Quantities, which prices shall include the cost of all labour and materials for cutting, bending assembly and installation of the supports and supporting them in place until the concrete is placed, and all other items including accessories necessary to complete the work.

T2.5.7 Disposal or use of materials from excavation

(1) General

The Contractor shall dispose of excavated materials, which are unsuitable for or which are not required for construction, in the spoil bank shown on the Drawings or elsewhere as approved by the PMO/Engineer. Suitable materials from various excavation shall be used in the Works.

The suitability of material obtained from the required excavation will be determined by the PMO/Engineer.

(2) Spoil bank

Unsuitable materials or not required materials from the required excavation shall be hauled to and placed at the designated spoil banks or elsewhere approved by the PMO/Engineer. The Contractor shall grade the top surface of all spoil banks and shall provide drains and other protective works suficient to ensure that surface runoff will not erode the surface of spoil banks and so as not to interfere with the operation of any facilities during the construction period. The spoil banks located without the reservoir area shall be levelled

and trimmed to the regular lines and provided with permanent drains and other protective works to produce sightly appearance and stable permanente embankment.

No separate payment shall be made for disposal of excavated material. The entire cost of hauling, spreading and grading of the materials removed in excavation and providing surface protection works shall be included in the unit prices stated in the Bill of Quantities for the various items of excavation.

(3) Use of excavated materials

Suitable materials as determined by the PMO/Engineer shall be used in the Works. Such suitable material shall be segregated by loads during the excavation and shall be placed at the designated final location in the Works or shall be placed in the designated stockpiles or elsewhere approved by the PMO/Engineer and later placed or processed and placed, at the designated final location in the Works.

Stockpiles shall be constructed in the same manner as stipulated in paragraph (2) of above.

If, by reason of the Contractor's not using all material from required excavation which is suitable and required for the Works, it is necessary to obtain material from other sources, the Contractor shall obtain, at his own expenses, a quantity of material equal to the quantity of suitable material from required excavation wasted by him, as determined by the PMO/Engineer.

No separate payment for hauling of the excavated materials to the Works or to the stockpiles and for construction of stockpiles shall be made.
The entire cost of hauling of the material removed in excavation to the Works or of hauling and placing of it in the stockpile, including providing of drains and other necessary protecting works, for use as embankment material, backfill or roadway material, shall be included in the unit prices stated in the Bill of Quantities for the various items of excavation.
However, such materials actually placed in the Works will be included for payment under appropriated items stated in the Bill of Quantities covering such construction.

T2.6 Embankment

T2.6.1 General

The largest part of the embankment work to be performed will be for constructing the main dam and cofferdam: however, there is also some embankment work in road construction, the specifications for which are mainly listed in CHAPTER T5. It should be understood that regardless of where the embankment work may be performed, the parts of this CHAPTER which supply to such work shall be adhered to.

For the purpose of these Specifications, the term "dam" means the main dam together with the cofferdam.

The following are lists of the various types of materials to be used for the main dam and cofferdam.

(1) Main dam:

(a)	Impervious core zone	(Zone 1)
(b)	Fine filter zone	(Zone 2)
(c)	Coarse filter zone	(Zone 3)
(d)	Rock zone	(Zone 4)
(e)	Riprap zone	(Zone 5)

(2) Upstream main cofferdam

(a)	Impervious Core zone	(Zone 1)
(b)	Fine filter zone	(Zone 2)
(c)	Rock zone	(Zone 4)

The Contractor shall, thirty (30) days before starting the embankment work, submit to the PMO/Engineer for approval a plan for placing the embankments for the dam, taking into account other related works such as the construction of the spillway, tunnels, etc.

The dam embankment shall be constructed to the lines, grades and dimensions shown on the Drawings; provided that the division lines between the various zones shall be subject to variation, at any time prior to or during construction, and the Contractor shall be entitled to no additional allowance above the unit prices stated in the Bill of Quantities by reason of such variation. In case where such variation will exceed more than 30 per cent of the volume stated in the Bill of

Quantities, adjustment will be made in the unit price stated in the Bill of Quantities based on negotiations between the PMO/Engineer and the Contractor.

No brush, roots, rod or other unsuitable material shall be placed in the embankments. The suitability of each part of the foundation for placing embankment material thereon and of all material for use in embankment construction will be determined by the PMO/Engineer. No embankment shall be placed on a prepared foundation surface until approved by the PMO/Engineer. The method of loading and hauling embankment material shall be at the discretion of the Contractor, as approved by the PMO/Engineer.

A part of the material to be excavated from spillway, dam, etc, will also be used for the dam embankment. It may be however that some of the excavated material is of an unsuitable quality so that it may not be used in permanent construction, and such material shall be hauled and disposed at the spoil banks as shown on the Drawings or as directed by the PMO/Engineer.

The Contractor shall maintain the embankments in an approved manner until final completion and acceptance of the Work. The Contractor shall be responsible for erosion control of the embankment surface and any embankment material lost by erosion shall be replaced by and at the expense of the Contractor.

Openings of any type made in the embankments during construction (for installing instruments, etc.) shall be subject to approval by the PMO/Engineer and such openings, if approved, shall be constructed so that the slope of the bonding surface between in place and embankment to be placed are not steeper than two horizontal to one vertical for the impervious core zone (Zone 1), fine filter zone (Zone 2) and coarse filter (Zone 3); and one and half horizontal to one vertical for the rock zone (Zone 4).

The bonding surface of the embankments shall be scarified and prepared to the satisfaction of the PMO/Engineer.

Trial embankment of material to be used in constructing the dam embankment shall be made in accordance with the stipulations of sub-clause T2.6.6. Tests on embankment materials shall also be made in accordance with the stipulations of sub-clauseT2.6.7.

The PMO/Engineer reserves the right to make adjustments to the specified gradation, moisture content, density, placing and compaction requirements for the various types of embankment as he

deems necessary and in such cases no adjustment will be made to the unit prices stated in the Bill of Quantities.

Each load of the material which is to be placed in the embankment, regardless of its source, shall be placed in the locations approved by the PMO/Engineer and the Contractor shall be entitled to no additional allowance above the unit prices stated in the Bill of Quantities on account of this requirement. All portions of the embankment will be measured and paid for an "in place" basis after being compacted, where compacting is required.

Embankment materials shall not encroach into adjacent zones further than allowed by the following tolerances measured perpendicular to the dam axis (in a horizontal plane) from the division line shown on the Drawings or as adjusted by the PMO/Engineer:

	Zone	Towards the former zone (m)	Towards the latter zone (m)
(1)	Between the impervious core zone (Zone 1) and fine filter zone (Zone 2)	0	0.5
(2)	Between the fine filter zone (Zone 2) and coarse filter zone (Zone 3) or rock zone (Zone 4)	0.5	0.5
(3)	Between the coarse filter zone (Zone 3) and rock zone (Zone 4)	0.5	1.0

Note: Measurement, for payment, of embankment materials will be made to the lines shown on the Drawings or as adjusted by the PMO/Engineer notwithstanding any variations from these lines as followed by the tolerances specified herein.

Except as approved by the PMO/Engineer, the differential height between adjacent zones of the dam measured at the division line between zones shall be maintained within the following limits:

(1)	Elevation of Zone 2 above Zone 1	plus	.....	60 cm
		minus	.....	zero
(2)	Elevation of Zone 2 above adjacent Zones 3 and/or 4	plus	.....	40 cm
		minus	.....	zero

Except as may otherwise be provided in the specifications or approved by the PMO/Engineer, portions of the embankments constructed to a higher level than the general level of the zone or embankment shall be constructed to the same general height from abutment to abutment.

The PMO/Engineer may order the suspension other embankment work when he judges it necessary to discontinue the work because of low quality pertaining to any part of the work, equipment, material, labor and efficiency, or because of unfavorable climatic conditions. The Contractor shall be entitled to no additional compensation above the unit prices stated in the Bill of Quantities by reason of it being necessary to discontinue the work as determined by the PMO/Engineer.

If work is stopped on any section of Zone 1 of the embankments on account of rain or impending rain, the surface shall be sloped and smoothed to facilitate drainage. Before work is resumed, the surface shall be scarified and the moisture content conditioned in accordance with the Specifications.

If, during or after placement, material in any zone has become contaminated with material from another zone or with soil or other objectionable material from the passage of construction machinery or by any other means, the contaminated material shall be entirely removed, and the Contractor shall not be entitled to any additional compensation above the unit prices stated in the Bill of Quantities for construction of, or placing and compaction of materials in, the zone by reason of this requirement.

The details of the Contractor's procedures for compacting the embankment materials shall be determined at the site by the PMO/Engineer. Compaction of each layer of the embankment materials shall proceed in a systematic, orderly and continuous manner approved by the PMO/Engineer, such as to ensure that each portion of the layer receives the compaction specified. The compaction shall be carried out by routing the compaction equipment parallel to the axis of the dam, except where such routing is impracticable such as in roller turning areas, in areas adjacent to the abutments or areas where otherwise authorized by the PMO/Engineer. Should the surface of the embankment materials become rutted or uneven subsequent to the compaction, it shall be re-levelled before the next layer of fill is placed, and, if required by the PMO/Engineer, recompacted by the Contractor at no additional expense to the Employer.

The types of equipment required for compaction of the embankment materials are to be as specified herein; however, the Contractor may propose other types. Use of alternative types of compaction equipment will be considered for approval provided that tests carried out by the Contractor on site, and at his expense, show that satisfactory compaction and other requirements meeting the provision of these Specifications can be obtained. Such tests shall be carried out simulating normal construction conditions using all equipment and methods proposed for placing and compacting the material. In submitting his proposal, the Contractor shall supply all details of the compaction

equipment including its previous use on similar work and shall state any advantages in time and cost to the Employer in adopting the Contractor's proposal.

The Contractor shall not be entitled to any additional compensation above the unit prices stated in the Bill of Quantities if it is necessary or required by the PMO/Engineer, for any reason, that material used for embankment construction be deposited in stockpiles prior to being placed in the embankment.

Temporary ramps for construction purposes will be permitted on the outside face of the dam embankment provided that:

(1) The locations of ramps shall be approved by the PMO/Engineer prior to constructing the ramps.

(2) The ramps are build with pervious material.

For material to be placed adjacent to concrete structures, the placement shall be deferred until the structures have attained an age of 7 to 28 days as directed by the PMO/Engineer. The material shall then be placed, insofar as possible, evenly around the concrete structures to minimize unbalanced loading on the structures which may not have been contemplated by the design.

Compaction by the approved roller shall not be allowed until the foundation of rock and concrete structure are covered with not less than 50cm thickness of respective materials which be compacted by means of hand tool and man-power or by using light equipment approved by the PMO/Engineer, as stipulated in sub-clause T2.6.2 (1) for Zone 1, unless otherwise directed by the PMO/Engineer.

The Contractor shall take special care not to injure the foundation rocks in Zone 1 or concrete structures in compacting dam embankment materials adjacent to them. Any damage caused to any concrete structure by the Contractor's equipment shall be repaired at the Contractor's expense of and by the Contractor.

T2.6.2 Impervious core zone (Zone 1) for dam embankment

(1) General

The impervious core zone (Zone 1) for the main dam and the main cofferdam shall be constructed in accordance with this sub-clause and other applicable specifications.

(2) Preparation of the foundation for the main dam

No materials shall be placed in any section of the impervious core zone of the main dam until the foundation for that section has been completely excavated, dewatered and suitably prepared, as approved by the PMO/Engineer. All portions of excavations which may be made for test pits or other subsurface investigations and all other existing cavities, fissures, and irregularities found within the main dam which extend below or beyond the established lines of excavation for the dam foundation, shall be filled with Zone 1 material and compacted as specified herein for the core zone of the main dam, or with concrete backfill (dental work) or as directed by the PMO/Engineer, and payment therefor will be made as provided in the appropriate items stated in the Bill of Quantities. Other applicable details concerning the preparation of the foundation, as listed in this Chapter of these Specifications shall be complied with. Excavation of the rock foundation shall be limited to a depth 30cm above the required formation so as to prevent the sides and bottom of the foundation from shattering due to overly exposing to weathering. Immediately before placing the core zone (Zone 1), the rock foundation shall be excavated completely to the required formation by the use of hand tools or other approved method in such manner as to prevent shattering of the surface of foundation.

Surfaces upon or against which the Zone 1 portions of the dam embankment are to be placed shall be cleared of all loose and objectionable materials in an approved manner by hand work or other effective means before placing the first layer of the Zone 1 material. Immediately before placing the impervious core material, any standing water shall be removed from depressions and the entire surface area of the foundation shall be properly moistened and sufficiently treated to obtain a suitable bond with the Zone 1 material which is to be placed.

A layer of special Zone 1 material which is to be 30cm thick after compaction as measured perpendicular to the formation foundation, shall be placed and compacted as specified in paragraph (7) of this sub-clause.

(3) Gradation of Zone 1 material

The impervious core zone material (Zone 1) shall be of excavated material from the borrow area as shown on the Drawings, unless otherwise directed by the PMO/Engineer. The gradation for this material is to be as follows:

(i) The maximum particle size shall be fifteen (15) cm.

