GOVERNMENT OF INDIA
MINISTRY OF IRRIGATION

REPORT
OF
COMMITTEE ON COST CONTROL
OF
RIVER VALLEY PROJECTS

VOLUME-III

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REPORT OF
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VOLUME III

SPECIFICATIONS

MASONRY DAM AND EARTH DAM

RAJGHAT DAM PROJECT

(U.P.)

PREFACE

The report of the Committee on Cost Control of River Valley Project comprise of Five Volumes. The report of the Committee on specific terms of reference and the recommendation are given in Volume I.

The Volume II of the report deals with Analysis of Rates both for Manual as well as Machinery work.

A review of the contract specifications of works adopted by various States show that every State project evolves its own specifications. It is felt that no uniform contract specifications, centrally drafted, can serve the purpose of every project due to enherent variations from project to project as well as in local practices ensure economy in construction. It is felt that in a large number of items connected with River Valley Project a standard pattern of uniform contract specifications can be drawn up. The effort has been made to obtain contractual specifications of few of the Major projects taken up recently for construction. These are given in volume III, IV and V for reference and guidance of project authorities.

SPECIFICATIONS

CONSTRUCTION OF MASONRY DAM AND APPURTENANT WORKS

C O N T E N T S

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PART-II

(Technical Provisions of Contract)

CONTENTS

USE OF EXCAVATED MATERIAL BY CONTRACTOR FREE OF COST

Notwithstanding any provision to the contrary contained in this document, the contractor shall be allowed to use suitable stone obtained from excavation of foundation free of cost in the execution of works under this contract. The decision of the Executive Engineer regarding the suitability of stones shall be final and binding of the contractor. The disposal of all un-used excavated material shall be governed by the provisions of this document.

SECTION-1

CARE AND DIVERSION

1.0.0 Care and Diversion

1.1.0 General

1.1.1 The river Betwa across which Rajghat Masonry Dam is proposed for construction has a river bed comprising over-burden and rock. The rocks exposed are predominently granite associated with minor proportions of quartzite and quartz-epidote rocks. The out crops are blocky, sheeted or massive depending upon the frequency of joints. The river has defined banks of rock over laid with overburden.

1.1.2 Non-monsoon discharge of the river during part of the working season from 1st Nov. to 15th June has been estimated to be 226 cumecs. This discharge has to be diverted suitably during the part working season from 1st Nov. to 15th June every year. The approximate 10-daily discharge of river Betwa near the dam site as available are contained in Part-III.

1.1.3 The diversion of non-monsoon discharge of River Betwa is proposed through Coffer Dam (Diversion flume). The scheme comprises construction of Masonry walls to provide a rectangular channel tied to the banks on the Upstream and Downstream of the masonry dam. The general arrangements of the scheme and its phases of construction are shown in the drawing attached in Part-III.

1.1.4 The Board has constructed the 1st Phase of the diversion scheme in which the masonry walls have been connected to the banks on the upstream and downstream of the proposed masonry dam to provide a rectangular channel having a bed width of 20 metres and is passing through Block No.15 of the proposed masonry Dam.

1.1.5 Subsequent phase of river diversion has to be constructed by the contractor such that the non-monsoon flow is channelised to pass through the river sluices of the masonry dam. The river sluices are proposed in block Nos. 18, 19 & 20 and their construction alongwith the works on the downstream of the masonry dam (Bucket/stilling basin) have to be constructed by the contractor as a part of the permanent work under this contract.

1.2.0 Excavation

1.2.1 General

Excavation has to be carried out in river bed and in the banks for laying foundation of the coffer dam walls. Excavation will be carried out after setting out of the works and cleaning the site.

1.2.2 Common Excavation

Common excavation shall include all over-burden dry or wet restricted to materials such as silt, earth, clay, sand, gravel, soft moorum, soft & disintegrated rock which can be removed by hand or by power showels or by drag line, without continuous and systematic blasting, barring and wedging.

1.2.3(i)Rock Excavation

Rock excavation shall include all excavation by blasting, barring, channelising, drilling and broaching, chieseling which in the opinion of the Executive Engineer cannot be efficiently worked out otherwise. It will also include removal of all boulders or of loose rock which are more than one metre in any direction. Excavation in rock may be progressed by systematic line drilling and broaching or by chieseling in locations to be specified by the Executive Engineer as a measure of safety of the works constructed in the neighbourhood of excavation or where the nature of rock so requires.

(ii) Blasting

All storing, handling, transport and use of explosives, detonators and the equipment thereof shall be strictly in accordance with the Indian Explosives Act and Explosives Rules - 1940 as amended from time to time.

1.2.4 Final Excavation, Foundation Preparation and Cleaning

Masonry walls have to be founded on generally hard rock as approved by the Executive Engineer. The foundation shall be prepared to present an un-even rock surface with rock out crops not projecting more than 15 cm. above the final level. The foundation trench will be cleared of all loose materials which can be removed by hand, air and water jet. Foundations will then be made dry by sponging.

1.2.5 Disposal

All excavated materials shall be disposed of within a radial distance of 1 km. from the site of excavation. The place of disposal

shall be as directed by the Executive Engineer. Materials obtained in common excavation shall be separated from the materials obtained in rock excavation. The disposal of common excavation shall be in waste piles which shall generally be trimmed off. The disposal of rock excavation shall be done in stock piles suitably trimmed off. All rock excavation shall be stacked properly in stock piles of selected materials separately at sites as directed by the Executive Engineer.

1.2.6 Pay Line and Over-breakage

All excavation shall be done according to lines levels and dimensions as shown in the drawing or as directed by the Executive Engineer. All over-breakage and excess excavation shall be carefully avoided. Silt deposited, if any, during the course of construction, due to slips, floods etc., shall have to be removed by the contractor and the quantities will not be included in the pay line.

1.2.7 Measurements and Payments

General

(i) The price entered in the schedule for various items of excavation is inclusive of all compensation for mobilising, de-mobilising, supply of equipments, materials, labour, supervision, cleaning of site, over-breakage done (without permission of Executive Engineer) filling of over-breakage by approved materials, clearance of silt deposited and all incidental work except for any item specifically exempted therefrom and for which in addition a specific payment item has been included in the schedule under Care and Diversion.

(ii) Before commencement of works, levels, levels shall be taken on cross section situated 3 metres apart at rightangles to the alignment of masonry wall. Levels on the cross section shall be taken at an interval of 1 metre along the cross section. After the completion of excavation in a particular class of excavation, the levels on the initial cross section shall again be taken at an interval of 1 metre along the cross section. The volume of excavation for a particular class of excavation shall be worked out with these cross sections. The net volume of common excavation shall be obtained after deducting the volume of boulder classified as rock excavation and contained in the line of common excavation. The rock excavation quantities shall also include the volume of boulders classified as rock in accordance with the provisions of the section. The volume of these boulders in common excavation/rock excavation shall be pre-determined.

(iii) Payment for various items of excavation under care and diversion shall be made on the basis of unit price per cum. entered for the particular item in the schedule.

1.3.0 Dewatering

1.3.1 General

Dewatering shall be carried out as per approval of the Executive Engineer to enable excavation, mucking, inspection, final preparation of surface, providing anchor bars, laying of concrete and masonry, grouting and allied constructional activities.

1.3.2 Dewatering by Electric Pumps

Electric pumps of only requisite capacity shall be installed in order to handle the seepage encountered. The switchgears and pumping sets shall be maintained in satisfactory condition to avoid loss of energy. Circuits for pumping set shall be isolated from any other electric installation.

1.3.3 Dewatering by Diesel Pumps

Diesel pumps of requisite capacity shall be installed in order to handle the seepage encountered. All costs of P.O.L., running and maintenance shall be deemed to have been included in the unit price for the particular item in the schedule of bid.

1.3.4 Measurements and Payment

(i) Dewatering by Electric Pumps

Measurements for payment of dewatering by electric pumps shall be on the basis of units of electrical energy consumed in dewatering through these pumps which shall be obtained from the difference of initial and final readings of the energy meters. The energy meters shall be carrying test certificates and will be installed by the contractor at his own cost. In case any energy meter gets defective, the contractor shall arrange to replace it by another tested meter within 3 days. Measurements of energy consumed in dewatering for these 3 days shall be based on the average consumption during the preceding 3 day period. In case the contractor fails to replace the defective energy meter within the 3 day period, no measurements for energy so consumed shall be taken. Payment for dewatering by eletric pumps shall be made on the basis of electrical energy consumed at the unit price entered for the particular item in the schedule of bid.

(ii) Dewatering by Diesel Pumps

Measurements for dewatering by diesel pumps shall be done in terms of Horse-Power Hours, the diesel pump has been used for dewatering purposes. The rated Horse Power of the pump as per manufacturer's specifications shall be the Horse Power of the pump.

Payment for dewatering by diesel pumps shall be made on the basis of unit price entered for the particular item in the schedule of bid.

1.4 Drilling holes for Anchor Bars and Grouting Bars in Place

1.4.1 General

Drilling will have to be carried out in foundation rock of masonry walls of the coffer dam for providing anchor bars. The number and site of these bars shall be as per drawing or as directed by the Executive Engineer.

1.4.2 Drilling Holes

Drilling shall be carried by means of dry percussion drilling to provide holes upto 40 mm dia with a minimum of 1½ times the dia. of anchor bars to be placed. The holes shall be drilled upto a depth as indicated in the drawing or as directed by the Executive Engineer. The holes shall be washed by air water-jet to remove loose chips.

1.4.3 Anchor Bars

Anchor bars of tor-steel of size 16 mm dia. shall be provided in length and of shape as indicated in the drawing or as directed by the Executive Engineer. The bars shall be cleaned and will be of total length of 2.8 metres each.

1.4.4 Grouting of Bars

The holes shall be cleared of all water and neat cement slurry of required consistency as approved by the Executive Engineer shall be placed into the hole to fill up completely and compactly. Anchor bars shall be forced into the hole before the grout has taken initial set. The anchor bar shall be vibrated or rapped into the hole until entire surface of the embedded portion of the bar is in intimate contact with the grout. Special care shall be taken to ensure against movement of the bars which have been placed. Anchor bars shall be placed into the holes not less than 3 days in advance of the concreting operation to allow the grout to become set. Special care shall be taken to prevent movements of the bars after the grout has been set. Anchor bars if found loose after setting of grout shall be replaced by and at the expense of the contractor.

1.4.5 Measurement and Payment

The rate for the item "drilling holes for anchor bars and grouting bars in places" is inclusive of all compensation for mobilising, de-mobilising, supply of equipment and materials, labour, supervision,

cost of anchor bars 2.8 m. each grout and all other incidental work except for any item specifically exempted therefrom and for which in addition a specific payment item has been included in the schedule. Payment for drilling holes and providing anchor bars shall be at the unit rate per metre of the depth of hole drilled and grouted as provided in the specific item of schedule of bid.

1.5.0 Cement Concrete

1.5.1 General

Concrete which is to be used in foundation and coping of masonry walls of coffer dam shall be composed of cement, sand, coarse, aggregate, water and other admixtures as specified, all well mixed and brought to the proper consistency.