(ii) The material shall contain minus No. 200 sieve (0.074mm sieve) more than fifteen (15) % and plus No.4 sieve (4.76mm) less than fifty (50) %.

The gradation limit of this material is shown on the Drawings.

(4) Moisture control and density

The moisture content of the Zone 1 material prior to and during compaction shall be maintained uniformly throughout each layer of the material. The allowable range of the moisture content of the material to be placed is based on design considerations. For the purposes of work on this project, the optimum moisture content is generally defined as "the moisture content which will result in the maximum dry density of the materials to be obtained from the borrow area or other areas as may be designated by the PMO/Engineer".

Unless otherwise approved or directed by the PMO/Engineer, the moisture content of the Zone 1 material shall be, during and after compaction, within the rage between the optimum moisture content and plus three (3) % of the optimum moisture content, and the fill dry density shall not be less than ninety-five (95) % of the maximum dry density under the Standard Proctor Compaction Effort. The fill moisture content and the optimum moisture content of the Zone 1 material will be determined by the PMO/Engineer from random selected samples. If the moisture content as determined from the samples does not fall within the required limits, the Contractor shall treat the material in such a manner that the moisture content is brought within the required limits as verified by a further series of tests.

The PMO/Engineer reserves the right to adjust the permissible moisture content limits based on information obtained from trial embankment and/or actual construction, and in such case no change will be made in the unit price per cubic meter of Zone 1 stated in the Bill of Quantities.

As detailed in sub-clause T2.6.2, prior to the removal of the Zone 1 material from the borrow area, the moisture content of the material shall be brought to the required level at the area and the material shall be hauled directly to the embankment site and placed; however, if the PMO/Engineer determines that the moisture content of the material in the borrow area is of a satisfactory level, permission may be granted to the Contractor to excavate the material at the borrow area and haul it directly to the embankment site for placing and compaction.

As far as practicable, the Zone 1 material shall be brought to the proper moisture content prior to it being delivered at the embankment site. If approved by the PMO/Engineer,

supplementary water not to exceed three (3) % of dry weight of material, may be added by sprinkling or other means to ensure uniformity of the moisture content. On the other hand, if the surface of any layer of Zone 1 material is too wet for proper compaction and bonding of the layer of material to be placed thereon, it shall be dried by worked with a harrow, scarifier or other suitable equipment to reduce the moisture content to the required amount and then recompacted. If the Zone 1 material cannot be brought to the specified moisture content, it shall be removed and replaced with suitable material.

It is the Contractor's responsibility to obtain the specified moisture content of the Zone 1 material in accordance with a method proposed by him which in turn has been approved by the PMO/Engineer.

(5) Placing

The distribution and gradation of the material placed shall be such that the layers will be free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation or moisture from the surrounding material. The combined excavation and placing operations shall be such that the material, when compacted, will provide the best practicable degree of compaction and stability.

The material shall be placed in continuous, approximately horizontal layers not more than thirty (30) cm in thickness before being compacted.

Successive loads of material shall be placed so as to produce the best practicable distribution of the material subject to the approval of the PMO/Engineer, and when necessary to achieve this purpose the PMO/Engineer may designate the locations in the embankment area where the individual loads shall be deposited.

Pieces of rock having maximum dimensions of more than fifteen (15) cm shall not be placed in the embankment. Should pieces larger than 15cm be found in otherwise approved material, they shall be removed by the Contractor before the material is compacted. Should pockets of gravel or rock be found around concrete structures, boundaries of the zones, abutments, or other places, they shall be removed so as to prevent possible piping along the contact surface.

Adequate slopes for drainage shall be provided before or during rainfall in the area being filled.

(6) Regular compaction

When each layer of material has been conditioned to have the required moisture content, it shall be compacted to at least ninety-five (95) % of the maximum dry density by means of a towed or self-propelled tamping roller or pneumatic tire roller or equivalent. This of 30 metric ton class self propelled will be accomplished by passing the tamping roller approximately eight (8) times over each strip (equal in width to the length of the roller's drum or tire) of the layer until the entire width of the zone's layer has been compacted to the required density, provided that when compacted the density shall be essentially uniform throughout the layer.

The actual number of passes required for the roller shall be determined based on the trial embankment to be constructed as stipulated in sub-clause T2.6.6 herein. As such, the PMO/Engineer will vary the number of roller passes depending on the results of the trial embankment and no adjustment will be made in the unit price stated in the Bill of Quantities in the event there is an increase or reduction in the number of passes. In addition, the PMO/Engineer will make tests as specified in sub-clause T2.6.7 herein to determine whether the required density is being obtained.

The specific type of tamping roller or pneumatic tire roller or equivalent proposed to be used by the Contractor shall be approved by the PMO/Engineer.

The loading, operation and speed of travel of the rollers shall be such as required to obtain the desired compaction. If more than one roller is used on any one layer, all rollers so used shall be of the same type and essentially of the same dimensions. Tractors used for pulling rollers shall have sufficient power to pull the rollers satisfactorily when the drums or tires are fully loaded. During the operation of rolling, the Contractor shall keep the spaces between the ends of the tamping feet or tire and the surface of the drum or tire clear of accumulated soil which would impair the effectiveness of the rollers or tires.

If, in the opinion of the PMO/Engineer, the rolled surface of a layer of material is too dry or smooth to bond properly with the layer of material to be placed thereon, it shall be moistened and/or worked with a harrow, scarifier, or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer of material is placed. If, in the opinion of the PMO/Engineer, the rolled surface of a layer of material in place is too wet for proper compaction of the layer of material to be placed thereon, it shall be removed and dried or be worked in place with a

harrow, scarifier, or other suitable equipment to reduce the moisture content to the required amount. It then shall be recompacted before the next succeeding layer of material is placed.

(7) Special compaction of Zone 1 material for main dam foundation

Material shall be selected from the finer more plastic material in the borrow area as directed by the PMO/Engineer, for the purpose of being placed and specially completed in a thirty (30) cm layer over the surface of the main dam foundation (including both abutments) and around the inspection gallery and spillway structures.

The material shall be deposited in approximately horizontal layers not more than ten (10) cm in thickness when compacted unless otherwise approved by the PMO/Engineer. It shall have a moisture content range of plus three (3) to plus six (6) % of the optimum moisture content and as such it will be wetter than that specified for the other Zone 1 material to be placed in the dam embankment. The material shall be compacted by hand-held mechanical tampers, or other approved means in such a manner that it is forced into all irregularities of the foundation surfaces and so that it is properly compacted against the concrete structures.

When material is being placed against the foundation's inclined surfaces it shall be sloped away from the foundation for a distance of at least two (2) m at an inclination of one (1) vertical to six (6) horizontal or steeper to allow for direct compaction of the material against the foundation's inclined surfaces. If, because of small irregularities in the foundation, compaction of Zone 1 material by means of hand-held mechanical tampers is impracticable or undesirable, such material shall be specially compacted as directed by the PMO/Engineer; however, no adjustment in the unit price shall be made on account of any such operation.

(8) Measurement and payment

Measurement, for payment, of the Zone 1 material (as specified in paragraphs (6) and (7) herein) in the dam embankment shall be made of all the accepted material in place, to the lines, grades and dimensions as shown on the Drawings or as revised by the PMO/Engineer.

Payment for construction of the Zone 1 in the dam embankment shall be made at the unit prices per cubic meter stated in the Bill of Quantities. Such unit prices shall be for all labor, materials and equipment necessary to perform the work including excavation of the material and other work in the borrow area (excluding stripping as outlined in sub-clause T2.6.8),

hauling, placing, spreading, regular compaction, wetting or drying and scarifying as required, and all testing to include construction of trial embankment. In each case where it is required that the Contractor is to make more or less than eight (8) roller passes, no adjustment shall be made to the unit price stated in the Bill of Quantities.

In case, however, the Contractor has to make more than ten (10) roller passes, adjustment will be made for cost of compaction portion only in the unit price of main dam embankment (core) stated in the Bill of Quantities, based on his breakdown of the unit price submitted in the Schedule 8.

No separate payment for the special compaction of Zone 1 material at the main dam shall be made. The Contractor's cost for it shall be included in the unit price for construction of the Zone 1 embankment as stated in the Bill of Quantities.

T2.6.3 Fine filter zone (Zone 2) and coarse filter zone (Zone 3) for dam embankment

(1) General

Material required for the fine filter zone and coarse filter zone for the main dam and the main cofferdam shall be that which has been obtained from the quarry site or other approved sites and processed through the crushing, classifying and/or washing plant in order to achieve the specified gradation requirements.

Zone 2 material shall be clean, cohesionless material consisting of basalt with a maximum particle size of ten (10) mm and shall contain minus No.200 sieve fraction in the amount of less than five (5) % and plus No.4 (4.75mm) sieve fraction amounting less than thirty (30) %.

Zone 3 material shall be clean, cohesionless material consisting of basalt with a maximum particle size of two hundred (200)mm and shall contain minus No.200 sieve fraction in the amount of less that five (5)% and minus No.4 (4.75mm) sieve fraction amounting less than thirty (30) %.

The gradation of Zones 2 and 3 material shall be as follows:

Nominal particle size (mm)	Zone 2 (Fine filter)	Zone 3 (Coarse filter)
200	100 %	100 %
100	100 %	70 - 100 %
80 (3")	100 %	65 - 100%
40 (1 3/4")	100 %	45 - 90%
25 (1")	100 %	35 - 75%
10 (3/8")	100 %	15 - 45%
5 (No.4)	70 - 100 %	10 - 30%
2 (No.10)	40 - 80 %	0 - 15%
1.2 (No.16)	30 - 60 %	0 - 10%
0.69 (No.30)	20 - 50 %	0 - 5%
0.3 (No.50)	5 - 30 %	-
0.15 (No.100)	0 - 15 %	-
0.074 (No.200)	0 - 5 %	0 - 5%

Prior to and during compaction, the material in each layer of Zones 2 and 3 shall be in wetted condition so as to achieve satisfactory compaction and trafficability and to prevent from segregation.

The size and gradation of Zones 2 and 3 material shall be examined at "in-place" by the PMO/Engineer after compaction.

(2) Placing

Any rock fragments found in the placed material which are larger than the specified size shall be removed before the material is compacted, unless otherwise authorized by the PMO/Engineer, and the rock fragments to removed which meet the rockfill requirement, may be placed in the rock zone (Zone 4).

The Contractor's operations in handling, placing and compacting Zones 2 and 3material shall be such as will result in an acceptable distribution and gradation of the materials throughout the zone. Gravel pockets and clusters of gravel which would interfere with proper compaction of the material will not be permitted.

The material for Zones 2 and 3 shall be placed in continuous, approximately horizontal layers in such a way as to prevent segregation or the formation of voids. The thickness of each layer shall be not more than forty-five (45) cm before compaction. If the placed surface becomes contaminated by other embankment materials, the placed surface shall be cleared of such contaminated material before the next lift is placed.

Successive loads of material shall be placed so as to produce the best practicable distribution of the material subject to the approval of the PMO/Engineer, and when necessary to achieve this purpose the PMO/Engineer may designate the locations in the embankment area where the individual loads shall be deposited.

(3) Compaction

Layer of material for Zones 2 and 3 shall be compacted to a relative density of at least seventy (70) %, and dry densities more than 1.90 and 2.00 tf/m^3, respectively by means of a vibratory roller weighing more than nine (9) metric tons. This will be accomplished by passing the roller approximately six (6) times over each strip (equal in width to the length of the roller's drum) of the layer until the zone's entire layer has been compacted to the required density, provided that the immediately preceding and adjacent roller tracks shall be lapped by more than 30cm, and when compacted, the density shall be essentially uniform throughout the layer.

The actual number of passes required for the roller shall be determined based on the trial embankment to be constructed as stipulated in sub-clause T2.6.6 herein. As such, the PMO/Engineer will vary the number of roller passes depending on the results of the trial embankment and no adjustment shall be made in the unit price stated in the Bill of Quantities in the event there is an increase or reduction in the number of passes. In addition, the PMO/Engineer will make tests as specified in sub-clause T2.6.7 herein to determine whether the required density is being obtained.

The specific type of vibratory roller to be used by the Contractor for compacting the Zones 2 and 3 materials shall be approved by the PMO/Engineer and shall, as a minimum, meet the following requirements:

(i) The static weight of the roller in operating condition, transmitted to the ground through the surface of the drum, shall be not less than 9,000kg.

(ii) The centrifugal force generated by the vibrating part of the roller shall be not less than 20,000kg at the maximum frequency permitted by the manufacturer for the continuous operation of the roller.

(iii) Each drum of a roller shall have an outside diameter of at least 1.5m and shall be not less than 2.1m in length.

The operation of the vibrating roller, including frequency of vibration, and speed of travel shall be as directed by the PMO/Engineer. If more than one vibrating roller is used, all rollers shall be of the same type and essentially the same dimensions. Tractors shall have sufficient power to pull the rollers satisfactorily under all conditions encountered on the embankment work. The surface of the rollers shall be kept free of adhering soil; however, if any soil or other material does adhere to the roller, it shall be removed. The rollers shall be properly maintained to ensure that they retain consistent compaction characteristics.