1.5.2 Materials

(i) Cement

Cement shall be ordinary portland cement conforming to IS 269 - 1976 (3rd revision) and as revised from time to time. The handling, storage and use of cement shall be in accordance with the relevant paras under section "Cement Concrete" contained herein-after for masonry dam.

(ii) Water

The water used shall be clean and free from any injurious amount of deletrious substances such as, but not limited to, silt, sewage, oil, acid, alkali, salts and organic matters.

(iii) Sand

Sand which may be of natural origin or obtained through processing shall conform to the provisions contained in the particular item under section "cement concrete" contained here-in-after for Masonry Dam.

(iv) Coarse Aggregate

The coarse aggregate to be used shall conform to relevant paras under section "Cement concrete" contained here-in-after for Masonry Dam.

(v) Admixtures

Admixtures such as wetting agents, air entraining agents etc., shall be used only under specific authorisation. The proportions and methods used shall be as directed by the Executive Engineer.

1.5.3 Classification

The concrete classification is related to the specified 28 days compressive strength and shall conform with the requirements mentioned in the drawings attached in Part-III or as directed by the Executive Engineer. Tests shall be carried out on the concrete at specified intervals during the progress of work and the mix modified as necessary in order to consistently secure the required strength, workability, density and impermeability together with maximum practicable economy. It is contemplated that concrete will range in character from the maximum aggregate size of 40 mm with a strength of 100 kg/Cm^2 in foundation to maximum aggregate size of 20 mm with a strength of 150 kg/Cm^2 in coping.

1.5.4 Tests

The concrete shall be of uniform consistency and quality throughout any pour and for similar parts of the same structure. The control of concrete has to be based, besides other factors, by maintaining a fairly uniform slump at the point of placement and keeping the water cement ratio as fairly as practicable to the desired value for the purpose. The slump shall be measured in accordance with the provision of the relevant I.S. Code. A minimum of 3 specimen tests shall be made for each 120 cum of each class of concrete for a give age. There shall be atleast 3 specimen tests for each day of concreting even if only a few cum. of a particular cement concrete is manufactured in a day. The tests shall certify the following criteria:

(i) The average strength of any 3 consecutive sample strengths shall be greater than the specified strength;

(ii) The over-all coefficient of variation for any 10 consecutive sample strengths shall be less than 0.15

(iii) Not more than 10% of the specimen strengths shall be less than 85% of the specified strength.

Additional tests shall be carried out as and when directed.

1.5.5 Batching Mixing and Transporting

Batching, mixing and transporting shall be in accordance with the relevant paras of the section "Cement concrete" for Masonry Dam contained herein-after.

1.5.6 Preparation for Placing of Concrete, Forms and Removal of Forms

(i) After the foundation level has been attained, foundation shall be cleared as described earlier in this section. All rock surfaces in

the bed and sides shall be removed of loose materials and shall be free from standing water, mud, debris etc. The surfaces upon which or against which concrete has to be placed will be kept wet for atleast 24 hours before placement of concrete. No concrete shall be placed unless the foundation has been inspected and approved by the Executive Engineer.

(ii) Form works for foundation concrete shall be of timber sheathing or lining of any type and grade meeting the dimensional requirements of surface finish. Steel sheathing or steel lining may also be used as forms for concrete in copping, timber sheathing or lining of common grade timber or better or ply-wood sheathing or lining shall be used. Steel sheathing or steel lining which is strongly supported may also be used as forms.

(iii) The forms may be removed as soon as the concrete has hardened but not earlier than 24 hours to prevent damage by careful form removal, thus facilitating satisfactory progress with specified curing and earliest practicable repair of surface imperfection. Subject to approval, forms of concrete surface close to excavated rock surface may be left in place provided that the distance between the concrete surface and the rock is less than 400 mm and that the forms are not exposed to view after completion of the work.

1.5.7 Placing and Compacting of Concrete

(i) Concrete shall be placed directly in its final position and shall not be caused to flow in any manner permitting to cause segregation. Delays may occur in placing subsequent layer of concrete within the specified lift of concrete. When placement is resumed while concrete is green and therefore capable of ready bonding, joining of the concrete placed against this surface is obtained by thoroughly and systematically vibrating over the entire area by penetration of the vibrator into the lower layer of concrete. In case the work has been suspended for a long time, the next layer shall be laid after thorough clean-up and applying layer of mortar 15 mm to 20 mm thick of the same proportion as of the concrete. The cost of mortar shall be borne by the contractor.

(ii) Compaction of concrete shall wherever practicable be carried out by use of immersion type vibrators. Concrete vibrators having vibrating heads upto 50 mm in dia shall be operated at speed of atleast 7000 RPM when immersed in concrete. Concrete shall be vibrated to give a compact mass without causing excessive vibration and the needle shall be used in near vertical position and slowly withdrawn. In no case concrete vibrator should be used to cause flow of concrete.

1.5.8 Curing

Curing shall be carried out in accordance with the relevant provisions under section "concrete work" of masonry dam contained hereinafter.

1.5.9 Repair of Concrete

Concrete shall be repaired by dry-pack method as described in the relevant paras of repairs of concrete under section "Cement concrete" in Masonry Dam contained here-in-after.

1.5.10 Measurements and Payment

The prices entered in the schedule for the incorporation of various classes of concrete required of this section shall be all inclusive constituting full compensation for mobilising, demobilising, supplying all equipment, forms, materials, labour, supervision and all incidental works including cement slurry with the cost of cement except for any item specifically exempted therefrom and for which in addition a specific payment item has been indicated in the schedule of bid. Except as otherwise expressly provided for in the specifications, measurements of concrete for payment shall be made on the basis of volume of concrete calculated as being contained within the concrete outlines shown on the relevant drawings. Measurements for payment for the concrete laid in pockets in the foundation shall be made on the basis of the volume pocket filled. No measurement shall be made for the concrete back-fill beyond the minimum lines of excavation shown on the drawing except where such payment is specifically authorised. The rates of various classifications of concrete in the schedule of bids shall be deemed to be on the assumption that in all types of concrete 200 Kg. of cement is used per cum. of finished concrete. If the contractor is required to use any different content of cement per cum. of concrete, the payment for variation in cement content in concrete shall be adjusted upward or downward on the following assumptions:

(i) That a consumption of 200 kg of cement per cum of concrete is covered in the rates for various classifications of concrete.

(ii) That all variations necessitated in labour, material and equipment is covered in the item "variation in cement content in concrete".

The cement content for the purpose of calculating "variation in cement content" shall be arrived at by dividing total cement consumption in all types of concrete as recorded at the mixing point for concrete and mortar approved for placement by the Executive Engineer by the total volume of finished concrete placed within the prescribed lines and grades. Payment for the various classes of concrete shall be made on the basis of unit price per cum. entered in respect of items in the schedule of bid.

1.6.0 Masonry

1.6.1 General

Masonry for the coffer dam shall be composed of stone placed in a matrix of cement, sand, water and any other admixture as specified.

1.6.2 Materials

(i) Cement: Cement shall unless otherwise specified be ordinary portland cement conforming to the Indian Standard specifications I.S. 269 - 1976 (third revision) as amended from time to time.

(ii) Water: The water shall be clean and free from injurious amount of deleterious substances such as, but not limited to silt, sewage, oil, acid, alkali, salts and organic matter.

(iii) Sand: The sand shall be conforming to the specifications laid in the relevant portion of section "masonry" under masonry dam.

(iv) Admixtures: Admixtures such as entraining agent shall be used only under specific authority of the Executive Engineer and wherever so permitted, the proportion and the methods of use shall be as directed by the Executive Engineer.

(v) Stone: The stone used for masonry shall be clean, hard, durable, tough and free from decay, sand, holes, weathered portions, adhering coatings, veins, flaws, cracks, soft seams, sharp corners and other defects. The stone shall be quarried only from approved quarries and shall be subject to thorough inspection and approval before use on the coffer dam. No individual stone for use in masonry shall be less than 40 kg. in weight. Spalls upto 20 cm. size shall be used to wedge into thick mortar spaces.

1.6.3 Cement Mortar

Cement mortar shall consist of cement, sand, water and other approved admixture, as required, each complying with its own specifications. The proportions of all materials entering into the mortar shall be based on adequate laboratory studies to ensure attainment of the standards required by these specifications. Cement mortar for use in masonry shall invariably be produced in mechanical mixture and by weigh batching. In exceptional circumstances under specific orders from Executive Engineer, volumetric batching may be resorted to. Hand mixing will not be permitted unless total requirement of mortar on a day is so small in quantity for use on a particular day that mechanical mixing by the smallest available mixer will produce mortar in quantity larger than the total requirement, thereby causing wastage of mortar. Mixing

and transporting of masonry shall be carried out as per specifications given under relevant clauses of section "masonry in dam and appurtenant works" contained here-in-after.

1.6.4 Tests

The test shall be made on the mortar at specific intervals during the progress of work and the mixing modified as necessary in order to consistently secure the required strength, work load, density, impermeability together with maximum possible economy. It is proposed to use the mortar of 100 Kg per Cm^2 at 28 days period. Tests for the compressive strength of mortar shall be in accordance with the procedure laid down in the Indian Standard specifications IS-2250 Appendix-A as amended from time to time.

A minimum of three test specimens shall be made for each 120 cum. of each class of mortar for a given age. There shall be atleast three test specimens of mortar for each day of masonry work even if only a few cubic metres of the particular mortar is manufactured in a day.

The tests shall satisfy the following criteria:

(a) The average strength of any three consecutive sample strength shall be greater than the specified strength.

(b) The over-all coefficient of variation for any ten consecutive sample strengths shall be less than 0.15.

(c) Not more than ten percent of the specimen strength shall be less than 85 percent of the specified strength.

Additional tests shall be carried out as and when directed.

1.6.5 Random Rubble Masonry

Immediately before placing the masonry surface of concrete on which masonry is to be placed shall be cleaned with wire brush, stiff broom, air water jet and any loose material shall be clearly removed. The surface will then be dried with sponges so that no standing pool of water exists. Masonry shall be commenced only after the preparation has been approved by the Executive Engineer. The masonry work shall be so arranged that a layer of masonry once laid is not subjected to any disturbance, either from the placement of subsequent layers or from any incidental traffic on the wall from the time the mortar in the first layer has lost its plasticity (workability) to atleast 24 hours from its placement. The stones shall be set on their flat beds as received from the quarry and without further dressing except knocking out weak corners and sharp edges. Stones shall be carefully laid so as to break

the joints as much as possible and solidly beded with joints. The mortar should be worked by a trowel to a quacky mass and the selected stones laid on flat bed and shaken to sink into mortar squeezing it out of the sides. The spalls shall be hammered down by a wooden mallet in the mortar filled in between the stones so as to reduce the thickness of the mortar joints. Additional mortar shall be used in the intervening spaces and well worked by the trowel and a light hand bar 12 mm dia. and 0.6 metre long to mix up well with the bottom mortar and the stones vibrated to the extent necessary to bring up all excess mortar and entrapped air in the mortar. The content or mortar in random rubble masonry shall not be less than 40% of the masonry. Masonry surfaces which have been exposed for a long time before the succeeding layer is built shall be treated in the same way as preparation of concrete surface for commencing masonry described above and in addition neat cement slurry shall be spread on the old masonry layer before commencing laying of next layer.

1.6.6 Curing

Curing of masonry shall be carried out in accordance with the specifications provided in the relevant portion of the section "cement concrete" given under masonry dam.

1.6.7 Measurement and Payment

1.6.7.1 General

The prices entered in the schedule for the incorporation of the various classes of masonry required by this section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition a specific payment item has been included in the schedule.

1.6.7.2 Measurement of the masonry for payment shall be made on the basis of the volume of the masonry work calculated as being contained within the relevant outlines shown on the drawings.

1.6.7.3 No allowance shall be made for the masonry back-fill beyond the minimum lines of excavation shown on the drawings except where such payment is specifically authorised. Measurement of masonry shall be made without deductions for space occupied by reinforcement.

1.6.7.4 Rates of various classifications of stone masonry in the schedule of bids are to be based on the assumption that in all types of masonry 150 kg. of cement is used per cubic metre of finished masonry. If the contractor is required to use any different content of cement per cubic metre of masonry, the payment to contractor shall be adjusted upward or

downward on the basis of such variation in cement content at the unit rate for the item "variation in cement content in stone masonry from 150 kg per cum. of masonry". The cement content for the purpose of calculating variation in cement content shall be arrived by dividing total cement consumption in all types of masonry as recorded at the mixing point of mortar (approved for use by the Executive Engineer) by the total volume of finished masonry placed within the prescribed lines and grades and shall be deemed to cover all labour, material and equipment employed for it.

1.6.7.5 Payment for the masonry shall be made on the basis of the unit price per cum. entered for the particular item in the schedule.

1.7.0 Cement Pointing and Cement Plaster

1.7.1 General

Cement pointing and cement plaster shall be required to be executed on the faces and sides of coffer dam walls. The work shall be executed and measurements carried out in accordance with the specification and provisions in relevant section for cement pointing and cement plaster contained here-in-after under "masonry" of Masonry Dam and paid on the basis of unit price for the relevant item in the schedule.

1.8.0 Maintenance of Coffer Dam

1.8.1 The contractor shall construct other temporary diversion and protective works, and shall furnish all materials required thereof. The contractor shall also furnish, install, maintain and operate all necessary pumping and other equipment for unwatering the various parts of the work and for maintaining the foundation, foundation galleries, shafts, pump drainage systems, grouting systems and other parts of the work free from water as required for constructing each part of the work and as required after any work is completed, for inspecting safety installation by the Board or for any reason determined to be necessary by the Executive Engineer. The galleries, shafts and sumps shall be lighted even though permanent lighting facilities may not be required and shall be readily accessible at all times. The contractor shall pump all water from the site of the dam and other appurtenant works, and shall keep the foundations free of water while excavating, preparing the foundation, pressure grouting, while placing concrete, or as otherwise required for completing the work and shall be entitled to no claim for damages or additional compensation by reason of any amount of water that may leak through, under or around coffer dams or other diversion and protective works.

Ten daily discharge of river Betwa near Dam site which is about half km. downstream of diversion dam site are contained in Part-III of

the contract. The contractor shall submit his own layout plan for other temporary river diversion and protective works within fourteen days of date of issue of the notice to proceed with the works and its design prior to starting the construction of temporary diversion and protective works for the approval of the Executive Engineer. Such approval shall not relieve the contractor of his responsibility for the adequacy of the temporary diversion works or repairing at his own expense any damage caused by failure or partial failure of the temporary diversion works. The contractor shall also maintain and repair the diversion arrangements, constructed by the Board and handed over to him at the start of work, at his cost during the entire period of the operation of the contract. The Coffer Dam shall be adequately protected from scour or other damages from flowing water at the cost of contractor. The contractor shall adopt layout and designs of temporary diversion and protection works so submitted after the approval has been accorded. The construction and maintenance of any required subsequent diversion channels shall be at the entire expense of the contractor but the payment for that part of the excavation of the diversion channel which falls within the specified lines and grades of excavation for the foundation of the dam and appurtenant works will be made at the applicable unit prices in the schedule of bids.

Nothing contained in this paragraph shall relieve the contractor from full responsibility for the adequacy of the temporary diversion and protective works.

1.8.2 Dismantling of Coffer Dam

After having served their purpose all coffer dams (diversion flume) handed over by the Board to the contractor or constructed by the contractor shall be removed to the extent hereinafter specified. Care shall be exercised during removal of coffer dam to prevent injury to the permanent works and any damage occasioned thereby shall be repaired, as directed by the Executive Engineer by and at the contractor's expense. Coffer dam materials shall be so disposed within a radial distance of 1 km. as not to interfere with the flow of water into sluices of dam. Plan of disposal of material shall be subject to prior approval of the Executive Engineer. All materials in downstream coffer dams and river arms of coffer dams shall be entirely removed. The contractor shall have absolutely no right on the materials obtained from removal of coffer dam which shall be the property of the Board. Material placed in downstream spoil areas shall be stacked and graded so as to present a neat appearance and sloped to facilitate general drainage and shall be subject to approval by Executive Engineer.

1.8.3 Measurement and Payment

(i) The prices entered in the schedule for work required by this section shall be all inclusive constituting full compensation for

mobilising, demobilising and supplying all equipment, material, labour and supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition a specific payment item has been included in the schedule.

Intermediate payment of "Maintenance of Coffer dam for which construction period of Masonry Dam" will be made as here-in-after provided, subject to the condition that the diversion works are constructed during the various years of construction in accordance with the proposals approved by the Executive Engineer as required in foregoing paras.

(a) 20 percent per annum of the lumpsum bid for the item payable after first year of the date of start for four years.

(b) The remaining 20 percent after the diversion work have been removed in accordance with foregoing paras. The lumpsum rate for the item "Maintenance of coffer dam for entire construction period of Masonry Dam" will include all temporary works required for the diversion of river during construction and clearance thereof including the works as detailed in foregoing paragraphs.

(ii) Measurement for dismantling will be for the volume of masonry and concrete rimmed between the lines and grades approved by the Executive Engineer and shall be pre-measured.

Payment shall be made on the basis of the Unit price entered for the particular item in the schedule.

SECTION-2

CLEARING OF THE SITE AND EXCAVATION

2.1.0 Clearing of the Site

2.1.1 General

The work to be done under this section consists of furnishing all plants, labour and materials and performing all work necessary to carry out all clearing and grubbing operation as hereinafter specified and or as directed by the Executive Engineer. The area to be occupied by the Dam and the appurtenant works has to be cleared of all vegetations including all trees, bushes, stumps, roots and other objectionable materials before starting excavations. The surface of all aggregate quarries and other working areas shall be cleared of all trees, jungle, grass stumps, roots, logs (buried or not) and other objectionable materials.

2.1.2 Disposal

All stumps, roots, bushes, buried logs and other debris within the area required to be cleared and where grubbing is to be done shall be burnt or otherwise completely removed from the site, to the satisfaction of the Executive Engineer. Disposal in the river bed and streams will not be permitted and no material shall be piled where, in the opinion of the Executive Engineer it is liable to be floated away by floods. Timber and fuel obtained in clearing shall be properly stacked at sites approved by the Executive Engineer. Disposal by burning will be allowed only on specific sanction of the Executive Engineer and shall be done under constant attendance until fires have been burnt out or have been extinguished to guard against spreading of fire.

2.1.3 Payments

No separate payment will be made for the required clearing and grubbing as stipulated above. Clearing and grubbing in the performance of this contract will be considered as incidental to the necessary excavation.

2.2.0 Excavation

2.2.1 General

The work to be done under this section consists of bringing all plants, labour and materials and performing all work required to do all excavation and maintain the excavated slopes and prepare the foundations as specified in these specifications and as may be directed by the Executive Engineer. Excavation for foundation of the masonry and appurtenant works shall be made to sound firm rock, free from weathered materials open seam and crevices, and shall be so shaped, cleaned and roughly stepped as to produce the desired surface as directed by the Executive Engineer. The excavation shall be open cut excavation which shall be made to the full dimensions required and shall be finished to the prescribed lines and grades in a workman like manner, except that sharp points of undisturbed wedge rock will be permitted to extend within the prescribed lines by not more than 15 cm. The bottom and side slopes of common excavation shall be made accurately to the dimensions shown in the drawings or prescribed by the Executive Engineer. The surface so prepared shall be moistened with water and tamped or rolled with suitable tools or equipment for the purpose of thoroughly compacting them and forming firm foundations upon or against which the concrete/masonry structure is to be placed. If at any point in ordinary excavation, material is excavated beyond the lines required to receive the structure, the over excavations shall be filled with selected materials in layers not more than 15 cm. thick, moistened and thoroughly compacted by tamping and rolling. If at any point in common excavation the natural foundation material is disturbed or loosened during excavation process or otherwise it shall be consolidated by tamping or rolling or it shall be removed and replaced with selected material which shall be thoroughly compacted. Where concrete/masonry is to be placed upon or against rocks, and average minimum thicknesses are shown, the excavation shall be sufficient to provide for the minimum thickness of concrete/masonry at all points and the prescribed average thickness shall be excavated as little as possible. Where concrete/masonry is to be placed upon or against rock and the thickness of concrete/masonry is not indicated on the drawings, the excavation shall be made to the lines as prescribed by the Executive Engineer. All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavations in the soundest condition. No blasting that might injure the work, will be permitted and any damage done to the work by blasting, including the shattering of the material beyond the required excavation lines, shall be repaired in a manner satisfactory to the Executive Engineer. All cavities in rock excavation as determined by the Executive Engineer or by removal of rock or other foundation materials needlessly damaged by blasting or other operations shall be filled solidly with concrete of the same mix as the foundation concrete or as per directions of the Executive Engineer.

After the excavation for the foundations of the dam and appurtenant works have been completed to the approximate grade specified by the Executive Engineer, all loose rock and other excavated material shall be removed and the surface shall be cleaned with air and water jet under high pressure, for the purpose of inspection. If the foundation is found to be unsatisfactory, additional excavation shall be made as directed by the Executive Engineer and the surface again cleaned for inspection. The procedure shall be repeated until satisfactory foundation is reached.

2.2.2 Classification

The material encountered during excavation shall be classified only as below:

(i) Common Excavation

Common excavation shall include all overburden dry or wet restricted to materials such as silt, earth, clay, sand, gravel, soft moorum, soft and disintegrated rock which can be removed by hand or by power showels or by drag line, without continuous and systematic blasting, barring and wedging.

(ii) Rock Excavation

Rock excavation shall include all excavation by blasting, barring, wedging, channelling drilling and broaching, which in the opinion of the Executive Engineer can not be efficiently worked until loosened by any of the methods given in this paragraph as also all boulders or places of loose rock which are more than one metre in any one direction.