If, on compaction of a layer of Zones 2 and 3, any part of the surface of the layer is such that it will obstruct free drainage of water through the zone, and/or prevent a satisfactory bond with the succeeding layer, the Contractor shall remove any materials which will obstruct free drainage when compacted and/or scarify or otherwise prepare the surface of the layer so that a satisfactory bond between layers can be obtained.

(4) Measurement and payment

Measurement, for payment, of Zones 2 and 3 in the main dam embankment shall be made of all material compacted in place to the lines, grades and dimensions as shown on the Drawings or as revised by the PMO/Engineer.

Payment for the construction of Zones 2 and 3 in the main dam embankment shall be made at the unit price per cubic meter stated in the Bill of Quantities. This unit price shall be for all labor, materials and equipment necessary to perform the work to include excavating material at the quarry site; processing and stockpiling the material at the crushing, classifying and/or washing plant; hauling, placing, spreading, drying/wetting or scarifying as necessary and compacting the material; and all required testing including construction of trial embankment. In each case where it is required that the Contractor is to make more or less than six (6) roller passes of the vibratory roller, no adjustment shall be made to the unit price stated in the Bill of Quantities.

In case, however, the Contractor has to make more than eight (8) roller passes, adjustment will be made for cost of compaction portion only in the unit price of main dam embankment

(filter) stated in the Bill of Quantities, based on his breakdown of the unit price submitted in the Schedule 8.

T2.6.4 Rock zone (Zone 4) for dam embankment

(1) General

Material for Zone 4 in the main dam and the main cofferdam shall be obtained from the quarry site or other approved areas and shall be a mixture of reasonably sound, durable, well-graded rock, boulders and gravel with maximum particle sizes less than one hundred (100) cm. Also, it shall not contain minus No.4 sieve fraction in an amount of move than ten (10) % nor No.200 sieve fraction in an amount exceeding five (5) %. The gradation limit of the rock material is shown on the Drawings.

At the locations where Zone 4 is adjacent to Zone 3, the Contractor shall take care to ensure that no material exceeding fifty (50) cm in size is placed at such locations.

The foundation under the Zone 4 in the dam embankment shall be prepared in a manner directed by the PMO/Engineer so that the surface of the foundation will be compacted and well bonded with the first layer of the Zone 4 material which is to be placed.

Material for Zone 4 shall not be placed in the dam embankment until the foundation has been suitable prepared in a manner approved by the PMO/Engineer.

(2) Placing

Material for Zone 4 shall be placed in continuous, approximately horizontal layers, in such a way as to prevent segregation, rock pockets or the formation of voids. Each layer shall not exceed one hundred (100) cm in thickness after compaction.

Successive loads of material shall be placed so as to produce the best practicable distribution of the material subject to the approval of the PMO/Engineer, and when necessary to achieve this purpose the PMO/Engineer may designate the locations in the embankment area where the individual loads shall be deposited.

(3) Compaction

Each layer of the material shall be thoroughly wetted to the extent directed by the PMO/Engineer and compacted to the required density by means of a vibratory roller

weighing more than nine (9) tons. This will be accomplished by passing the roller approximately four (4) times over each strip (equal in width to the length of the roller's drum) of the layer until the zone's entire layer has been compacted to the required density of which the void ratio and dry density are less than 0.45 and more than 2.10 tf/m^3, respectively; however, the PMO/Engineer may vary the number of passes of the vibratory roller depending on the results of field tests and the construction of trial embankment.

Other applicable specifications for compacting the Zone 4 material, including those for the vibratory roller, shall be as stipulated in sub-clause T2.6.3(3).

(4) Measurement and Payment

Measurement, for payment, of Zone 4 in the dam embankment shall be made for all material compacted in place to the lines, grades and dimensions as shown on the Drawings or as revised by the PMO/Engineer.

Payment for construction of Zone 4 in the dam embankment shall be made at the unit price per cubic meter stated in the Bill of Quantities. Such unit prices shall be for all labor, materials and equipment necessary to perform the work to include excavating material from the quarry site and hauling it to the embankment site; placing, spreading, wetting, and roller compacting of the materials; ripping and sluicing where directed; and testing including construction of trial embankment. In each case where it is required that the Contractor is to make more or less than four (4) passes of the vibratory roller, no adjustment shall be made to the unit price stated in the Bill of Quantities.

In case, however, the Contractor has to make more than five (5) roller passes, adjustment will be made for cost of compaction portion only in the unit price of main dam embankment (filter) stated in the Bill of Quantities, based on his breakdown of the unit price submitted in the Schedule 8.

T2.6.5 Riprap (Zone 5) for main dam embankment

Material for Zone 5 in the dam embankment shall be obtained from the quarry site shown on the Drawings or other sources approved by the PMO/Engineer, and shall be a mixture of sound, durable, well-graded rock fragments with maximum particle size less than one hundred (100) cm and a mean particle size (D50) not less than 40cm.

The rock fragments in riprap need not be compacted but shall be dumped and graded off in the following manner or as directed by the PMO/Engineer.

- to ensure that the larger rock fragments are uniformly distributed on the surface,
- to ensure that the smaller rock fragments serve to fill the spaces between the larger rock fragments and give the uniform thickness of riprap as shown on the Drawings.

Measurement, for payment, of Zone 5 in the dam embankment will be made for all material compacted in place to the lines, grades and dimensions as shown on the Drawings or as revised by the PMO/Engineer.

Payment for construction of Zone 5 in the dam embankment shall be made at the unit price per cubic meter stated in the Bill of Quantities. Such unit prices shall be for all labor, materials and equipment necessary to perform the work to include excavating material from the quarry site and hauling it to the embankment site; placing, spreading, wetting, and roller compacting of he materials; ripping and sluicing where directed; and testing including construction of trial embankment.

T2.6.6 Trial embankment

(1) General

This sub-clause covers the construction of trial embankment to determine the effectiveness of various methods of quarrying, placement, spreading and compaction of available material for the construction of the dam embankment. After the trial embankments have been constructed, they shall be removed by the Contractor unless directed otherwise by the PMO/Engineer.

Before the construction of the dam embankment (including main cofferdam), basic field tests shall be conducted to evaluate the quarrying, handling and placement requirements and the compaction capabilities of typical embankment as designated by the PMO/Engineer, complete with all grading, ramps, turnarounds and other necessary features, and compaction of trial embankment by means of the roller specified. In this regard, the following paragraphs will be applied:

(i) Embankment materials requiring trial embankment

(a) Impervious core material (Zone 1)

(b) Rock (Zone 4)

(c) Other material deemed necessary by the PMO/Engineer.

(ii) Scope of testing

Field tests shall made on the specified materials for evaluation of:

(a) The methods proposed by the Contractor for quarrying, handling and placing materials.

(b) The effect of layer thickness.

(c) The effects of roller passing and compacting.

(d) Other items deemed necessary by the PMO/Engineer.

Quarrying, handling and placement tests will be directed toward establishing construction procedures which will consistently produce and retain proper material gradations for the specified zones.

(iii) Test schedule

Trial embankment shall be carried out, and all tests required shall be completed, for each zone of material before the placement and compaction of each type of material in its respective embankment zone. Trial embankment construction and the production of materials therefor shall be coordinated and scheduled to insure completion of tests and evaluation of results in accordance with the requirements of the construction schedule.

(iv) Tests

The PMO/Engineer will perform gradation, density, permeability in-situ moisture content and other laboratory tests as deemed necessary tests, and make settlement observations and inspections as required to evaluate the trial embankment construction. The Contractor shall furnish such assistance as the PMO/Engineer may require in the performance of this work.

The quantities of material to be provided for the trial embankment shall be provisionally estimated as follows:

(a)	Impervious core material	:	4,000 m^3
(b)	Rock material	:	4,000 m^3
(c)	Other material	:	as directed by the PMO/Engineer

(2) Equipment

All construction equipment shall be furnished by the Contractor as required for the excavating, processing, stockpiling, hauling, placing, spreading, moisture control, and compaction of trial embankment. Except as otherwise approved by the PMO/Engineer, rolling and any sprinkling equipment shall be of the same types as will be used in the construction of the dam embankment. The use of alternative equipment in embankment construction will be permitted by the PMO/Engineer only if the tests indicate that its capabilities are at least equal to those of the specified equipment, as determined by the basic tests.

(3) Trial embankment

(i) Source of material

Material for construction of the trial embankment shall be obtained from the approved borrow area, quarry site or elsewhere as directed by the PMO/Engineer.

(ii) Processing of material

As for the materials which have to be processed to the required gradations at the crushing plant, adjustments to the basic blending method(s) shall be made as required at no extra expense in order to correct any deficiencies revealed by the testing procedures, and additional tests shall be made as required in evaluating the modified method. If, during the course of the work, the blending procedure is modified, supplemental tests shall be performed as necessary for the evaluation of the method and the effect of the modification on placing, spreading and compaction prior to approval.

(iii) Subgrade preparation

The subgrade at each trial embankment location shall be stripped of vegetation and all debris and other objectionable material. The test area shall be graded as required to provide an adequately drained surface suitable for the tests. When the surface at each trial embankment location has been stripped, graded, cleaned and approved by the PMO/Engineer, the subgrade shall be compacted as directed by the PMO/Engineer.

(iv) Placing and spreading

Material shall be placed and spread in approximately uniform layers over the entire width and length of the trial embankment area. The layer thickness will be as directed by the PMO/Engineer. The maximum size of fragments permissible in the layers to be compacted shall not exceed the thickness of the layer. The methods used for transporting, placing and spreading shall be of a type which will reduce segregation of the material sizes to a minimum. After each layer has been spread to a uniform thickness, a grid system as designated by the PMO/Engineer shall be laid out on the surface of the trial embankment from reference marker stakes located beyond the trial embankment limits. Steel plates shall be placed at the grid intersections on top of the layer and their location identified with a splash of paint for subsequent observation of changes in elevation as compaction proceeds.

(v) Moisture control

Moisture control and watering will be required in connection with the placement of Zones. Moisture content shall be adjusted through a process approved by the PMO/Engineer within allowable limits of variation from the optimum value as determined by the PMO/Engineer.

(vi) Compaction

Compaction shall be performed by successive passes over the trial embankment with the specified compaction equipment. Each trial embankment section shall receive the number of passes necessary to obtain the required density. Hauling, spreading, and sprinkling equipment passing over the embankment shall not be taken into account in evaluating densities and settlements, and such traffic shall be distributed over the surface of the trial embankment to avoid areas or lanes of excessive compaction. Any areas showing the effect of excessive traffic shall be harrowed and redeposited prior to starting compaction operations.

(4) Tests

Samples of fill materials for testing of gradation, density and moisture content will be taken by the PMO/Engineer and tested at frequent intervals, and corrections or adjustments or modifications of methods and moisture content which the tests indicate as being desirable, shall be made by the Contractor at no extra expense in order to obtain the required information and test data. The rate of placement of trial embankment materials and the

progress of the trial embankment program will be influenced by the required sampling and testing operations. The compaction obtained in the individual test sections will be determined from field-in-place density tests and on materials having large particles which might unduly affect the results obtained, by settlement measuring or by both methods if so required. Test trenches shall be excavated across the compacted embankment at locations as directed by the PMO/Engineer to determined the overall efficiency and effectiveness of the embankment construction methods used. Photographic records of the exposed surface shall be made as directed by the PMO/Engineer at the Contractor's expense.

(5) Payment

No separate payment shall be made for trial embankment or supplemental trial embankment. Costs for constructing the trial embankment and supplemental trial embankment for a particular zone and their removal as directed by the PMO/Engineer shall be included in the unit prices of each applicable zone in the dam embankment stated in the Bill of Quantities.

T2.6.7 Tests on embankment materials

(1) General

The Contractor shall establish a field laboratory which will include the equipment listed in Appendix VIII of the General Specifications, shall provide a trained staff to the satisfaction of the PMO/Engineer, and shall assist the PMO/Engineer to make all tests necessary to ensure that the embankment materials satisfy all requirements of these Specifications. These tests will include three (3) field density and rapid compaction tests for each 1,500 m^3 of Zone 1 material placed in the embankment, and shall include three (3) field density tests and laboratory density tests for each 1,000 m^3 of Zones 2 and 3 material. Also they shall include one (1) grain size test for each 500 m^3 of Zones 2 and 3 material. Other tests as may be required by the PMO/Engineer for Zone 1 shall also be made. Tests for the other zones will be performed as deemed necessary by the PMO/Engineer.

Except as otherwise provided for in this sub-clause, field and laboratory tests on embankment materials shall be in accordance with the current testing methods and recommended practices of the American Society for Testing and Materials (ASTM), Japanese Industrial Standards (JIS), or other approved standards, with the following provisions being applied:

(i) Samples of Zone 1 shall be prepared for testing in accordance with ASTM Designation D2217, Procedure B, except that reduction of moisture content of the samples shall be at temperatures not exceeding 50°C.