(iii) Line Drilling and Broaching

Excavation in rock shall be progressed by systematic line drilling and broaching or by chiselling in locations specified by the Executive Engineer.

2.2.3 Blasting

Blasting shall be permitted only when proper precautions are taken for the protection of persons, work and property. Any damage done to the work or property by blasting shall be repaired immediately. Blasting may be done only to depth and extent approved by the Executive Engineer with explosives of only approved quality and charge and in such locations as may neither crack nor damage the rock outside the prescribed limits of excavations. Explosives shall be stored in a safe place at a sufficient distance from the works and under special care of a watchman so that in case of accidents, no damage occurs to the other

parts of the works. All storing, handling, transport and use of explosives, detonators and the equipment thereof shall be strictly in accordance with the Indian Explosives Act and the explosives Rules - 1940 and as amended from time to time.

Holes shall be drilled not exceeding two-thirds of the depth of rock to be excavated, from the elevation at which the hole is started. The holes shall not be larger than necessary to permit easy passage of whole sticks of explosives to the bottom of the holes. As the excavation approaches its final limits, the depth of holes for blasting and the amount of charge for hole shall be reduced progressively. Whenever in the opinion of the Executive Engineer further blasting may injure the rock upon or against which concrete is to be placed, the use of explosives shall be discontinued and the excavation shall be completed by wedging, barring, channelling, drilling or broaching or by other suitable methods. Care should be taken to remove all loose slabs before masonry/ concrete is placed for the dam. Rock bolting compared to excavation of rock may be useful at places in excavation of foundation. The Executive Engineer will direct where to locate rock bolts and where to excavate by barring.

Charging, tamping and firing of drilled holes shall be done by the Foreman or by some licensed person under his personal directions. Proper signals by siren or bugles shall be given before each operation of blasting. In charging a hole, the cartridge shall be inserted one at a time and each squeezed home gently with wooden rod. Metal or bamboo rods shall not be used for this purpose. The primer cartridge with fuse and detonator shall be lowered gently into the hole and shall not be squeezed home under any circumstances. The fuses shall be out in such a way that the firing of the holes can easily be counted unless electric firing is used. No more holes shall be fired at any one time, that can be easily counted in order that it may be determined definitely whether all the holes fired have discharged properly. If a misfire occurs no one should approach the misfired hole until a safe time has elapsed. The tamping of the misfired hole shall be carefully removed and wooden stick placed to indicate direction of hole. A second adjacent hole not nearer than 23 cm. shall then be drilled parallel to misfired hole charged and fired and then the debris shall be searched thoroughly for unfired detonators and cartridges. Special care shall be taken to keep the fuses dry and the explosives protected from the direct rays of sun.

The final prepared foundation shall roughly present a saw tooth outline and shall have atleast 50% horizontal area to give resistance against sliding or as per direction.

2.2.4 Excavation in Shafts in Foundation Faults and Seams

Where seams and faults are found in the foundation for the dam, such seams and faults shall, generally be excavated in open trenches. It may be necessary or desirable as determined by the Executive Engineer after the excavation to excavate shafts below the bottom of such excavation for the purpose of sealing the faults and seams. The excavation shall extend into sound rock on each side of the fault or seam to the depth given by the Executive Engineer. All drilling and blasting shall be performed skillfully and carefully so that the material outside the required line will not be shattered. No blasting that might injure the work shall be permitted and any damage done to the work by blasting, including the shattering of material beyond the required excavation lines, shall be repaired in a manner approved by the Executive Engineer. Rock needlessly damaged by blasting or other operations during the work shall be removed and the space so formed shall be filled solidly with concrete of approved mix. Suitable temporary timbering including loggings shall be used where such temporary timbering is necessary to support the sides of the shafts.

2.2.5 Benching and Chiselling

Chiselling and Benching shall not ordinarily be resorted to for roughening foundations. In case at non-specified locations chiselling and benching is specially required by the Executive Engineer, it shall be carried out as per his directions.

2.2.6 Line Drilling and Broaching for Rock Excavation

Where vertical or square faces of rock are required in portions of abutments or elevator shafts, such faces of excavations shall be formed by line drilling and broaching. This procedure will also be called for in case of excavation near structures which have been built up and where excavation by ordinary drilling and blasting methods is not desirable. The spacing of drill holes shall be sufficiently close to ensure that the rock will break to the desired lines. No blasting will be permitted in the holes along the sides of excavation but light blasting will be permitted in areas adjacent to the holes provided that where further blasting might injure the rock upon or adjacent to which masonry/concrete is to be placed the use of explosive shall be discontinued and excavations completed by wedging, barring or other suitable methods.

2.2.7 Final Excavation, Foundation Preparation and Cleaning

When the excavation has reached sound rock level, the surface of the rock shall be cleaned of all mud and rock debris by an air water jet and examined for joints, springs, and seams. If the foundation surface

is satisfactory in all respects, further blasting shall be stopped and this level of foundations is called "non-blasting level". Due to blasting, where joints which were originally tight became loose, the loose rock shall be removed under the supervision of the Executive Engineer. All protruding rocks and overhangs shall be removed and sharp and brittle edges hammer dressed. If the overhangs are not easily removable by crow bars, the Executive Engineer shall at his discretion, get them removed by light-blasting or by using half a cartridge of gelatine after satisfying himself that the other rock in the vicinity does not get loose from the seating. At the time of final preparation of foundation, the Executive Engineer shall examine it for loose rock by hitting with a hammer on the surface. The portions giving hollow sound shall be removed by chiselling and wedging.

Just prior to the placing of concrete, a cleaning shall be made by barring, wedging and picking or by other approved methods. All loose, shattered or disintegrated materials shall be removed and surface shall be cleaned with jets of air and water under high pressure. Shoring and timbering whenever required shall be done by the contractor as per direction of the Executive Engineer and deemed to have been included in the applicable item of schedule of bid.

2.2.8 Pay Line and Overbreakage

All excavation shall be done according to the lines, levels and dimensions shown in the drawings. All overbreakage and excess excavation shall be carefully avoided. The rate of excavation includes rate of filling of overbreakage and excess excavation which shall be filled by the materials specified by the Executive Engineer according to the location of work.

In case of special situations, where excavation is not possible according to lines, levels and dimensions shown in the drawing, the Executive Engineer at his discretion may permit excavation with maximum side slopes of ¼:1 in case of all rock and 1:1 in case of over burden but in any case no overbreakage horizontally at the designed level or below designed level shall be permitted. Wherever the Executive Engineer permits excavation as above only the excavation shall be paid but its filling with the approved material as directed by him shall be done by the contractor at his own cost, which shall be deemed to have been included in the item of excavation.

Silt deposit if any during the course of construction due to floods etc., shall have to be removed by the contractor and no extra payment shall be made on this account and deemed to have been included in the item of excavation of schedule of bid.

2.3.0 Disposal

2.3.1 All suitable materials from excavation of the dam and appurtenant works under this contract including excavations in shafts, in foundation, faults and seams shall be used in the rock fill, back-fill and rip-rap so far as practicable and as determined by the Executive Engineer. All other material shall be stacked properly in stock-piles of selected materials separately within a radial distance of 1000 Metres from the place of excavation as directed by the Executive Engineer.

Excavated materials not fit for use shall be wasted. The disposal of wasted materials shall be subject to the approval of the Executive Engineer. Waste piles of excavated materials from the foundation of dam shall be located within 1000 metres as measured radially. Where required by the Executive Engineer, waste piles shall be levelled and trimmed to reasonably regular lines and the contractor shall be entitled to no additional compensation on account of this requirement. The cost of disposing of all excavated materials shall be deemed to have been included in the unit price per cubic metre of excavation in the schedule of bids. But in case the contractor is directed by the Executive Engineer to dispose of the excavated material at a distance greater than that specified above, the contractor will be allowed extra rates for the same as per applicable item of the schedule of bids.

2.4.0 Dewatering

2.4.1 General

Dewatering shall be carried out as per approval of the Executive Engineer to enable excavation, mucking, inspection, final preparation of surface, providing anchor bars, grouting, laying of masonry, laying of concrete and allied constructional activities.

2.4.2 Dewatering by Electric Pumps

Electric pumps of only requisite capacity shall be installed in order to handle the seepage encountered. The switchgears and pumping sets shall be maintained in satisfactory condition to avoid loss of energy. Circuits for pumping set shall be isolated from any other electric installation.

2.4.3 Dewatering by Diesel Pumps

Diesel pumps of requisite capacity shall be installed in order to handle the seepage encountered. All costs of P.O.L., running and maintenance shall be deemed to have been included in the unit price for the particular item in the schedule of bid.

2.5.0 Measurement and Payment

2.5.1 General

The prices entered in the schedule for the work required by this section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour supervision and all incidental work except for any item specifically exempted therefrom and for which in addition, a specific payment Item has been included in the schedule.

2.5.2 Common Excavation

Measurements for payment of common excavation shall be made on the net volume of common materials contained, prior to excavation, within the minimum lines for such excavation shown on the drawings or as specifically directed. The profile of the original over-burden surfaces prior to excavation shall be established by taking levels on a 3 metre square grid. The final surface profile of common excavation shall similarly be taken on a 3 metre square grid. With these profiles, the total volume of common excavation shall be worked out. The net volume of common excavation referred to in the foregoing shall mean the total volume of common excavation contained within the specified lines minus the volume of boulders included for payment purposes as rock excavation contained within such specified lines.

No allowance shall be made for over excavations beyond the specified minimum lines of excavation, except where specifically authorised. No extra payment for any overbreakage and subsequent repairs shall be payable and deemed to have been included in the applicable item of schedule of bid.

Payment for common excavation shall be made on the basis of the unit price per cubic metre entered for the particular item in the schedule.

2.5.3 Rock Excavation

Measurement for payment of rock excavation in open cut as required by this section shall be made of the total volume of rock in cubic metres contained, prior to excavation, within the minimum lines for such excavation shown on the drawings or as specifically directed. The profile of the original rock surface, prior to excavation shall be established by taking level on a 3 metre square grid. The final finished surface shall similarly be taken on a 3 metre square grid. With these profiles, the rock excavation shall be worked out.

Measurement for payment for rock excavation in open cut shall also include for measurement of the volume of boulders classified as

rock in accordance with the provisions of this section. The volume of such boulders whether they occur separately or in groups shall be determined prior to the removal of the same.

No allowance shall be made for over excavation beyond the minimum lines of excavation except where specifically authorised. No extra payment for any overbreakage and subsequent repairs shall be payable and deemed to have been included in the applicable item of schedule of bid.

Payment for rock excavation shall be made on the basis of the unit price per cubic metre entered for the particular item in the schedule.

2.5.4 Dewatering by Electric Pumps

Measurements for payment of dewatering by electric pumps shall be on the basis of units of electrical energy consumed in dewatering through these pumps which shall be obtained from the difference of initial and final readings of the energy meters. The energy meters shall be carrying test certificates and will be installed by the contractor at his own cost. In case any energy meter gets defective, the contractor shall arrange to replace it by another tested meter within 3 days. Measurements of energy in dewatering for these 3 days shall be based on the average consumption during the preceding 3 day period. In case the contractor fails to replace the defective energy meter within the 3 day period, no measurements for energy so consumed shall be taken. Payment for dewatering by electric pumps shall be made on the basis of electrical energy consumed at the unit price entered for the particular item in the schedule of bid.