(ii) The maximum dry density and optimum moisture content of Zone 1 materials as well as embankment and subgrade materials for permanent access roads shall be determined according to ASTM D698 or JIS A-1210, providing that:

(a) Fresh test material shall be prepared for each specimen to be compacted. Re-use of material compacted in a test will not be allowed.

(b) Test material subsamples for specimens to be compacted drier than fill moisture content may be individually airdried to the desired test moisture content for each specimen.

(iii) For Zone 1, as routine control of placement, field density is to be measured at the embankment site according to ASTM D 1556 and the balance of field water content and the optimum water content, and the ratio of the field dry density and maximum dry density are to be determined according to the principles set out in ASTM Special Technical Publication 479, 5th Edition, in the "Suggested Method of Test for Rapid Compaction Control" by J.W. Hilf. A concise test procedure based on these principles will be provided by the PMO/Engineer. When using this procedure, the mechanical mixing of test materials shall not be used, and all of the operations during the preparation, mixing and compaction of test materials shall be performed in a humidified atmosphere.

(iv) For other zones, field density will be measured by a method as to be determined by the PMO/Engineer, and the maximum and the minimum dry densities are to be determined in accordance with Part B of Designation E-12 (Relative Density of Cohesionless Soils) of the U.S. Bureau of Reclamation's Earth Manual, Second Edition (Revised in 1974), or equivalent method.

(2) Payment for tests on embankment materials

No response payment shall be made for the tests required by this paragraph. The Contractor's costs for performing such tests shall be included in the applicable unit prices for construction of the embankments for the dam and permanent access roads stated in the Bill of Quantities.

T2.6.8 Operation of borrow area

The Operation of the borrow area shall be the responsibility of the Contractor under the PMO/Engineer's direction.

The material for Zone 1 shall be obtained from the borrow area as shown on the Drawings.

The boundary lines of the borrow area as shown on the Drawings are only approximate and may be extended if required. In the event of such extension, the Contractor shall be entitled to no additional allowance above the unit prices stated in the Bill of Quantities for such material.

The borrow area shall be cleared and stripped as stipulated in Clause T2.2 of this CHAPTER to a depth as directed by the PMO/Engineer. The Contractor shall maintain all stripped surfaces free of vegetation until excavation operations in the borrow area are complete. Materials obtained from stripping shall be temporarily placed in approved areas at or adjacent to the borrow area. If unsuitable materials or materials not required for permanent construction purposes are found in the borrow area, such materials shall be left in place or excavated and placed in the area designated for the stripped material, as directed by the PMO/Engineer.

The Contractor will direct, as approved by the PMO/Engineer, the sequence and depth of the excavation operation in the borrow area so as to ensure to the greatest extent possible that the gradation of the materials, when compacted in the dam embankment, is acceptable.

The borrow area shall be operated so as not to impair its usefulness or mar the appearance of any part of the Project. The shapes and locations of the stripped or unsuitable material from the borrow area shall be such that erosion will be at a minimum.

The flat portion of the borrow area shall be covered with the top soil stripped in preparation of the borrow area so that plantation shall be possible after borrowing work there finished. The top soil stripped shall be preserved until the borrowing work will finish in a proper area as approved by the PMO/Engineer. The slope generated by borrowing work shall be provided with a surface protection works for permanent slope to the satisfaction of the PMO/Engineer.

Should rock fragments having maximum dimensions of more than fifteen(15) cm be found in the borrow area, they shall be removed by the Contractor either at the borrow area or at the dam embankment site before the material is rolled and compacted.

During operation of the borrow area, the Contractor shall provide necessary measures for control of dust in the vicinity of the borrow area and along the roads used to haul the material.

If at any location in the borrow area (before or during excavation operations) there is excessive moisture, as determined by the PMO/Engineer, steps shall be taken to reduce the moisture such as: by selective excavation to secure the drier materials, by aerating, by stockpiling the material which has been found to contain excess moisture and allowing it to dry, or by any other approved means. The Contractor shall be entitled to no additional allowance above the unit prices stated in the Bill of Quantities for the Zone 1 material on account of any difficulties caused by wet materials in the borrow area.

The Contractor will be required to excavate sufficient suitable material to complete the dam embankment under these Specifications, regardless of whether wet conditions are due to ground water, precipitation, difficulty of draining, or for any other reason.

To avoid the formation of pools of water in the borrow area, drainage ditches from the borrow area to the nearest outlet shall be excavated by the Contractor where, in the opinion of the PMO/Engineer, such drainage ditches are necessary. The Contractor shall protect the borrow area to prevent excessive erosion by the construction of drains, catch basins, revetments, etc. where required.

The Contractor shall be responsible to design, construct and maintain a temporary construction road (approach road) for the borrow area to the satisfaction of the PMO/Engineer.

Not less than sixty (60) days before starting operations, the Contractor shall submit to the PMO/Engineer for approval details of the proposed method of working the borrow area, including the sequence of operations, height of batters, location of benches and the plan outline of the proposed borrow area. Horizontal berms shall be formed at regular intervals and the borrow area shall be left in a tidy and safe condition to the satisfaction of the PMO/Engineer.

The Contractor shall take all necessary precautions to ensure at all times the safety of the public and the safety of personnel, equipment and other property near and within the borrow area.

The Contractor shall not remove material from the borrow area for his own use without the approval of the PMO/Engineer. If so directed by the PMO/Engineer, materials excavated from the borrow area by the Contractor for his own use that otherwise could be used in the permanent works shall be measured separately.

The cost of all the works (except stripping and removing unsuitable material at the borrow area) including but not limited to excavation, drainage, maintaining uniform stable slopes, soil conservation measures, and other work being done physically at the borrow area shall be included in the unit prices for construction of the impervious core zone (Zone 1) in the dam embankment stated in the Bill of Quantities.

Measurement, for payment, and payment of the material to be stripped from the borrow area shall be made as stipulated in sub-clause T2.2.3 of this CHAPTER.

Measurement, for payment, of any unsuitable material which may have to be removed from the borrow area and placed in the area designated for stripped material shall be made of square meter stripped, in place, to the line, grade, depth and dimensions as directed by the PMO/Engineer. Payment for excavating and placing the unsuitable material in the area designated for the stripped material shall be the same as the unit price per cubic meter for stripping work stated in the Bill of Quantities.

The applicable specifications pertaining to excavation work which are included in this CHAPTER shall be fully complied with during the period the Contractor is operating the borrow area.

T2.6.9 Operation of quarry site

The operation of the quarry site shall be the responsibility of the Contractor under the PMO/Engineer's direction.

It is planned that the following materials will be obtained from the quarry site for use as shown on the Drawings:

(1) Fine filter Zone 2 and coarse filter Zone 3 for use at the main dam and the main cofferdam being processed at the crushing plant.
(2) Rock Zone 4 for use at the main dam and main cofferdam.
(3) Riprap for use at the main dam
(4) Rock to be processed at the crushing plant to produce graded aggregate for concrete and for the permanent access road.

As determined during the time the detailed survey and investigation made at the site and as stated in the report, the rock material at the quarry site generally consists of hard and fresh rock of basalt and agglomerate.

Rock material to be used for producing Zones 2 and 3 material, aggregates for concrete and aggregates for the permanent access roads will be excavated at the quarry site and transported to the crushing plant (to be set up next to the quarry) for processing and stockpiling. After processing, the Zones 2 and 3 material will be transported to the embankment site for placing and compacting and the aggregates will be used as required.

Rock which is not suitable for use as embankment materials or other necessary works shall be left in place or excavated and placed in the areas as directed by the PMO/Engineer.

The boundary lines for the quarry site, as shown on the Drawings, are only approximate and may be extended if required. In the event of such extension, the Contractor shall be entitled to no additional allowances for the material excavated.

The Contractor shall construct catch drains or other suitable forms of drainage where required to divert surface runoff away from the quarry site.

The applicable specifications pertaining to excavation work which are included in this CHAPTER shall be fully complied with during the period the Contractor in operating the quarry site.

The haul road from the damsite up to near the quarry site will be constructed under Lot - I as shown on the drawing.

The Contractor shall be responsible to design, construct and maintain a temporary construction road (approach road from the end of the haul road to be constructed under Lot - I) for the quarry site to the satisfaction of the PMO/Engineer.

Not less than sixty (60) days before starting operations, the Contractor shall submit to the PMO/Engineer for approval details of the proposed method of working the quarry site including the sequence of operations, height of batters, location of benches, a plan outline of the proposed quarry site, etc. Horizontal berms shall be formed at regular intervals and the quarry site shall be left in a tidy and safe condition to the satisfaction of the PMO/Engineer.

The Contractor shall take necessary precautions to ensure at all times the safety of the public and the safety of personnel, equipment and other property near and within the quarry site.

The Contractor shall not remove material from the quarry site for his own use without the approval of the PMO/Engineer. If so directed by the PMO/Engineer, materials excavated from the quarry site

by the Contractor for his own use that otherwise could be used in the permanent works shall be measured separately.

The cost of all the works at the quarry site (except clearing and removing unsuitable material) including but not limited to excavation, drainage, maintaining stable slopes and other work being done physically at the quarry site shall be included in the unit prices for applicable work items such as the construction of Zones 2, 3, and 4 for the dam embankment, concrete (aggregate), base course and surface course aggregate for roads, etc. as stated in the Bill of Quantities.

Measurement, for payment, and payment for clearing and stripping the surface area of the quarry site shall be in accordance with Clause T.2.2.

Measurement, for payment, of any unsuitable rock which may have to be removed from the quarry site and placed in the areas designated by the PMO/Engineer shall be made by survey crews. Payment for excavating and placing the unsuitable rock in the areas shall be included in the unit price for clearing and stripping the quarry site stated in the Bill of Quantities.

T2.6.10 Operation of crushing plant

A crushing plant of the type approved by the PMO/Engineer is to be erected and maintained at the location as shown on the Drawings. The Contractor shall be entrusted to operate and maintain the crushing plant. Material excavated from the quarry site will be hauled to the crushing plant for processing it into Zone 2 fine filter material and Zone 3 coarse filter material for the dam embankment as well as for processing it to produce coarse and fine aggregates for concrete, sand for grout/mortar, graded material for the base and surface courses of the permanent access roads, etc. After the material from the quarry site has been processed by the crushing plant, it will be stockpiled nearby in a suitable manner so as to prevent segregation.

The entire area around the crushing plant will be graded for drainage and suitably maintained to the satisfaction of the PMO/Engineer. The proportional cost of operating and maintaining the crushing plant, in regard to processing the fine filter material, coarse filter material, concrete aggregates, sand, course materials of roads, etc. shall be included in the applicable unit prices in the Bill of Quantities.

T2.7 Backfill and Miscellaneous Embankment

T2.7.1 General

The Contractor shall perform embankment, backfill and miscellaneous fill as shown on the Drawings or directed by the PMO/Engineer. This work shall include selecting, stockpiling, spreading, wetting or drying, compacting, shaping and finishing materials, and all incidental items of the work. Unless otherwise approved, materials to be used for backfill and miscellaneous fill shall be those obtained from open-cut excavation or underground excavation.

Materials for backfill or embankment shall be obtained from excavation for permanent structures or from stockpiles of excavated material as far as they meet the requirements of these Specifications. Distribution within embankments of construction materials from excavation shall be done in the way approved by the PMO/Engineer. Embankment fills shall be preferably constructed during periods of relatively low precipitation.

The surface to be covered with filling material shall be treated by the Contractor as follows:

- Clearing and stripping shall be done in accordance with the requirements as specified in Clause 2.2. Stump holes or other small excavations in the limits of backfill and miscellaneous fill shall be backfilled with suitable material and thoroughly tamped by approved methods before commencement of the work.

- Springs and seepage along the foundation of the work shall be treated by the method as approved by the PMO/Engineer.

- Where backfill and miscellaneous fill are to be placed on sloped foundation, care shall be taken to prevent slipping and shall be treated by means of step cutting or other method as approved by the PMO/Engineer.

- Bearing test will be carried out, if it is deemed necessary in the opinion of the PMO/Engineer, at the locations as directed by the PMO/Engineer.

Unless otherwise specified or directed by the PMO/Engineer, the height of extra embankment shall be 3% of the designated height and shall be in the tolerance of less than around 5 cm. The volume of the extra embankment shall not be taken into account for measurement for payment.

T2.7.2 Free draining backfill

Free draining backfill shall be placed to the lines and dimensions as shown on the Drawings or as directed by the PMO/Engineer.

The materials to be used for free draining backfill shall be selected previous mixtures well graded with the maximum grain size of 20 cm. Fragments larger than 20 cm may be used if approved by the PMO/Engineer, provided that such fragments shall be evenly distributed in the backfill. The free draining backfill shall not contain, more than 5% by weight, material passing a 0.074 mm mesh sieve provided in JIS.

The material shall be handled and placed in such a manner as to prevent segregation. The method of placing free draining backfill shall be subject to the approval of the PMO/Engineer. Free draining backfill on either side of each structure shall be kept approximately at the same elevation as the placing of backfill progresses. Free draining backfill shall be placed and roughly levelled off in layers not more than 50 cm in thickness after being compacted. Free draining backfill shall be thoroughly compacted to the satisfaction of the PMO/Engineer by approved means.

T2.7.3 Random fill and backfill

Random fill and backfill shall be placed to the lines and dimensions as shown on the Drawings or directed by the PMO/Engineer.

The materials to be used for Random fill and backfill shall be selected mixtures well graded with the maximum grain size of 30 cm. Random backfill shall be placed and roughly levelled off in layers not more than 50 cm in thickness after being compacted. Prior to and during compaction operations, the material shall have the optimum moisture content required for the purpose of compaction, as determined by the PMO/Engineer, and the moisture content shall be uniform throughout each layer. Each layer shall be thoroughly compacted to the satisfaction of the PMO/Engineer by approved means.

T2.7.4 Miscellaneous embankment

The materials to be used for embankment shall be selected mixtures well graded with the maximum grain size of 20 cm. Of the embankment materials, rock fragments shall be tough and durable to withstand both the procedures involved in procuring and placing them and the normal weathering process as it prevails in the areas of the works. Furthermore, the rockfill material shall be free from cracks, seams and other defects and from any deleterious matter such as clay, silt, friable rock, etc.

Maximum size of the embankment material shall be less than 20 cm unless otherwise approved by the PMO/Engineer, except the rockfill material. When approved by the PMO/Engineer, materials more than 20 cm in size may be used at locations designated by the PMO/Engineer, provided that the voids in these coarse materials shall completely be filled with finer materials as approved by the PMO/Engineer. The materials shall be placed and spread so that no single layer exceeds 30 cm in thickness after compaction. The compaction equipment shall be suitable to the materials which will be embanked to the place.

Placement of materials shall not be permitted to commence in any portion of the foundation of the embankment until the section is completely drained and suitably prepared and has been approved by the PMO/Engineer.

Before placing embankment material on the foundation and on the surface of the already placed fill, each portion in the entire area shall be properly moistened, graded and the surface scarified before the following lift is placed. The fill of each lift shall be moistened, if required, and compacted in specified lift heights and passing by suitable equipment, approved by the PMO/Engineer to reach the density specified by PMO/Engineer.

Each lift or layer shall be continuously placed and compacted without any delay. The thickness of lifts and the passes of the compaction equipment for the different kinds of material will be subject to the approval of the PMO/Engineer.

When any layer fails to comply with the degree of compaction specified above, the Contractor shall recompact, wet or dry, improve or replace the materials immediately. Any soft or yielding areas which may develop in the embankment during construction shall be corrected by recompaction, or removing the unsuitable materials and replacing it, immediately after the direction ordered by the PMO/Engineer. No direct payment shall be made for such works unless otherwise approved by the PMO/Engineer and the cost hereof shall be compensated by the Contractor at his own expense.

Provision shall be made on the construction site for well functioning drainage system by means of sufficient inclination in lifts to the outside of the embankment and for additional trenches and drainage ditches of suitable size and area to provide a continuous run-off in case of rain, etc. The entire site shall be kept in such condition that water puddles do not occur on completed layers. Compacted layers with water puddles on the surface may be subject to rejection upon the decision of the PMO/Engineer. Muddy surface due to adverse weather conditions shall be removed or dried out before the next layer is applied.

The rockfill material shall be dumped and distributed within the embankment as shown on the Drawings or as approved by the PMO/Engineer. However, the gradation in any layer shall be such that the material is suited for satisfactory compaction to ensure a good mechanical lock, high relative density and stability of the rockfill body.

T2.7.5 Gravel bedding and gravel metalling

Gravel bedding and gravel metalling shall be placed at the location, shown on the Drawings or as directed by the PMO/Engineer.

The materials shall be selected from previous mixtures well graded with the maximum size of 80 mm for gravel bedding and 40 mm for gravel surfacing. The materials shall not contain more than 5%, by weight,of material passing a 0.074 mm mesh sieve provided in JIS.

The Contractor shall handle and place the material in such a manner as to prevent segregation. The method of placing gravel bedding and gravel surfacing shall be subject to the approval of the PMO/Engineer.

T2.7.6 Measurement and payment

Measurement for payment of backfill and miscellaneous fill shall be made of the volume of material in place to the prescribed lines, grades and dimensions.

Payment for backfill and miscellaneous fill shall be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all labour, materials and equipment, and for all incidental work connected herewith, but excluding the cost of obtaining and transporting materials for which payment is provided in the Bill of Quantities for various items of excavation for permanent work.

T2.8 Gabion Mat

T2.8.1 General

This Clause shall specify gabions mat in all areas of the Site as shown on the Drawings or as directed by the PMO/Engineer.

T2.8.2 Material

The Contractor shall provide the gabions at the position as shown on the Drawings or as directed by the PMO/Engineer.

Prior to setting gabions, the foundation for gabions shall be prepared as clean and plane to the lines by excavation or fills to the satisfaction of the PMO/Engineer. The materials for the foundation fills shall be same gravel or rocks as that of the gabion or approved equivalent and shall placed uniformly and compacted firmly.

If not otherwise clearly specified in the Drawings, the Contractor shall submit a proposal of the type and dimension of gabions, the stonefill (type, strength, grain size, etc.), the method of placing and the time schedule for delivery and construction. The Contractor shall not commence the construction of gabions before approval of the PMO/Engineer.

The size of mesh will be 15 cm in hexagonal. The frames will be woven with the specified iron wire at other place near by the setting position separating the lower part of the frame from the top surface net.

The lower part of the gabion frame shall be arranged on the foundation prepared already as shown on the Drawings or as approved by the PMO/Engineer. The cobbles or rocks in gabions shall be filled densely enough alternating between large and small sizes.

The Contractor shall be subject to the inspection of degree of cobble or rock packing by the PMO/Engineer before closing of the top surface net.

T2.8.3 Measurement and payment

Measurement for payment of gabions will be made on the basis of placed volume of gabions in cubic meters determined by the lines and positions as shown on the Drawings or as approved by the PMO/Engineer.

Payment of gabion will be made for the number of cubic meters measured as provided above at the unit price stated in the Bill of Quantities. The unit prices shall include all labour, tools, materials and all other costs for preparation of foundation, weaving and setting of gabion frame, packing of cobbles or rocks, finishing and other items necessary to complete the Works.

T2.9 Drainage

T2.9.1 General

The work under the Clause shall cover the construction of drainage structure including the general items pertaining to materials, excavation, foundation, construction or installation and backfill in connection with the drainage structure.

T2.9.2 Materials

(1) Steel drain pipes and fittings

The Contractor shall furnish and install steel drain pipes including necessary fittings as shown on the Drawings or as directed by the PMO/Engineer. The steel pipe shall conform to the requirements of JIS G3452-84, Carbon Steel Pipes for Ordinary Piping, or as approved equivalent.

(2) Corrugated steel pipes and fittings

The Contractor shall furnish and install corrugated steel pipes including necessary fittings as shown on the Drawings or as directed by the PMO/Engineer. The corrugated steel pipe shall conform to the requirements of JIS G3471-77, Corrugated Steel Pipes and Sections, or approved equivalent.

(3) Reinforced concrete drain pipes

The Contractor shall furnish and install reinforced concrete drain pipes as shown on the Drawings or as directed by the PMO/Engineer. Reinforced concrete drain pipe shall conform to the requirements of JIS A5302-84, Reinforced Concrete Pipes, or approved equivalent, and provisions stipulated in CHAPTER T4, CONCRETE WORK.

(4) P.V.C. drain pipes and fittings

The Contractor shall furnish and install the polyvinyl chloride (P.V.C.) drain pipes including necessary fittings as shown on the Drawings or as directed by the PMO/Engineer. The P.V.C. drain pipe shall conform to the requirements of JIS K6741-84, Unplasticized Polyvinyl Chloride Pipes, or approved equivalent, and provisions stipulated in CHAPTER T4, CONCRETE WORK. Perforated P.V.C. pipes shall be the same specification as that in this paragraph.

(5) Drain ditches, gutters and pits

The Contractor shall furnish and install drain ditches, gutters and pits made of reinforced concrete or non-reinforced concrete as shown on the Drawings or as directed by the PMO/Engineer. Concrete to be used for the drain ditches shall be of Class B and shall conform to the applicable provisions of CHAPTER T4, CONCRETE WORK.

Excavation for trenches shall be performed in accordance with the applicable requirements of Clause T2.4, Open-Cut Excavation, in these Specifications. Bedding surface shall provide a firm foundation of uniform density. Each section of pipe shall rest upon the pipe bed for its full length, with recess excavated to accommodate bells and joints.

Each pipe shall be carefully inspected before it is laid. Any defective or damaged pipe shall be rejected. The laying of pipe shall proceed upgrade beginning at the lower end of the pipe line. Under no circumstances pipe shall be laid in water and no pipe shall be laid when the trench conditions or weather is unsuitable for such work. Full responsibility for the diversion of drainage and dewatering of trenches during construction shall be borne by the Contractor.

When pipe laying is interrupted, the Contractor shall seal the ends of the pipe line to prevent the entry of water or foreign matter. No backfill or concrete shall be placed over or around the piping until the installation has been approved by the PMO/Engineer.

Unless otherwise specified by the PMO/Engineer or shown on the Drawings, bedding material below pipe shall be clean sand or other approved granular material and remaining backfill in the pipe trenches shall be approved material free from stones lager than 80 mm and other objectionable materials.

Concrete used for drainage structures shall conform to the applicable requirements of CHAPTER T4, CONCRETE WORK in these Specifications. Mortar shall be stiff and composed of 1 part Portland cement and 2 parts sand by weight.

Surface drainage with concrete gutters, ditches and catch basins, and drain pipes installed on the shotcrete protective coatings are considered a part of concrete work.

After cutting, and before threading, all steel pipes shall be reamed and have burs removed. All screw joints shall be made with graphite or other approved compound applied to make

threads only. Thread shall be full cut and not more than 3 threads on the pipe shall remain exposed.

Flanged joints shall be faced true, packed and made up perfectly square and tight. Gaskets shall be ring type 1.5 mm thick sheet asbestos, or as approved by PMO/Engineer.

Joints in P.V.C. pipes and fittings shall be socket or threaded joints made up as recommended by the manufacturer.

After the bedding has been prepared and the pipe installed, backfill material at a moisture content which will facilitate compaction, shall be placed alongside the pipe in layers not exceeding 15 cm in depth unless otherwise specified or shown on the Drawings.

Care shall be taken to ensure thorough compaction of the fill under the pipe. Each layer shall be thoroughly compacted by rolling, tamping with mechanical rammers, or by hand tamping with heavy iron tampers of which the tamping face area shall not exceed 150 sq.cm. This method of filling and compacting shall be continued until the fill has reached an elevation 30 cm above the top of the pipe. The remainder of the trench shall be backfilled and thoroughly compacted in layers not exceeding 15 cm. The density of compaction shall be as specified by the PMO/Engineer.

The test shall be made as directed by the PMO/Engineer where considered necessary by the PMO/Engineer.

(6) Geo-textile-made drain

The Contractor shall furnish and install geo-textile-made drain behind walls to be connected with 250 mm diameter perforated P.V.C. pipe below the bottom slab of the spillway as shown on the Drawings or as directed by the PMO/Engineer.

The drain shall be sponge mat made of polyethylene with void ratio more than 90% and covered by previous non-sheet filter or equivalent approved by the PMO/Engineer.

The drain shall be chemical action proof and not harmful to the surroundings.

The width and thickness of the mat shall be shown on the Drawings or as directed by the PMO/Engineer.

T2.9.3 Measurement and payment

(1) Steel drain pipes and corrugate steel pipes

Measurement for payment for steel drain pipe and corrugate steel pipes will be made of the installed length of steel drain pipes and corrugate steel pipes determined by the approved Drawings or the direction of the PMO/Engineer.

Payment will be made for the installed length of steel drain pipes and corrugate steel pipes at the respective unit prices per linear meters stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing, loading, hauling, unloading, installing and jointing the pipes and fittings, and other items necessary to complete the works.

(2) Reinforced concrete drain pipes

Measurement for payment for reinforced concrete drain pipes will be made of the length of pipes actually installed in accordance with the Drawings or the direction of the PMO/Engineer.

Payment will be made at the unit prices per meter stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of concrete work and earth work, all labour, tools, equipments and materials therefor including furnishing, installing and jointing the pipes and fittings, and other items necessary to complete the works.

(3) P.V.C. drain pipes

Measurement for payment for P.V.C. drain pipes including perforated ones will be made of the length of pipes actually installed in accordance with the Drawings or the direction of the PMO/Engineer.

Payment will be made at the unit price per linear meter stated in the Bill of Quantities, which unit price shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing and installing and jointing the pipes and fittings, and other items necessary to complete the works.