2.5.5 Dewatering by Diesel Pumps

Measurements for dewatering by diesel pumps shall be done in terms of Horse-Power Hours the diesel pump has been used for dewatering purposes. The rated Horse Power of the pump as per manufacturer's specifications shall be the Horse Power of the pump.

Payment for dewatering by diesel pumps shall be made on the basis of unit price entered for the particular item in the schedule of bids.

2.5.6 Line Drilling and Broaching

Measurements for payment of rock excavation carried out by line drilling and broaching shall be in terms of surface area of the rock surface so executed at the applicable Unit price entered for the particular item in the schedule of bid.

SECTION-3

DRILLING

3.0.0 Drilling

3.1.0 General

Drilling shall be required to be carried out in rock, concrete or masonry for grouting, drainage and placing anchor bars for masonry dam and appurtenant works. Drilling shall be done by wet percussion methods. The drill holes could be vertical inclined or horizontal as per requirement of work shown in the drawings or as directed by Executive Engineer. The size of drill holes shall be varying from 47 mm diameter to 75 mm diameter as per drawings or as directed by the Executive Engineer. The depth of drilling in rock may extend upto 25 metres for individual holes. The contractor will not be entitled to any compensation whatsoever nor any rebate recovered on the basis that holes of a particular diameter, within the above mentioned range, have been got drilled in excess or otherwise.

3.1.1 Where necessary, as determined by the Executive Engineer, the drilling and grouting shall be performed in successive operations, consisting in each case of drilling the hole to a limited depth, grouting at that depth, cleaning out the grout hole by washing or other suitable means before the grout in the holes has set sufficiently to require re-drilling, allowing the grout surrounding the grout hole to attain its initial set all as determined by the Executive Engineer, drilling the hole to an additional depth, and then grouting and then successively drilling and grouting the hole at various depths within the stages until the required depth of the hole is completely drilled and grouted. Re-drilling required because of the contractor's failure to clean out a hole before the grout has set shall be performed at the contractor's expense but where the grout has been allowed to set by the directions of the Executive Engineer, the required re-drilling will be paid at the rate 50 percent of the schedule price for the item "Drilling grout holes 47 mm to 75 mm. dia by wet percussion drilling in stages between 0 to 25 m. including routine washing.

3.2.0 Measurements and Payments

3.2.1 The prices entered in the schedule for the work required by this section shall be all inclusive constituting full compensation for

mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which in addition a specific payment item has been included in the schedule.

3.2.2 Measurement for drilling holes shall be made from the surface of rock, concrete or masonry from where the drilling is actually commenced upto the depth actually drilled and duly washed but limited to the depths indicated in the drawings or as initially approved by the Executive Engineer. Payment shall be made at unit price entered for the respective item in the schedule.

SECTION-4

GROUTING

4.0.0 Grouting

4.1.0 General

The principal objective of foundation grouting is to establish an effective barrier to seepage, thereby reducing hydrostatic up-lift under the structure. A secondary objective is to consolidate the rock under the structure and thus secure a more unified and monolithic foundation. The procedure to be followed in grouting a foundation is governed by the height of the structure and the characteristics of the rock. Any plan for a grouting programme can only be tentative and must be modified to suit actual conditions after grouting operations are started.

The general plan for grouting the foundation rock under the dam provides for preliminary low pressure shallow grouting to be followed by double line high pressure deep grouting. "High pressure" and "low pressure" are relative terms only. The pressures that are used are usually the maximum that will ensure the complete filling of all joints, crevices and voids without causing any up-lift or lateral displacement of foundation rock.

4.1.1 The work of low pressure and high pressure grouting shall include but may not be limited to the following:

(i) Surface treatment like cleaning;

(ii) Grouting test holes within the grouting area;

(iii) Casing of drill holes as required and testing site of the grout holes and grouting the rock (both at low and high pressure);

(iv) Installation and maintenance of special recording instruments required for the work covered by this section;

(v) Clean up of the grouted areas.

During drilling, testing and grouting operations, the rock surface in the grout area and the surrounding ten metre strip shall be kept

clean and free of oil, grease, drill cuttings, muck, grout, cement pozzolan, excess water or any kind of waste.

Appearance of grout from any of the joints, openings, cavities or drilled holes in the grouting area shall be watched for and remedial measure taken as necessary. All open side holes, cleaned out faults, cavities and large cracks in the bed rock and the drill holes in the concrete/masonry shall be protected at all times during the progress of the work from becoming plugged or filled with oil, grease, drill cutting muck, grout, pozzolan, cement or any kind of waste.

4.2.0 Grouting

4.2.1 Low pressure grouting is applied to surface zone, to provide a general consolidation of the surface rock and to fill and seal major surface seams and crevices. Usually this operation is carried out before any of the concrete/masonry of the structure is placed. This is accomplished by drilling and grouting relatively shallow holes called 'B' holes. The extent of the area to be grouted and the depth to which these holes are to be drilled will depend upon actual site conditions after grouting operations are started.

The low pressure grouting will be through holes which are not less than 1⅞" (47 mm) in diameter generally arranged at 6 metre centre to centre staggered both ways to depths of about 10 metres. As the construction work progress the development of leakage or the condition of the surrounding rock may indicate that the parts of the foundation already covered with concrete require to be grouted in which event hole shall be drilled through the concrete/masonry and the underlying or surrounding rock and pipes for grout connections shall be placed as directed. It may be necessary after holes in a region have been drilled and grouted to drill additional holes.

4.2.2(i) High Pressure Grouting

High pressure grouting is applied to holes called 'A' holes and drilled relatively deep near the upstream face of the dam to form the principal grout curtain or double line seepage barrier. The minimum diameter of the grout holes shall not be less than 1⅞" (47 mm). The work of curtain grouting shall not be started until all masonry/concrete required within a radius of 60 metre has been placed to a height of 25 metres or otherwise specified. It is anticipated that the holes for grouting will be drilled at approximately 3 metres spacing or as specified in the drawing and to a maximum depth of 25 metres or as shown in the drawing.

The actual number and spacing of the holes and the pressure to be used for grouting injection will depend upon, besides the nature of the rock as disclosed by the foundation excavation, the results of water pressure test, grout acceptance and other tests and the results of the progressive grouting operation itself.

It may be necessary to drill and grout the holes for foundation grouting in successive operations consisting in each case of drilling the hole to a limited depth, grouting at that depth, cleaning out the grout hole by washing or other means before the grout has sufficiently set to require re-drilling, drilling the hole to an additional depth and then grouting the hole in stages until the required depth of hole is completely drilled and grouted. After each stage of grouting, the grout surrounding the hole shall be allowed to set, before proceeding with the next stage of drilling. The depth of each successive drilling, the grout mixture used, the pressure of each stage of grouting and other details of the grouting procedures shall be as directed. The depth of each stage is anticipated to be from 4 to 6 metres.

A primary series of holes about 8 - 12 metres apart (according to site condition) shall first be treated thus to a depth of at least two stages (to begin with) over a reasonable length of curtain which should be not less than 30 metres. A secondary series of holes spaced midway between the primary series shall then be treated to the same depth. Water tests shall be made on the third series of holes midway between the primary and secondary series and compared with these made on the treated holes prior to grout injection to determine the efficiency of the previous injections. These holes may then be used for grouting if they fail to pass the permeability requirements when tertiary holes are found to be generally satisfactory on test, there is no need for these holes to be grouted though isolated holes may still require grouting. If the majority of the tertiary holes required to be grouted a fourth series of holes shall be drilled and tested and grouting continued if necessary.

It is essential that short drilling, pressure testing and grouting programme be performed early in the work which, together with the first blanket grouting results and the detailed geology of the area, may indicate the pattern of drilling and grouting to be adopted. If during drilling of any grout hole the drill water is lost or a large artesian flow is encountered, the drilling should be stopped and the hole grouted before further drilling is resumed. Upon the completion of drilling of a hole it shall be temporarily capped to prevent entry of foreign matter until grouting operations require to be opened. The holes shall be filled with cement slurry when they are no longer required. It may be found necessary after holes in a region have been drilled, to drill additional holes for treatment.

(ii) 'C' Holes for Grouting

For additional safety against up-lift, 'A' holes will be supplemented by a line of holes called 'C' holes drilled through the gallery as shown in the drawing. The depth of these holes and their spacing are approximately the same as for 'A' holes. The supplementary grout curtain formed by grouting this line of holes serves to reduce the hydrostatic uplift that would otherwise be exerted on the base. Drilling and grouting of these holes should be accomplished after the drilling and grouting of the 'A' holes as a second line of grout curtain. Stage grouting shall be adopted for these 'C' holes as in 'A' holes.

4.3.0 Special Washing of Holes

The washing out of loose materials, silt sand and clay from the seams and fissures is important for proper grout injection and shall be carried out as directed by Executive Engineer. The pumping of water into one hole whilst blowing compressed air into adjacent holes is more effective than the pumping of water alone, particularly if the blowing of air under pressure is transferred from one side to the other of the hole receiving water. Washing of holes shall follow a pattern which will prevent deposition of washed out material in other cleaned out portions of the foundation. Individual seams in a hole, if thick, shall be treated by using packers on either side of the seam. The washing process shall be continued until the return water becomes clear and no drill cutting rock fragments or other materials are found in it.

4.4.0 Pipe Connection in Holes

4.4.1 Low Pressure Grout Holes

As soon as the drilling of a pattern is completed and all holes washed out properly, standard 40 mm or 60 mm black iron pipes of suitable length shall be properly anchored into the drill holes with grout, mortar, lead wool and other suitable material in order to make connections for grouting, the upper ends of all the pipes shall be threaded and a coupling installed for convenience in making grout connections and the couplings fitted with a standard cast iron plug which will be screwed in loosely to prevent the entrace of debris or other foreign material. Where permitted by the condition of the rock however, grout holes connections may also be made directly to the hole by means of a mechanical or pneumatic expander without the use of embedded pipes.

4.4.2 High Pressure Grout Holes

Standard 75 mm black iron pipe and fittings shall be installed in foundation, concrete or masonry as shown in the drawings for drilling as well as grout holes connections. The space between the pipes and the

rock into which they are inseated shall be carefully covered with grout mortar, lead wool or other suitable material to prevent entry of concrete/masonry. The pipes shall be thoroughly cleaned and firmly held in position and protected from damage while masonry/concrete is being built around them. The upper ends of the pipes shall be threaded and a coupling installed for convenience in making grout connections and the coupling fitted with cast iron plugs which will be screwed in loosely to prevent the entrace of debris or other foreign material.