(4) Drain ditch, gutter and pit

Measurement and payment for earthwork and concrete work for drain ditches, gutters and pits shall be made in accordance with provisions set forth in sub-clauses T2.4.7, T.2.7.6 and T4.1.18.

(5) Geo-textile-made drain

Measurement for payment for geo-textile-made drain will be made of the length of drain actually installed in accordance with the Drawings or the direction of the PMO/Engineer.

Payment will be made at the unit price per linear meter stated in the Bill of Quantities, which unit price shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing and installing and jointing the drains and fittings, and other items necessary to complete the works.

T2.10 Slope Protection

T2.10.1 General

These specifications cover the slope protection works including furnishing, transporting, excavating, backfilling, concreting for the construction of slope protections. The Contractor shall construct slope protection and other to the lines and grades as shown on the Drawings or as directed by the PMO/Engineer.

T2.10.2 Sod facing

The Contractor shall perform the sod facing on the embankment or cut slopes as shown on the drawings or as directed by the PMO/Engineer.

The sod used for the slope protection shall be fresh, dense, and well rooted and the length of cut sod piece shall not be shorter than 20 cm. All areas to be sodded shall be fine graded to a uniform surface and the surface loosened to a depth of 3 cm. Where directed by the PMO/Engineer top soil shall be placed on the prepared surfaces. The sodded face shall be tamped by a suitable tool to make smooth surface. The contractor shall be responsible for special care of all completed sodding for period of 30 days and shall water the sodding whenever necessary to ensure rooting and when directed to do so by the PMO/Engineer. During this period any part which is dead shall be removed and replaced by the Contractor.

T2.10.3 Grouted anchor bar

In areas specifically designated by the PMO/Engineer, the Contractor shall drill holes in rock surfaces and install therein anchor bars as directed and as soon as possible after designation. The locations, depth of holes and lengths of anchor bars will be determined by the PMO/Engineer. Anchor bars shall be of a type shown on the Drawings or approved by the PMO/Engineer. The holes for anchor bars shall be filled with mortar as approved by the PMO/Engineer. The holes for anchor bars in rock shall be thoroughly cleaned out by washing and blowing prior to mortar fillings. Steel bars for anchor bars shall conform to the requirement of JIS G 3112-85 or approved equivalent. The Contractor shall not touch and not disturb the anchor bars set in rock with mortar until the filling mortar has hardened.

Diameter of each hole for the anchor bar shall not be less than 2 times the diameter of the anchor bar specified for that hole.

Anchor bars in rock shall be tested in place once per 10 holes with approved equipment and tools, locations as directed by the PMO/Engineer. Anchor bars shall be tensional equal to the specified minimum yield point. If it is revealed by the test that the anchor bars tested have been failed to set, the test shall be performed for all of the remaining anchor bars untested of a test group and the anchor bars failed to set shall be successfully reset.

T2.10.4 Stone pitching

The Contractor shall perform the stone pitching to the lines and grades as shown on the Drawings or as directed by the PMO/Engineer.

The stone for the pitching shall be natural or crushed stone having sufficient strength and durability required for the use and the minimum size is not less than 30 cm.

The foundation for stone pitching shall be constructed with sufficient thickness of gravel and cobble stone layer, tamped sufficiently. Stone shall be arranged to avoid extreme irregularity of the pitching surface, and joint surface shall be smoothed with hammer. Gaps shall be filled with granular fill materials so that no stone will move.

Placing of the stone pitching shall not begin until the finishing stakes have been set according to the Drawings.

The stones shall be cleaned and thoroughly saturated with water immediately prior to any pitching placement, and the foundation bed shall be cleaned and moistened before the mortar is spread. The joints shall be full and flushed with mortar. The exposed faces of individual stones shall be parallel to the face f the slope.

Stone pitching with mortar shall be satisfactorily protected from the sun and shall be kept thoroughly wet for at least 3 days for curing.

T2.10.5 Measurement and payment

(1) Sod facing

Measurement for payment for sd facing shall be made of the actual surface area covered at the direction of the PMO/Engineer.

Payment for sod facing shall be made at the unit price per square meter stated in the Bill of Quantities, which unit price shall include the cost of carrying out all work including applications of water and topsoil.

(2) Grouted anchor bar

Measurement for payment for grouted anchor bar shall be made of the length of anchor bar in place as shown on the Drawings or as directed by the PMO/Engineer.

Payment for grouted anchor bar shall be made at the unit price per linear meter stated in the Bill of Quantities, which unit price shall include the cost of all labour, materials and equipment required for the work, drilling anchor hole and filling it with mortar and also the cost of test so specified hereabove.

(3) Stone pitching

Measurement for payment of stone pitching will be made of the actual area of stone pitching constructed.

Payment for stone pitching will be made at the unit price per square meter stated in the Bill of Quantities, which unit price shall include the cost of all work and material for excavation of footings, gravel bedding, backfill concrete, concrete in footings and others required to complete the work.

T2.11 Removal of Concrete

The item stated in the Bill of Quantities for demolishing concrete in river outlet work shall consists of the following portions of concrete structures:

- a portion of the concrete lining of diversion tunnel where the valve chamber under the Contract is provided.

For the portion mentioned above, blasting shall be performed with care so that the rock surrounding the lining concrete to be removed, and the lining outside the boundary line shown on the Drawing shall not be damaged.

All shattered or loosened concrete and surrounding rock shall be replaced by concrete at the expense of and by the Contractor.

Measurement for payment for demolishing concrete will be made at the unit price per cubic meter stated in the Bill of Quantities. The cost of furnishing all labour, equipment and materials including handling demolished concrete to designated disposal area, and for all incidental work for removal of concrete shall be included in the unit price .

CHAPTER T3 DRILLING AND GROUTING

T3.1 General

The work covered by this CHAPTER comprises the following operations and work incidental thereto;

(1) Backfill grouting for filling up the gaps between the lining concrete of such tunnels as inspection tunnel, valve chamber access shaft horizontal tunnel and grout tunnel, by means of injecting cement-sand grout into the gaps,

(2) Consolidation grouting for filling up the openings in rock such as fissures, joints and cracks in foundation rock of the spillway and rock surrounding the diversion tunnel to unite and strengthen the foundation rock and rock around the tunnel by means of injecting cement grout into them,

(3) Curtain grouting for forming a low permeability zones in foundation rock of dam and foundation of the existing municipal dike to cut off water leakage through it by means of injecting cement grout into the foundation rock.

(4) Contact grouting for filling up an openings between the lining concrete and the plug concrete in the diversion tunnel by means of injecting cement grout into the openings.

(5) Blanket grouting for forming low-permeability zones in shallow parts of foundation rock upstream and downstream of the curtain grouting zone to hinder leakage and dispersion of grout injected for the curtain and to make the curtain grouting effective, and also to hinder direct contact of the impervious core base with seepage water through its foundation by means of injecting cement grout into the opening in rock such as fissures, joints and cracks.

(6) Rim grouting for the purpose of extending the grout curtain beyond the wing of the dam or dam abutments. The hole shall be arranged in one lane in the grout tunnels. The size of the holes and the procedure of drilling and grouting shall be similar to those for curtain grouting. Hereinunder, the rim grouting means curtain grouting to be performed through holes drilled downward from the grout tunnels on both dam abutments.

In relation to the above-listed grouting operation, the Contractor shall perform all the works necessary for drilling through concrete or rock, washing and pressure testing grout holes and

supplying, transporting, mixing and injecting grouting materials: supply and installation of grouting pipes, headers, risers, grooves, grout outlets, sleeve pipes and packers: drilling drainage holes: drilling and water pressure test holes: all as shown on the Drawings or as directed by the PMO/Engineer.

The amount of drilling and grouting that will be required is uncertain and the Contractor shall not be entitled to additional compensation above the unit prices stated in the Bill of Quantities by reason of increase or decrease of such quantities.

The location, direction, and depth of each grout hole shall be as shown on the Drawings or directed by the PMO/Engineer. The order in which the holes are drilled and the manner in which each hole is drilled and grouted, the proportions of all grout mix, the time of grouting, the pressure used in grouting, and all other details of the grouting operation shall be as specified in this CHAPTER or as directed by the PMO/Engineer.

The Contractor shall submit to the PMO/Engineer the operation plan and time schedule for grouting work for his approval prior to the commencement of the work.

During the grouting operation, reliable foremen shall be stationed at the mixing plant and in the vicinity of injection holes to ensure quality. All grouting operation shall be performed in the presence of the PMO/Engineer.

Unless otherwise approved, no grouting operation shall be performed until all concrete within a distance of 15 m has been in place for at least 4 weeks and drilling and water pressure test shall not be performed within a distance of 10 m from the section of hole being grouted or which has been grouted within the preceding 4 hours.

If, during the grouting of any hole, grout is found to flow from adjacent grout holes or grout connections in sufficient quantity to interfere seriously with the grouting operation or to cause appreciable loss of grout, such holes or connections may be capped temporarily. Where such capping is not essential, ungrouted holes shall be left open to facilitate the escape of air and water.

Unless otherwise directed by the PMO/Engineer, the grouting operation shall not be discontinued before completion of the work.

The Contractor shall submit to the PMO/Engineer the detail record in the form approved by the PMO/Engineer of all of drilling, grouting and incidental operations. Such record shall cover, but not limited to;

a. Daily progress record,

b. Actual injection record in detail (concentration, pressure, injection time, injection quantities) presented in tables and figures,

c. Lugeon value of each stage at the time of water pressure test,

d. Miscellaneous record and data as directed by the PMO/Engineer.

After the grouting work has been completed, the Contractor shall clean the work site to the satisfaction of the PMO/Engineer.

T3.2 Grout Material

Grout will consist of cement and water, or sand. Admixtures (if necessary) shall be subject to the approval of the PMO/Engineer.

Cement for grout shall be in conformity with the requirement of JIS R 5210-79 ordinary Portland cement or approved equivalent.

Mixing water for grout shall be reasonably clean and free from objectionable quantities of oil, silt, organic matter, alkali, salt, acid and other impurities.

Sand shall be clean, hard, durable and of proper grading, and it shall be free from objectionable quantities of dirt, silt, organic matter and other deleterious materials. Sand shall pass a 2.5 mm standard screen in 100% and pass a 0.6 mm screen in not less than 50%.

T3.3 Equipment

T3.3.1 Drilling equipment

Grout holes shall be drilled with either rotary type drills or percussion type drills, provided that where holes for subsequent grouting cannot be drilled satisfactorily with percussion type drills, the rotary type drills will be directed by the PMO/Engineer. The minimum diameter of each grout hole shall be not less than 45 mm.

T3.3.2 Water pressure testing equipment

Water pressure testing equipment shall include single packer type or double packer type water pressure test assemblies, water storage facilities, flowmeters, pressure gauge including gauge

savers, valves, hoses, fittings and pumps capable of delivering at least 60 litres/min. at 60 kg/cm^2 of the maximum pressure and maintaining constant pressures. Packers shall be of a mechanically expanding rubber ring type, or a pneumatically expanding sleeve type.

T3.3.3 Grout plant

The grout plant shall be of a type approved by the PMO/Engineer and shall be capable of supplying, mixing, agitating and pumping grout to fulfill the following requirements;

(1) Grout pumps of a reciprocating piston type having a capacity to force thick grout (water-cement ratio; 0.7) into the grout holes or grout connections in a continuous, uninterrupted flow at any pressure up to a maximum of 15 kg/cm2 , and at the maximum discharge of not less than 100 litres/min.

(2) Mixers of a mechanical operated, double drum, high speed (more than 800 r.p.m.) colloidal type with each drum capacity of not less than 200 litres. Apparatus shall be provided at the mixer for an accurate measurement of the grout materials so that the mix proportions can be carefully controlled and recorded.

(3) Pressure gauges having the maximum capacity of 20 to 25 kg/cm^2 and the reading intervals of not more than 0.5 kg/cm^2. The pressure gauge shall be provided at the pump and at the hole collar.

(4) Packers will be of a mechanically expanded rubber ring type or pneumatically expanded sleeve type. The type of packer shall be determined to suit rock conditions. The packer shall be designed so that they can be expanded to seal the drill hole at the specified position.

(5) The grout plant shall be maintained in a manner approved by the PMO/Engineer and so as to insure continuous and efficient performance during any grouting operation.

T3.4 Backfill Grouting

T3.4.1 General

The Contractor shall backfill with cement-sand mortar, under low pressure, gaps between the lining concrete and the surrounding rock, at the locations as shown on the Drawings or directed by the PMO/Engineer. The mortar shall be injected through steel pipes set in the concrete or drilled holes as shown on the Drawings.

The grout shall be composed of cement, sand and water. The flow value of mortar shall be in the range of 18 to 20 seconds.

No grouting operation shall be made until four (4) weeks has elapsed after placing of the lining concrete unless otherwise directed by the PMO/Engineer.

T3.4.2 Steel pipe for backfill grouting

Steel pipes, 50 mm diameter carbon steel pipe, shall be furnished and embedded by the Contractor for backfill grout connection and air vent. The pipes shall be held firmly in position and protected from damage while concrete is placed. A gap shall be left between the rock and the upper ends of pipes and the lower ends shall be made flush with the interior surface of the lining concrete.

Care shall be taken to avoid clogging or obstructing the embedded pipes and any pipe that becomes clogged or obstructed from any cause shall be thoroughly cleaned by the Contractor.

T3.4.3 Grouting operation

The grout shall be injected through grout pipes. Prior to starting and finishing the mortar injection, the cement grout with concentration of 1:4, 1:2 and 1:1 shall be injected. Mix proportion of mortar shall approximately be 1:2:1 of ratio of cement/sand/water by weight in principle unless otherwise directed by the PMO/Engineer.

Maximum allowable pressure shall be 2 kg/cm^2 measured at near the hole collar or as directed by the PMO/Engineer. Grouting shall be continued until the injection rate decreases to zero under the maximum allowable pressure, unless otherwise directed by the PMO/Engineer.

In case that injected mortar flows out from other holes, those holes shall be plugged and, if required, re-drilled afterwards by the use of drift for further grouting. The backfill grouting shall be completed by cement grouting injected after the pressure of backfill grouting reached at the maximum pressure of 2 kg/cm^2.

T3.5 Consolidation Grouting

T3.5.1 General

The Contractor shall perform the grouting under pressure to foundation rock of the spillway and elsewhere as shown on the Drawings or directed by the PMO/Engineer for the consolidation of the

rock. Holes shall be drilled, washed, pressure tested and grouted in a sequence which shall be determined in the field by the PMO/Engineer to suit the field conditions.

T3.5.2 Drilling grout holes

Grout holes shall be drilled by the Contractor into the formation, and the location, direction, order of drilling and depth of each hole shall be as shown on the Drawings or directed by the PMO/Engineer. The use of bentonite, rod dope, rod grease or other lubricants on the drilling rods or in the grout holes will not be permitted.

When the drilling of each hole has been completed, clean water shall be circulated through the hole until it is flushed free of all drill cuttings. Then the hole shall be protected from becoming clogged or obstructed by being capped temporarily until grouting operations requires it to be opened. Any hole that becomes obstructed before it is grouted shall be opened completely by the Contractor at his own expense.

T3.5.3 Grouting operation

Grouting shall be performed at one stage by setting a packer at the top of the stage. Provided that it is deemed necessary in the opinion of the PMO/Engineer, the grouting shall be carried out in stages. The grouting shall be started after conducting water pressure test prescribed in Clause T3.10.

The maximum allowable grouting pressure shall be 2 kg/cm^2 unless otherwise specified or directed by the PMO/Engineer.

Grouting shall be started with grout of a concentration of 1:10 in cement-water ratio by weight. Then, the concentration shall be successively changed thicker in accordance with the grout take as directed by the PMO/Engineer. The maximum concentration of grout shall be 1:1 unless otherwise specified or directed by the PMO/Engineer.

When the maximum allowable grouting pressure has been attained, the grouting shall be continued under the same pressure with the same concentration of grout until 30 minutes after the grout take decreases below 0.2 litres per minute per liner meter of the hole. After the grouting is completed, the final or residual pressure shall be maintained on the grout until the grout has set sufficiently to be retained in the hole.

T3.5.4 Concentration of grout

Unless otherwise specified or directed by the PMO/Engineer, grouting shall be started with grout of a concentration of 10:1 in water/cement ratio by weight. In accordance with changes in injection volume and pressure, the concentration of grout shall be successively changed to 6:1, 4:1, 2:1, 1:1.

Unless otherwise directed by the PMO/Engineer, standard injection rates for changing of grout concentration for consolidation grouting shall be as follows:

No.	Concentration of grout before changing (c/w)	Standard injection rates for changing (liter/10 min./m)	Concentration of grout after changing (c/w)
1	1:10	more than 100	1:6
2	1:6	" 50	1:4
3	1:4	" 30	1:2
4	1:2	" 20	1:1

Note : The maximum concentration shall be 1:1 unless otherwise specified or directed by the PMO/Engineer.

T3.5.5 Time of completion

When the maximum allowable pressure has been attained, injection of grout shall be continued keeping the same pressure by regulating the return line valve, and keeping the same concentration, until the injection rate decreases below 0.2 litres per minute per metre. Then the injection shall be continued under the maximum allowable pressure for 30 minutes.

T3.5.6 Rejection of prepared grout

If the grouting process is interrupted by failure of the equipment, or by any other reasons, for more than one hour, grout prepared in the mixer shall be wasted.

When the quality of the prepared grout is unsatisfactory in the judgement of the Engineer, it shall be wasted.

T3.5.7 Treatment of grout leakage

When injected grout leaks from cracks, fissures, etc. in the course of grouting, these sources of leakage shall be effectively sealed or caulked. During the grouting of a hole, adjacent holes shall be left uncapped to facilitate the passage of air and water. If sufficient grout leaks from these holes to

interfere with grouting, these holes shall be temporarily capped. These holes shall be grouted as soon as possible before the grout which has flowed into them has set.

T3.6 Curtain Grouting

T3.6.1 General

The Contractor shall perform the curtain grouting in stages in order to form a low permeability zone around the dam foundation, spillway and dam abutments at the location as shown on the Drawings or directed by the PMO/Engineer. Unless otherwise specified herein, the curtain grouting operation shall be performed in conformity with the stipulations prescribed in Clause T3.5.

The curtain grout holes shall be arranged at an interval of 2m on two parallel lines which are 1m apart and will be applied to the sections of dam foundation and spillway foundation.

The curtain grouting for the dam foundation in the area designated as shown on the Drawings shall not be carried out until the area to be grouted has been covered with the core materials not less than 15m, unless otherwise directed by the PMO/Engineer.

The curtain grouting for the spillway foundation shall be carried out from the surface of the first layer of levelling concrete for the overflow weir and side channel. The injection of grout shall not be started until four(4) weeks has elapsed after placing those concrete unless otherwise directed by the PMO/Engineer.

The curtain grouting shall be done in stage of 5m and by split-spacing method. The split-spacing method is the procedure in which so-called primary holes including pilot holes are drilled and grouted at first at intervals of 12m and subsequently so-called secondary holes are drilled and grouted midway between two adjacent primary holes, and then comes tertiary holes midway between the previously grouted two holes and so on.

T3.6.2 Drilling grout hole

No core recovery shall be required in drilling of grout hole unless otherwise directed by the PMO/Engineer.

The use of bentonite, rod rope, and grease or other lubricants on drill rod shall not be permitted.

The holes shall be drilled downward from the inspection gallery and the first layer of levelling concrete for overflow weir of spillway.

The diameter of the holes shall not be less than 45mm.

After completion of drilling each hole and prior to grouting, the hole shall be thoroughly washed with clean water from the end of drill rods inserted to the bottom of the hole. The washing shall be continued for not less than 10 minutes and until the return water is clear.

After washing, each hole shall be capped to prevent the entry of foreign materials. No drilling shall be carried out closer than 10 meter to a stage of hole being grouted or which has been grouted within the preceding 4 hours. Redrilling in the stage method shall not be carried out until six(6) hours has elapsed after the completion of previous grouting in the same hole.

Water pressure test shall be made by stage not more than 5m in the length unless otherwise directed by the PMO/Engineer. Whenever the drilling water is completely lost or heavy spring water is encountered, the drilling shall be stopped and the Contractor shall inform it to the POM/Engineer and shall perform necessary measures as directed by the PMO/Engineer.

T3.6.3 Grouting operation

After completion of water pressure test for the stage, the curtain grouting shall be started.

Packers shall be set at the top of section to be granted.

Unless otherwise directed by the PMO/Engineer, the curtain grouting procedure shall be as follows:

(1) Curtain grouting shall be commenced by injecting grout at the concentration of 1/10 in cement/water ratio by weight.

(2) The concentration of grout in cement to water ratio by weight shall be changed from 1:10 to 1:6, 1:4, 1:2, and 1:1 in the successive order whenever injection of 600 litres of grout in the same concentration does not increase the grout pressure.

(3) The grouting shall be suspended when the total volume of grout injected to a certain stage of the hole exceeds 4,000 liter but the grout pressure does not reach to the maximum allowable pressure specified for the stage. In this case, the Contractor shall inform it to the PMO/Engineer and perform the subsequent operations as directed by the PMO/Engineer.

(4) Maximum allowable refusal pressure for grouting each stage shall be as follows:

Stage	Depth (m)	Maximum allowable pressure (kg/cm^2)
1	0 - 5	3
2	5 - 10	5
3	10 - 15	7
4	15 - 20	10
5	20 - 25	15
6 or more	25 - 30 or more	15

The pressures tabulated on the above may be changed at the direction of the PMO/Engineer.

(5) Time of completion

Time of completion, rejection of pressure grout and treatment of leakage shall be same as stipulated in the sub-clauses T3.5.5, T3.5.6 and T3.5.7, respectively.

(6) The grout hole where the stage method is applied shall be backfilled with grout of 1:1 concentration or mortar unless otherwise specified or directed by the PMO/Engineer.

T3.6.4 Rim grouting

Curtain grouting for rim shall be carried out downward from the grout tunnels with hole arrangement on one lane and at the following intervals.

Type	Interval	Location
Rim L-1	3.0m	Left abutment
Rim L-2	2.0m	Left abutment
Rim R-1	2.0m	Right abutment
Rim R-2	fanned out at every 3 degrees	Right abutment

Other specifications shall be same as those for the curtain grouting, unless otherwise directed by the PMO/Engineer.

T3.6.5 Curtain grouting for foundation of the existing municipal dike

Curtain grouting for foundation of the existing municipal dike shall be carried out on the crest of the dike of which height is about 5m.

Grout holes shall be arranged on one lane and at 1.5 meter intervals as shown on the Drawings or as directed by the PMO/Engineer.

Other specification shall be same as those for the curtain grouting, unless otherwise directed by the PMO/Engineer.

T3.7 Contact Grouting

T3.7.1 General

The Contractor shall execute contact grouting at the locations and numbers as shown on the Drawings or directed by the PMO/Engineer.

Grouting method and procedure shall be proposed by the Contractor to the PMO/Engineer for his approval prior to commencement of the work. Grouting shall be injected through grout pipe system embedded in the concrete.

The Contractor shall fill, with grout of neat cement, the gaps between the concrete lining and plug concrete which remain unfilled after the placing of concrete due to any cause.

Contact grouting for the gaps shall be performed without limit until all gaps are completely filled.

Contact grouting shall not be performed within 4 weeks after the concrete has been placed.

T3.7.2 Contact grouting for backfill and plug concrete

(1) Grout pipe system

Grout pipe system in the plug or fill concrete shall consist of supply headers, return headers, vent headers and vent return headers, all being steel pipes of 40 mm in diameter, and of steel riser pipes of 25 mm in diameter which connect supply headers to grout outlets and vent headers to drilled holes. Valves shall be attached at the ends of all headers.

Prior to placing, all the pipes shall be cleaned inside and outside, of any objectionable materials in a manner to the satisfaction of the PMO/Engineer. The grout pipes shall be carefully laid and kept in position as shown on the Drawings or as directed by the PMO/Engineer when the concrete is placed.

Grout outlets of approved type shall be provided in positions and a manner as shown on the Drawings or as directed by the PMO/Engineer.

(2) Grouting operation

Prior to the grouting, all pipes and openings along contact joints shall be thoroughly washed with clean water injected through supply headers under a pressure not higher than the maximum allowable pressure. The pressurized water shall be kept in the pipes, and if leakage of water is found on the surface of the plug or any other location, it shall be caulked effectively in a manner to the satisfaction of the PMO/Engineer. The water shall be drained off before grouting is commenced.

The concentration of grout to be used shall range from 1:2 to 1:0.7 of cement to water by weight. The changing concentration shall be directed by the PMO/Engineer.

Grout shall be injected through the supply headers; when the injected grout leaks from the ends of the return headers, valves attached to these headers shall be closed one by one, until all header valves are finally closed. When the maximum allowable pressure has been attained and the injection rate has decreased to zero, the valve of the supply header shall be closed. Grout shall then be injected through the vent headers until the injection rate drops to zero under the maximum allowable pressure. After the entire process described above is completed, all valves shall be kept closed. The grouting shall be completed if the maximum pressure is maintained for 30 minutes.

The valves of headers shall not be opened until the injected grout has set and does not flow under release of pressure.

When injected grout leaks from cracks, fissures, etc., in the course of grouting, the leakage shall be effectively caulked as directed by the PMO/Engineer.

The maximum allowable pressure shall be determined at the site by the PMO/Engineer, but will be not more than 10 kg/cm^2.

T3.8 Blanket Grouting

T3.8.1 General

The Contractor shall execute blanket grouting in foundation of the impervious core zone of the dam. The holes, 5m (Type-I : 6 lanes) and 10m (Type-II : 2 lanes) deep in the foundation, shall be arranged at 3 m spacing on lines parallel to and on both sides of the curtain grouting lines, as shown on the Drawings.

The diameter of the holes shall be not less than 45 mm. The blanket grouting shall be done prior to commencement of the curtain grouting.