4.5.0 Pressure Testing of Holes

During and after drilling of the holes or during or after grouting of the holes, they shall be water tested as required and as directed. The grout holes shall be tested with clean water at a pressure upto the required grouting pressure. Drill cuttings and slurry shall be removed before pressure testing by applying water and air into the bottom of the hole and returning the wash water through the hole to the surface. All holes sufficiently tight to build up the maximum required pressure shall be washed at such pressure and the washing shall continue as long as there is any increase in the rate at which water is taken, such increase indicating that fractures are being opened by the washing operations. In all grout holes, when abnormal gain or loss of drill water is observed, the drilling shall be discontinued the hole water pressure tested and grouted before proceeding further with the drilling. If, during drilling caving of the hole or jamming of the bit occurs or the drill rocks fall suddenly • as through an open cavity, it may be required that drilling is discontinued, the debris cleared, the effected position of the hole filled with thick cement slurry and drilling continued after the slurry sets.

The procedure for water pressure testing is specified here-under.

If the hole is drilled to full depth, the section of the hole to be tested shall be isolated by sealing it off with double packers. If stage drilling method is followed a single packer may be used to isolate the section to be tested. Water then shall be pumped into the test section under the pressure and for the periods specified below in one continuous operations and leakage in water observed.

Step No.	Pressure	Elapsed time (minutes)
1	1/3p	5
2	2/3p	5
3	p	10
4	2/3p	5
5	1/3p	5

Note: The pressure P shall be determined based on the geological conditions and on the depth of the upper packer. This pressure is not expected to exceed 15 kg/cm2 at the gauge. After steps 4 & 5 the valve shall be closed, and the pressure drop observed and relaxed for a minimum period of 3 minutes in each instance.

The length of the test section shall be measured parallel to the direction of hole. Hole shall generally be tested in 2 - 3 metre sections. The pressure testing apparatus shall be subject to the periodic tests for accuracy and satisfactory operation.

A desirable degree of impermeability is considered to exist when the leakage obtained by applying a water test to any section of the holes drilled is less than one litre/metre/minute under a pressure equivalent to 10 kg/cm^2 at the gauge point applied for a period of 10 minutes.

4.6.0 Grout Material and Procedure

4.6.1 Materials

(i) General: Grout for injection shall be composed of portland/pozzolan cement and water. It is possible that in special cases the addition of sand, and calcium chloride or other mixtures may also be required.

(ii) Cement: Cement shall, unless otherwise specified, be ordinary portland cement conforming to standard specifications IS 269 - 1967 (Second revision) as revised from time to time or ordinary portland pozzolan cement conforming to IS 1489 - 1976 as amended from time to time.

Handling, storing, transporting and use of cement shall be in accordance with provisions contained in relevant portion of the section "Masonry" under Masonry Dam.

(iii) Sand: Coarse and fine sand some times required as filler in the grout, shall conform to the standard specifications. IS - 383 - 1970 as revised from time to time.

(iv) Water: The water used for grout shall be clear and free from injurious amount of deleterious substances such as, but not limited to, silt, sewage, oil, acid, alkali, salts and organic matter.

4.6.2 Grouting Procedure:

(i) The work shall include the setting up of lines and equipment and loading, transporting, handling, mixing and injecting of the grout materials.

(ii) Plant:

The grouting plant shall be capable of supplying, mixing, stirring and pumping the grout as directed. The equipment used shall be capable of grouting through the full range of pressures upto 20 kg/cm^2.

It shall be kept in a satisfactory working condition and any grout hole lost or damaged due to mechanical failure of the grouting equipment or inadequacy of the grout supply shall be replaced by another hole immediately at the cost of the contractor.

(iii) Procedure:

In general a single line grout system can be used but it may be required that a double line circulating pumping system be used where the single line system proves to be ineffective.

The grout system shall be flushed periodically with water to prevent fouling. Any leakage shall be caulked satisfactorily to ensure full retention of the grout at the maximum specified grouting pressure. Grout that cannot be placed within one hour after mixing shall be wasted. The initial grout consistency shall be governed by the conditions disclosed in washing and pressure testing. It is customary to start with a thin grout (water cement ratio by volume of say 1:10) and gradually thicken the grout as the hole tightens. This procedure enables the grout to reach remote seams at the same time offering minimum disturbance to the natural formation. A mixture of one part of cement to the two parts of water is frequently adopted for the final grouting but where the rock is loose, a mixture having a water cement ratio of 0.5 by volume may have to be used.

In general, if pressure tests suggest a tight hole, grouting shall be started with a thin and if an open hole is indicated, it shall be started with thicker mix. With the grout pump operating as early as possible at consistent speed, the water cement ratio will be decreased, if necessary, until the allowable pressure has been reached. If decreasing the water cement ratio does not produce the desired pressure, a sanded grout may have to be used, and the mix varied to suit. If the pressure raises too high, the water-cement ratio shall be increased or the sand grout mix changed, or stopped as may be necessary.

During the grouting of a hole, adjacent underground holes should be left uncapped to facilitate intake of air and water. If grout flows from these holes, an expanding type of packer shall be set in these holes immediately above the point of inter connection and the inter connected holes washed out when grouting is completed and before the grout has had time to set.

To relieve premature stoppage during grouting periodic application of water under pressure shall be made and sudden increase in pressure or pumping rate shall be avoided.

4.7.0 Grouting Pressure

Grouting pressures must be related to the depth of the stage of treatment, the weight of the superimposed structure on the rock, the extent and dip of the stratification and the rate of acceptance of grout. The possibility of uplift or disturbance of the rock strata increase with the pressure, but the higher the pressure, the greater the benefits from the injections particularly where fine fissures have to be treated. High pressure are however, no substitute for a proper dilution of grout. It is expected that in general grout pressure may go upto 5 kg/cm^2 in case of the blanket grouting and 15 kg/cm^2 in case of curtain grouting.

4.8.0 Extent of Grout Injection

The grouting should be continued on any hole unless prevented by leakage or otherwise directed until at the limiting grouting pressure the grout acceptance is less than 2 litres per minute averaged over a period of 10 minutes. If the size and continuity of fracture is such that it is found impossible to reach the required pressure after pumping a reasonable volume of grout at the minimum workable water-cement ratio, the speed of the pumping shall be reduced or the pumping shall be stopped temporarily and intermittent grouting shall be performed allowing sufficient time between injection for the grout to stiffen. If this is not successful, grouting shall be discontinued subject to approval. The hole shall then be cleaned and the grout allowed to set. Additional drilling and grouting shall then be done in this hole or in the adjacent area until the desired resistance is built up.

After the grouting of a hole is completed, the hole shall be washed free of grout to the depth specified. If re-grouting is required, it shall be done in the same manner as specified above and after completion the hole shall be washed clean of grout to the depth specified. Re-grouting should be done not sooner than two days after the initial grouting is completed. After a minimum period of two days, after grouting, or re-grouting, the portion of the hole washed free of grout, shall be packed with a dry mixture of cement, sand and water.

4.9.0 Detection of the Movement or Upheaval of Foundation

The surface bed rock may be particularly sensitive to movement or upheaval due to hydraulic pressure developed during pressure testing or grouting. Such displacement shall be controlled with the aid of careful observations of "Foundation Displacement Indicators" specially insalled for this purpose. For this, 25 mm diameter pipes shall be anchored by grouting to the bottom of holes drilled at specific locations indicated at site. 1.5 metres deeper than the proposed grout holes. Above the anchorage the pipe shall be encased in a 50 mm asphalt dipped fibre conduit and the hole filled up with lean mortar.

An iron yoke or bridge shall be anchored to the surrounding rock or masonry. Measuring tips shall be set at the top of the pipe and on the under side of the yoke. The gap between the tips shall be frequently measured during grouting and pressure testing operations. For any progressive upheaval, greater than a specified figures, the pressure shall be reduced and grouting operations continued thereafter. If, necessary, the pressure shall be relieved (by allowing the grout to flow out of the holes until the gauge shows that the settlement has ceased) before continuing the operations.

4.10.0 Test of Grouting Work

To test the efficiency and penetration of grout curtain and shallow grouting area core drill holes shall be drilled by the Board in a plane of the grout curtain after deep grouting operation are completed and in the shallow grouting area. The contractor will supply the required services of air and water free of cost for core drilling.

The core drill holes shall be tested by the Board under a water pressure equal to or little less than the pressure adopted for high pressure grouting or shallow grouting as the case may be and the amount and rate of leakage in each hole measured. If any hole should show excessive leakage, it shall be grouted under pressure at the cost of contractor. A new test hole shall be driven by the Board and tested under pressure in the same manner.

4.11.0 Technical Field Records of Grouting

Drilling, washing, pressure testing and grouting records shall be kept neatly and systematically as work proceeds. The exact location of all holes with reference to axis and chainage along the dam shall be recorded and an accurate log of all operations kept. Record maps and sections shall be completed showing all sub-surface conditions as found and corrected by grouting operations. Representative cores shall be suitably boxed and referenced by the Board. All information regarding the grouting, amount of grout taken, effects observed in the surrounding holes or rock etc., may be kept under the following heads:

(a) Hole number;

(b) Type of hole and method of drilling;

(c) Position chainage with distance upstream and downstream of the the dam axis line;

(d) Top level and depth;

(e) Date of completion;

(f) Date and time of commencement of grouting;

(g) Quantity of cement consumed;

(h) Observation during grouting, concerning the behaviour of holes under air and water pressure, appearance of wash water, quantity and proportion of the grout used, time and pressure of grouting, application and retention of grout pressure, connection to and effect on adjacent holes, method of application of grout, stage grouting etc., and the conditions noted while drilling and grouting to enable compilation of complete geophysical record of the foundation.

4.12.0 Measurements and Payments

4.12.1(i) The prices entered in the schedule for the work required by this section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition, a specific payment item has been included in the schedule.

(ii) Sand used in grout shall be considered as incidental to the work required under this section and its cost deemed to have been included in the unit price for the item "Pressure grouting with packers including cost of cement" of the schedule.

(iii) Pipes and pipe connections actually used in work required under this section shall be measured and paid in accordance with provisions of relevant portions of the section "Machinery and Metal works" and paid at unit price entered for the particular item in the schedule.

(iv) For the work required regarding "detection of the movement or upheaval of foundation" as described in this section, measurements will only be taken for (a) the actual drilling done, (b) the 25 mm dia. pipes with fittings used and (c) the contact grouting done for the 25 mm dia pipes in accordance with the provisions in relevant portion of the section on "Drilling" "Machinery and Metal Works" and "Grouting" respectively. These shall be payable at unit price entered in the schedule for the respective items.

(v) Measurement for grouting shall be made on the basis of weight of cement in the grout actually forced into the holes and paid at unit price for the particular item in the schedule.

(vi) No payment will be made for cement lost in grout due to improper anchorage of grout pipes or connection or rejected by Executive Engineer on account of improper mixing or lost by leakage due to failure of contractor to caulk surface leaks when directed by Executive Engineer.

(vii) Measurement for "Making connections to grout holes, their pressure testing and washing preparatory to grouting of holes including special washing wherever necessary" shall be done for the holes where this work has been executed as per drawing or as per directions of the Executive Engineer and payment shall be made on the basis of unit price entered in the schedule for this item.

SECTION-5

ANCHOR BARS IN ROCKS

5.0.0 Anchor Bars in Rocks

5.1.0 Drilling Holes for Anchor Bars

Wherever shown on the drawing or as directed, holes shall be drilled into the rock to receive bars for anchoring concrete, masonry and ground mat to the rock. The dimension of the anchor bars and the location, diameter and depths of the anchor bars holes shall be as shown in the drawing or as directed. The diameter of anchor bar holes shall be not less than 1½ times the diameter or greatest transverse dimension of the anchor bars specified for that hole.

5.2.0 Placing Anchor Bars and Grouting

Anchor bars shall be cleaned thoroughly before being placed. The holes shall be cleaned thoroughly, kept flagged until placing the bars and shall be filled completely and compactly with grout or mortar mixed in the proportions and to the consistency specified by the Executive Engineer. All water shall be removed from the hole when the anchor grout is placed. The anchor bars shall be forced into place before the grout of mortar has taken its initial set and where practicable shall be vibrated sufficiently so that entire surface of the embedded portions of the bars is in intimate contact with grout. Special care shall be taken to ensure against movement of the bars which have been placed. Anchor bars shall be placed not less than 6 days in advance of concrete/masonry operations to allow the grout to become set. Anchor bars found loose after setting shall be replaced by and at the expense of the contractor.

5.3.0 Measurements and Payments

5.3.1 The work of drilling holes for receiving anchor bars shall be measured in accordance with provisions of the relevant portion of the section of "Drilling" and shall be payable at the unit price entered for the item "wet percussion drilling 47 mm to 75 mm. dia holes". The work of providing anchor bars shall be measured in accordance with the provisions of the relevant portion of the section of "Reinforcement" and shall be payable at the unit price for the respective item of "Reinforcement". The grout actually utilised in filling holes of anchor bars shall be measured in accordance with provision of the relevant portion of the section "Grouting and shall be payable at the Unit price for the item "Contact grouting "including cost of cement".

SECTION-6

DRAINAGE SYSTEM

6.0.0 Drainage System

6.1.0 General

The dam and appurtenant works will be drained by systems of drains, the material and construction detail of which will depend on the desired functional performance. Care shall be taken to avoid clogging of the drains during the progress of the work.

6.2.0 Foundation Drains for Dam

Drainage of the dam foundation is accomplished by drilling one or more lines of holes immediately downstream from the main grout curtain. The size, spacing and depth of these holes are arbitrarily assumed on the basis of judgement of the physical characteristics of the rock and effectiveness of the grouting operations. Usually 75 mm diameter holes are adopted for the purpose. The spacing is influenced by the foundation conditions and the depth of the reservoir. The depth may vary from 20 to 40% of the hydrostatic head or 75 to 80% of the main grout curtain. Drainage holes are drilled after all foundation grouting has been completed in the area. They are drilled from the foundation galleries within the structure or from drift tunnels through previously installed black steel pipes 100 mm in diameter. Where no gallery is provided the drain holes may be drilled from the upstream face or from the top of some lift through previously installed pipes After drilling, the pipes are plugged at the top and seepage water from the hole is taken off at a Tee connection in the pipe which leads to a collection header or drain. Care shall be taken to avoid clogging of the drains during the progress of the works and should any drain become clogged or obstructed from any cause before final acceptance of the work, it shall be cleaned in a manner approved by the Executive Engineer by and at the cost of the contractor. If after a given area is grouted and drilled for drainage, it is found necessary to drill and grout additional grout J holes, the earlier drainage holes may be opened by redrilling to secure perfect drainage. The foundation drainage pipes shall be set and caulked into holes drilled to a depth of not less than 150 mm into the rock foundation and shall be held securely in position while concrete is placed about them. In general, the elevation of the bottom of the drainage holes shall be higher than the bottom of an adjacent

grout hole. Drainage holes shall not be drilled until all adjacent holes within a minimum distance of 45 m have been drilled and grouted.

6.3.0 Drain Pipes in Dam

Internal drainage in dam is very essential to reduce pore pressure inside the body of the dam. This drainage is accomplished by 200 mm dia drain holes formed in the concrete of the dam at 3 m. centre to centre as shown in the drawing of the dam. Particular care shall be taken that these drain holes do not get clogged or obstructed during the progress of work. The top of each vertical drain hole or drain pipe shall be sealed with standard C.I.Pipe and fittings. The bottom of each vertical drain hole or pipe shallbe connected to the foundation gallery by standard pipe and elbows as shown in the drawing.

6.4.0 Metal Pipe Drains

Cast iron pipe drains shall be constructed as outlets for the spillway, drainage system connecting the drainage gallery and the spillway drainage system and also for the drain from the roadway gutters at spillway bridge and elsewhere as shown in the drawing.

6.5.0 Open Drains

Open drains shall be constructed at the places as shown in the drawing or as directed by the Executive Engineer. The drains shall have sections as shown in the drawing or as directed by the Executive Engineer.

6.6.0 Measurements and Payments

The prices entered in the schedule for the various works required by this section shall be all inclusive constituting full compensation for mobilising demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which in addition, a specific payment item has been included in the schedule.

Measurement for the various items of the work shall be in accordance with the provisions in the relevant portion of the particular section and payments shall be at the unit price entered in the schedule for the particular item of work.

SECTION-7

MASONRY IN DAM AND APPURTENANT WORKS

(OTHER THAN CARE & DIVERSION)

7.1.0 General

Masonry for the dam and appurtenant works shall be composed of stone placed in a matrix of cement, sand water and any other admixture as specified. Tests shall be made on the masonry as well as the mortar matrix at specified intervals during the progress of the work and the mixes modified as necessary in order to consistently secure the required strength, workability, density and impermeability together with the maximum possible economy. It is contemplated that the mortar for the masonry will range in character from a lean mix with a cement content of approximately 350 Kg/cum of mortar to a rich mix with a cement content of approximately 500 Kg/cum. of mortar. The water cement ratio for the mortar will be regulated by the requirements of strength, durability and workability.

7.2.0 Masonry Classification

Masonry classification is related to the type of work and the specified 28 days compressive strength of the mortar to be used and shall conform with the requirements set out in table given hereunder. In cases wherein approved puzzolan is used as part replacement of cement, the puzzolan mortar shall be designed to attain the same 365 days strength as would be attained at the end of 365 days by a corresponding cement mortar.

Tests for the compressive strength of mortar shall be in accordance with the procedure laid down in the Indian Standard Specification IS-2250, Appendix-A as amended from time to time.

A minimum of three test specimens shall be made for each 120 cum. of each class of mortar for a given age. There shall be atleast three test specimens of mortar for each day of masonry work even if only a few cubic metres of the particular mortar is manufactured in a day.

The tests shall satisfy the following criteria:-

i) The average strength of any three consecutive sample strength shall be greater than the specified strength;

ii) The overall coefficient of variation for any ten consecutive sample strengths shall be less than 0.15.

iii) Not more than ten percent of the specimen strength shall be less than 85 percent of the specified strength.

Additional tests shall be carried out as and when directed.

Table-7.2.1

Masonry classification & location details:

Masonry	Locations (Non-over flow/Over-flow)	Classification details: Type of masonry	Min. allowable comp. strength of masonry kg/Cm^2 (strength of mortar) 28 days	365 days	Type of mortar	Max. allowable permeability (cm/sec) of cement mortar).
M1	The location of various type of masonry shall be as per zoning of materials drawing and shall be governed by the specification in para 7.6.0	Coursed rubble	175	200	Rich cement mortar not leaner than 1:3 by volume	2.4×10^{-9}
M2	-do-	Uncoursed rubble	175	200	-do-	2.4×10^{-9}
M3	-do-	Uncoursed rubble	100	140	Rich cement mortar not leaner than 1:4 by volume	4.8×10^{-9}

The upstream and downstream faces shall be flush pointed, the joints shall be raked square for a minimum 60 mm depth at the appropriate time (between 12 and 24 hours after the masonry is laid when mortar is firm but not hard to the extent needing chieseling). The refilling and pointing of joints shall be deferred as long as possible, in any case pointing shall not be done earlier than twenty one days after the masonry has been laid. Before pointing, the joint snall be thoroughly cleaned of any dirt or lossely, adhering cement, and washed out thoroughly wetted with a jet of water under pressure. These shall then be filled with cement mortar 1:2 proportion by weight thoroughly rammed and caulked into the joints. The mortar shall have just enough water so that it will stick together on being moulded into a ball by a slight pressure of the hand and will not excude free water when so pressed but will leave the hands damp. Proper consistency is that which will enable water to appear as a shining film at the surface when the mix is well rammed. When the joints are completely filled the mortar shall be rubbed hard with a small/narrow trowel. The pointed surface shall be cured in accordance with clause 7.3.0.

7.3.0 Materials

7.3.1 Cement

Cement shall unless otherwise specified be ordinary portland cement conforming to the Indian Standard Specification IS-269 - 1976 (3rd revision) as amended from time to time.

Cement that has been in storage for more than four months shall not be used without a special inspection, testing and approval.

7.3.2 Water

The water used shall be clean and free from injurious amount of deleterious substances such as but not limited to slit, sewage, oil, acid, alkali, salts and organic matter.

7.3.3 Sand

The term sand is used to designate fine aggregate with maximum size of particles 4.75 mm. The sand used shall be of coarse category conforming to the Indian standard specifications IS - 2116 - 1965 "sand for masonry mortars" as revised from time to time.

Where sand from different sources are being used at one mixer at the some time, they shall be so blended to ensure uniform grading in successive batches.

Variations in the grading of sand being obtained from the same source shall be controlled by means of the fineness modulus test.

The following control limits shall be used:-

(a) Controlled to limits of plus and minus 0.25 of running average of ten consecutive test samples.

(b) for natural sand fineness modulus shall be greater than 2.30 and less than 3.10.

For manufactured sand, the specification should be as in relevant section under specifications for concrete.

7.3.4 Air Entraining Admixtures

The quantity of air entraining admixture to be added shall be as per direction of the Executive Engineer from time to time in order to improve the workability of cement mortar. The percentage air entrained shall be tested by the Executive Engineer for which the contractor will afford facility to obtain mortar. The percentage of air entrained shall normally be 8 to 12% of the volume of cement mortar.

7.3.5 Stone

The stone used for masonry shall be clean, hard durable, tough and free from decay, sand, holes, weathered portions, adhering coatings, veins, flaws, cracks soft seams, sharp corners and other defects. The stone shall be quarried only from approved quarries and shall be subject to thorough inspection and approval before use on the dam and appurtenant structures. The stone shall be roughly cubical in shape and no stone weighing between 75 and 150 kg shall be less than 25 cm. in any direction. Spawls upto 20 cm. size shall be used to wedge into thick mortar spaces. No individual stone for use in masonry shall be less than 40 kg. in weight.

The percentage of water absorption (according to tests conforming IS - 1124 -1974) shall not exceed 5 percent. The stone should not contain crytocrystalline silica or chert mica or any other deleterious material like iron-oxide, organic impurities etc. Where considered necessary the stone shall be examined petrographically in accordance with IS -1123 - 1975.