T3.8.2 Drilling grout hole

Grout holes shall be drilled by the Contractor at the location, to the direction, in the order of drilling and to the depth as shown on the Drawings or as directed by the PMO/Engineer. The use of bentonite, rod dope, rod-grease or other lubricants on drill rods shall not be permitted.

After completion of drilling, each hole shall be thoroughly washed with pressured air-water jet for not less than 5 minutes and until the return water is clear in case that the drilling has been made by percussion method. After washing, each hole shall be capped to prevent entry of foreign materials.

T3.8.3 Grouting operation

Grouting shall be started after completion of water pressure test when it is directed by the PMO/Engineer.

The maximum allowable grouting pressure shall be 2kgf/cm^2 for the depth up to 5 metres and 4kgf/cm^2 for the depth from 5 metres to 10 metres unless otherwise specified or directed by the PMO/Engineer.

T3.8.4 Concentration of grout

Unless otherwise directed by the PMO/Engineer, grouting shall be started with grout of a concentration of 1:10 cement/water ratio by weight. In accordance with changes in injection volume and pressure, the concentration of grout shall be successively changed to 1:6, 1:4, 1:2, 1:1.

Unless otherwise directed by the PMO/Engineer, standard injection rates for changing of grout concentration for blanket grouting shall be as follows:

No.	Concentration of grout before changing (c/w)	Standard injection rates for changing (liter/10 min./m)	Concentration of grout after changing (c/w)
1	1:10	more than 100	1:6
2	1:6	" 50	1:4
3	1:4	" 30	1:2
4	1:2	" 20	1:1

The maximum concentration shall be 1:1 unless otherwise directed by the PMO/Engineer.

T3.8.5 Time of completion

When the maximum allowable pressure has been attained, injection of grout shall be continued keeping the same pressure by regulating the return line valve, and keeping the same concentration, until the injection rate decreases below 0.2 liters per minute per meter. Then the injection shall be continued under the maximum allowable pressure for 30 minutes.

T3.8.6 Treatment of grout leakage

When injected grout leaks from cracks, fissures, etc., in the course of grouting, these shall be treated in the same manner as in the consolidation grouting as stipulated in the sub-clause T3.5.7.

T3.8.7 Rejection of prepared grout and treatment of grout leakage

Rejection of prepared grout and treatment of grout leakage shall be the same as stipulated in the sub-clauses T3.5.6 an T3.6.3, respectively.

T3.9 Check Hole

After completion of grouting, the effect of grouting will be checked by drilling holes inclined and water pressure testing at the locations as directed by the PMO/Engineer. A rotary type drill shall be used, when directed by the PMO/Engineer, to recover cores. The diameter of the test holes shall be not less than 65 mm nor greater than 87 mm, unless otherwise directed by the PMO/Engineer. This prescription does not mean to reject a drilling in larger diameter for the purpose of casing the hole when it is necessary.

The Contractor shall keep a driller's log, available to the PMO/Engineer, of each hole drilled, on which shall be recorded coordinates, location, elevation and final depth of the hole, the nature of the

rock drilled and other pertinent data usually recorded in logs of drill holes, such as core recovery percentages, R.Q.D., etc.

Core samples shall be placed in suitable wooden boxes with hinged covers to be furnished by the Contractor. The core samples in different runs shall be put in the box separated by a divider and shall be identified with a wooden tag inserted at the end of the run, upon which the depth of the run shall be marked. All core boxes shall be clearly marked with the number of the hole from which the core is taken and the date of drilling. After core inspection and the logging work have been completed, those core boxes shall be delivered by the Contractor to the place of storage at the Site as designated by the PMO/Engineer.

Before the core boxes are stocked all core samples shall be photographed in colour at a reduced scale of 1:7 so that details marked on the inside of the box are visible in the photo. A linear scale shall be included in the photo. The Contractor shall supply to the PMO/Engineer the negative and two positives of each photo. The core samples shall be washed before photographing and shall be still damp when photographing, so as to bring out the nature and characteristics of the rock.

Water pressure tests in the check holes shall be done in descending stage of each 5 m length or less in the manner as prescribed in Clause T3.10 as directed by the PMO/Engineer .

The test holes, including pilot holes and check holes for the effect of grouting, shall be grouted by descending stage of every 5 m unless otherwise directed by the PMO/Engineer.

Unless otherwise directed by the PMO/Engineer, the test holes shall be tightly packed to the full length with mortar or dense cement grout.

T3.10 Water Pressure Test

Prior to commencement of curtain, consolidation and blanket groutings, water pressure test for each hole shall be performed by the Contractor in order to assess the rock condition. Water injection shall be continued at least for 10 minutes under a constant pressure not exceeding the maximum allowable refusal pressure for grouting of the stage, after water take has become stable.

The water pressure test shall be done in core-drilled check holes or other holes as directed by the PMO/Engineer. Packers shall be set tightly within about 0.5 m above the top of the stage to be tested and clean water shall be pumped into the hole under varied steps of pressures of 1kgf/cm^2, 4kgf/cm^2, 7kgf/cm^2, 10kgf/cm^2, 7kgs/cm^2, 4kgf/cm^2 and 1kgf/cm^2. Water-take shall be observed for 10 minutes at each stage of the pressure.

The Contractor shall record all necessary data of each test, including hole number, stage, elevation of manometer, elevation of water table, position of packer, pressure, injection rate, etc. and submit them to the PMO/Engineer. The head loss produced during the test, between the manometer and the test section, shall be computed.

For a water pressure test under several different pressures, the results of the water pressure test shall be supplied in the form of graphs, all of which at the same scale, showing in abscissa the effective pressures in the stage, taking into account the static head and the loss of head, and in ordinates the rates of outflowing water in litre per minute and per metre.

T3.11 Drilling Holes for Piezometer Installation

Holes for installation of piezometer or pore pressure meter shall be drilled with the diameter, to the depth and at the angle as shown on the Drawings or as directed by the PMO/Engineer. On completion of the drilling, the holes shall be washed with pressured clean water until the return water is clear, and shall be capped to protect the holes from entrance of any foreign material until the piezometers are installed. Measurement and payment for drilling holes for piezometer installation are described in CHAPTER 10 MEASURING APPARATUS.

T3.12 Measurement and Payment

T3.12.1 Drilling grout hole

Measurement for payment for drilling curtain, blanket and consolidation grout holes will be made on the basis of linear metre in the length of the grout hole which has been drilled without core sampling in accordance with the Specification and/or the direction of the PMO/Engineer. The length of the section of grout hole which has been re-drilled for an ordinary procedure of down-stage grouting or because of the Contractor's deficiency or failure shall not be subject to measurement and payment. The length of drilling for casing the hole and for clearing inside the hole once drilled shall not be subject to measurement and payment.

Measurement for payment for the ranges of depth of drilling for curtain, blanket and consolidation grout holes, will be made for drilling the sections of grout holes within the designated range of depth exclusively. Accordingly, different unit prices will be applied for drilling different parts of a grout hole, according to depth of the parts. Unit price of drilling can also be varied according to angle of the hole, that is vertical hole and inclined hole.

Payment will be made at the unit prices per meter stated in the Bill of Quantities, which unit prices shall include all costs of furnishing labour, material, plants and of all operations required for drilling through rock and concrete, shifting machines, pressure washing of drill hole, protecting hole until grouted, re-drilling hardened grout in case of the descending stage method and all incidental work concerned with drilling.

T3.12.2 Core drilling test hole

Measurement for payment for core drilling test hole downward, will be made on the basis of linear metre in the length of the test hole which has been drilled in accordance with the Specification and/or the direction of the PMO/Engineer. The length of the sections of test hole which have been re-drilled because of the Contractor's deficiency or failure shall not be subject to measurement for payment. The length of drilling for casing the hole and for clearing inside the hole once drilled shall not be subject to measurement for payment.

Measurement for payment for the range of depth of drilling for core drilling test hole will be made for drilling the sections of test holes within the designated range of depth exclusively. Accordingly, different unit prices will be applied for drilling different parts of a test hole, according to depth exclusively. Accordingly, different unit prices will be applied for drilling different parts of a test hole, according to depth of the parts.

Payment will be made at the unit prices per meter stated in the Bill of Quantities which unit price shall include all costs of furnishing labour, material, plants and of all operations required for core-drilling through rock and concrete, shifting machines, pressure washing of drill hole, protecting hole until grouted, re-drilling hardened grout for grouting in the descending stage method and all incidental work concerned with core drilling.

T3.12.3 Water pressure test in borehole

Measurement for payment for water pressure test in borehole, will be made on the basis of times when water intake in test sections under a single or varied pressures has been measured for water pressure test in accordance with the Specifications and/or directed or approved by the PMO/Engineer.

Payment will be made at the unit prices per time stated in the Bill of Quantities, which unit prices shall include all costs of furnishing labour, material, plants and of operations required for the water pressure test and all incidental work concerned.

T3.12.4 Furnishing and setting up packer

Measurement for payment for furnishing and setting up packer, will be made on the basis of time of packer settings which have been actually made for the purpose of water pressure tests and/or grouting except backfill grouting in the grout holes and the test holes.

Measurement for payment for furnishing and setting up packer in sequence of descending stages from the neck of hole toward the bottom, will be made for the packer setting-up in the hole or the part of hole which has been water-pressure-tested and/or grouted in the descending stage method.

Measurement for payment for the ranges of depth, as designated in the Bill of Quantities, will be made of the packer setting-up within the designated range of depth exclusively.

Payment will be made at the unit price per time stated in the Bill of Quantities, which unit price shall include all costs of furnishing labour, material, equipment and of all operations required for setting and removing packers, connecting to injection pipes and manifold and all incidental work concerned.

T3.12.5 Curtain, blanket and consolidation groutings

Measurement for payment for curtain, blanket and consolidation groutings, will be made on the basis of ton in the weight of dry cement actually injected into grout holes and test holes.

Payment will be made at the unit price per ton stated in the Bill of Quantities, which unit price shall include all costs of furnishing labour, material other than grout material, plants, grout supply and return systems and all operations required for connecting grout supply line with grout pipe or injection pipe, washing hole, handling grout material, mixing and injecting grout, re-drilling holes if they become choked by flowing out of grout, and all incidental work concerned with grouting.

T3.12.6 Grout material

Measurement for payment for supply of grout material, will be made on the basis of ton in the weight of dry grout materials such as cement, sand and bentonite if directed, which have been actually injected into curtain, blanket and consolidation grout holes and test holes and used for slush grouting, except the grout materials for the backfill grouting and curtain grouting for repair of existing municipal dike.

Payment will be made at the unit price per ton stated in the Bill of Quantities, which unit price shall include all costs of the materials and supplying them to Site. The grout materials which have been

wasted or compelled to be wasted without appropriate reason or because of the Contractor's failure shall not be subject to measurement for payment.

T3.12.7 Contact grouting

Measurement and payment for contact grouting in periphery of tunnel plug or fill concrete will be made at Contract lump sum prices stated in the Bill of Quantities, which lump sum prices for contact grouting shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing and installing of metal tubing with headers, risers, grooves, grout outlets and grout stops, grout supply and return systems and of all operations required for handling, mixing and injecting grout and other items necessary to complete the works.

T3.12.8 Backfill grouting

Measurement for payment of backfill grouting for tunnels will be made of the volume of cement-sand mortar actually injected as shown on the Drawings or as directed by the PMO/Engineer.

Payment for backfill grouting will be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all the labour, materials and equipment, including furnishing and installing steel pipes and for all incidental work connected thereto.

T3.12.9 Curtain grouting for repair of existing municipal dike

Measurement for payment of curtain grouting for repair of existing municipal dike will be made of the depth in meter actually drilled and grouted in accordance with Drawings or as directed by the PMO/Engineer.

Payment for curtain grouting will be made at the unit prices per meter stated in the Bill of Quantities, which unit prices shall include the cost of all the labour, material, equipment and all incidental works connected thereto.

T3.13 Drilling Drainage Holes

T3.13.1 Drilling operation

Drainage holes for pressure relief shall be drilled, as shown on the Drawings or as directed by the PMO/Engineer, into surrounding formation through concrete lining of the diversion tunnel in downstream of the main plug. The diameter, depth and direction thereof shall be as shown on the Drawings or as directed by the PMO/Engineer.

The drainage holes shall be generally be drilled upward. Unless so requested by the PMO/Engineer, the drilling may be made of drilling, the sides of all holes shall be cleaned with a scraping pool of a type directing high pressure jet laterally onto the sides of the holes, so as to set perforated P.V.C. drains pipes in the holes smoothly as shown on the Drawings or as directed by the PMO/Engineer.

T3.13.2 Measurement and payment

Measurement for payment for drilling drainage holes will be made on the basis of the actual depth in linear meter of the hole drilled through soil, rock and concrete.

Payment will be made at the unit price per meter stated in the Bill of Quantities, which unit price shall include all costs of furnishing labour, material, equipment and of all operation required for drilling through soil, rock and concrete, and all incidental works concerned with the drilling.