The stone for face work shall be as follows:-

i) Stretcher - 25 cm. height, not less than 45 cm. in width and not less than 30 cm. in length dimentions perpendicular to the axis).

ii) Header:- 25 cm. height, 30 cm. width and length shall be more than 50 cm. with the area at the smaller end at the specified length not less than 50% of the area at the face.

The face stone shall be hammer-dressed on face and one line chiesel dressed on bed, top and sides for a minimum depth of 75 mm from front face. Beyond depth of 75 mm. the stone may taper but the tail end of the stones shall, at the minimum length specified have atleast half area of the face.

7.4.0 Cement Mortar

7.4.1 General

The cement mortar shall consist of cement, sand water and other approved admixtures, as required, each complying with its own specifications. The proportions of all materials entering into the mortar shall be based on adequate laboratory studies to ensure attainment of the standards required by these specifications. Cement mortar for use in masonry shall invariably be produced in mechanical mixture and by weigh batching. In exceptional circumstances under specific orders from Executive Engineer volumetric batching may be resorted to. Hand mixing will not be permitted unless total requirement of mortar on a day is so small in quantity for use on a particular day that mechanical mixing by the smallest available mixer will produce mortar in quantity larger than the total requirement, thereby causing wastage of mortar. However in exceptional circumstances hand mixing may be permitted under the specific orders of the Executive Engineer.

7.4.2 Storage of Sand

Water used for washing sand shall be clean and free from alkali, salts and other impurities. After washing, the sand must be stored in stock piles with a free draining base for at least 3 days to ensure that the material delivered to the batching plant will have a reasonably uniform moisture content.

7.4.3(i) Batching

The prescribed amount of the various materials for mortar including water, cement, admixtures and sand shall be measured and controlled within the specified limits of accuracy. The amount of water, cement and sand shall be determined by weighing. In the case of sand, the surface moisture shall be determined in accordance with the method prescribed in IS 2386 Part-III - 1963 as revised from time to time.

ii) The proportion of the various materials shall be changed as directed in order to maintain the desired quality of the mortar. The batching equipment shall be constructed and operated so that the combined inaccuracies in feeding and measuring the materials will not exceed one and a half percent for water, cement or puzzolan and 2 percent for sand.

iii) The operating performance of each scale or other measuring device shall be checked by test weights and the tests shall cover the ranges of measurements involved in the batching operations. Tests of equipment in operation shall be made atleast once every fortnight and adjustments, repairs,or replacements made as necessary to meet the specified requirements for accuracy of measurement.

iv) Sand shall not be batched for mortar when water is dripping from the sand,

7.4.4(i)Mixing

The mortar ingredients shall be mixed thoroughly in batch mixers of satisfactory type and sizes which are so designed as to ensure uniform distribution of all the component materials throughout the mass at the end of the mixing period. The plant shall be so designed and operated that all materials entering the mixer can be accurately proportioned and readily controlled. The entire batch within the mixer shall be discharged before recharging. The volume of mixed materials per batch shall not exceed the rated capacity.

ii) For any one batch, the difference between unit weights of air-free mortar in samples taken from the front and end of the mixer or mix discharge, when determined in accordance with the provisions of the mixer performance test, designation 26 in the Appendix of VII edition of the United States Bureau of Reclamation Concrete Manual, shall not exceed 1.6 percent of the mean value. Excessive variation in the unit weight of air free mortar indicates that mixing time should be increased. Mixer efficiency tests shall be made at the start of the job and at such intervals as may be necessary to ensure compliance with the requirements for effective mixing. The minimum mixing time specified herein may be reduced if mixer efficiency tests confirm that the reduced time permits satisfactory mixing.

The first mortar batch at the start of the day's work shall be made richer by the addition of the extra cement as directed.

iii) The mixing of each batch shall continue for not less than the period stated in the following table after all materials are in the

mixer, unless tests of mixer performance show that variation in these prescribed time is necessary and is acceptable.

	Capacity of mixer(M^3)	Time of mixing natural aggregate
1.	1.5 or less	1½ minutes
2.	2.5	2 minutes
3.	3	2½ minutes
4.	4	2¾ minutes
5.	4.5	3 minutes

Each mixer shall have a timing device for indicating the completion of the required mixing period. The actual time of mixing shall be checked atleast twice during each shift and the timing device shall be adjusted if in error. The timing device shall be so interlocked with the discharge gate of the batch hopper that timing does not start until the discharge gate is fully closed and all ingredients are in the drum. A suitable record shall be kept of the average time consumed in charging, mixing and discharging a batch during each run.

The full contents of the drum shall be discharged quickly so as to avoid segregation.

The minimum mixing periods specified are conditional on the materials being fed into the mixer in a manner which will facilitate efficent mixing and on operation of the mixer at its designed speed. The following sequence of charging the mixer may be adopted:-

(a) Five to ten percent of the total quantity of water required for mixing, adequate to wet drum thoroughly, shall be introduced before the other ingredients in order to prevent any caking of the cement on the blades or sides of the mixer.

(b) All dry ingredients (cement, puzzolan & sand) shall be simultaneously ribboned into the mixer in such a manner that the period of flow for each ingredient is about the same. Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly alongwith the dry ingredients.

(c) The remaining quantity of water shall be added after all the other ingredients are in the mixer.

(d) Water shall be added prior to, during and following the mixer charging operations. Excessive covermixing requiring addition of water to preserve the required mortar consistency will not be permitted. Mortar which has been kept unutilised for more than

30 minutes after the addition of water shall be wasted unless the mortar continues to be in such a workable condition that its use is specifically permitted.

(e) When the mixer is stopped before placing again any ingredients in the mixer all hardened concrete or mortar shall be removed from the inner surface of the mixer.

(f) The retempering of partially hardened mortar requiring renewed mixing with or without the addition of cement, sand or water shall not be permitted.

7.4.5 Transporting mortar

(i)(a)Mortar shall be transported from the mixer to the placing position as rapidly as practicable by methods that will prevent loss of ingredients or consistency, or in air content of more than two percent before the mortar is placed on the work. Whenever the length of haul from the mixing plant to the place of deposit is such that the mortar unduly compacts, suitable agitators shall be installed in the conveying system.

(b) Where the time of haul exceeds 20 minutes, mixed mortar shall be transported under cover and protected from evaporation.

(ii) Chutes used for conveying mortar shall be of such size and shape as to ensure a steady uniform flow in a compact mass and shall be protected from wind and sun where necessary to prevent loss of consistency by evaporation and shall be furnished with a discharged hopper. The free fall or drop of mortar shall be limited to 150 cm. Buckets shall be of the bottom drum type permitting an even controlled flow into the site of placing or hopper without undue splashing or segregation cars, trucks, and ships shall be designed to facilitate uniform delivery rather than quick dumping.

(iii) The chute sections shall be made of or lined with metal and all runs shall have approximately the same slope not flatter than one vertical to 2½ horizontal. The required consistency of the mortar shall not be changed in order to facilitate chuting. Where it becomes necessary to change the consistency, the mortar mix shall be completely redesigned. Wherever there is a free fall within the conveying system, suitable baffle plates, splash boards or downspouts shall be provided to prevent segregation, splashing or loss of ingredients. Wherever it is necessary to hold the discharged end of a chute more than 3 metres above the level of the fresh concrete, a flexible downspout shall be used to break the fall and confine the flow. The lower end of the spout shall be held close to the place of deposit. Wherever depositing is intermittent a discharge hopper shall be provided. All chutes shall be thoroughly cleaned before and after each run. All wash water and debris shall be wasted outside the forms.

(iv) Equipment used for transporting mortar from the mixer to the place of masonry shall be maintained free from deposits of still mortar and leakage of mortar.

7.5.0 Preparation for Placing Masonry

7.5.1 Masonry shall not be placed until embedded parts, if any are all installed and checked and surface prepared for placing. All surface of embedded material that have become encrusted with dried mortar or grout shall be cleaned thoroughly before the surrounding or adjacent masonry is placed. No masonry shall be placed until the foundation has been inspected and approved.

7.5.2 Immediately before placing masonry all surface of foundation upon or against which masonry is to be placed shall be free from standing water, mud & debris. All surfaces of rock upon or against which masonry is to be placed shall in addition to the foregoing requirements, be cleaned and free from oil, objectional coating and loose semi detached or unsound fragments. The surfaces of absorptive foundation upon or against which masonry is to be placed shall be moistened thoroughly and kept sufficiently wet for atleast 24 hours immediately prior to placing so that moisture will not be drawn from the freshly placed cement slurry and mortar. The cleaning and roughening of the surface of rock shall be performed by the use of high velocity air water jet, wet sand blasting, stiff brooms, picks or by other effective means. The washing and scrubbing process shall be continued until the wash water collecting in puddles is clear and free from dirt. In the final cleaning process the wash water may have to be removed by sponges. If any drilled hole is left in the foundation surface which are no longer needed, the hole shall be cleaned with air water jetting and filled up, completely with cement slurry. The preparation of the foundation as specified above shall be done not earlier than 72 hours before starting masonry work on it.

If for any reason construction on the foundation surface thus prepared is delayed, the area shall be examined thoroughly for any defects and necessary rectifications carried out. The foundation shall them be kept moistened for the 24 hours prior to masonry placement.

7.5.3 The surface of construction joints shall be clean, rough and damp but free from standing pools of water when receiving the next lift. Clean-up shall comprise removal of all laitence, loose or defected masonry/concrete, coating sand, sealing compound if used and other foreign materials, if necessary by scrapping and chipping or other suitable means. The surfaces of construction joints shall be cleaned by use of high pressure water jet analogous to green cutting concrete surfaces for preparing such surfaces to receive further work. The water jetting, sand blasting and washing shall be performed at the last opportunity prior to the placement of the masonry.

7.5.4 Immediately preceding the placement of masonry on foundation rock, the cleaned-up surface shall be coated with a thin layer of cement slurry (comprising one cement to two thirds water by volume). The slurry shall be spread only on a small area of about half a square metre at a time and the layer of mortar (which has to follow) shall be spread immediately thereafter but in no case later than five minutes after the slurry coat is given in order to avoid stiffening-up of cement slurry which may prevent satisfactory bonding. The layer of mortar 50 to 75 mm. thick shall be spread over the slurry and worked into all the irregularities of the foundation surface. The composition of the mortar shall be the same as for the masonry being placed over it. The stone of the first course of masonry shall be carefully pressed into the mortar immediately so as to force the mortar around the corners. The layers of mortar shall be made thicker if stones larger than one twentieth cum. are placed.

Water from any springs or leakage through the surrounding area shall be kept out of the foundation and from any masonry till later has set. Where pumping is resorted to, care shall be taken to ensure that no work already carried out is disturbed or damaged.

Masonry surfaces which have been exposed for a long time before the succeeding layer is built shall be treated in the same way as the foundation rock.

7.5.5 The clean up of construction joints in running masonry work can be accomplished with ease if a freshly placed layer is gone over with air and water jet just after a lapse of three to four hours when the mortar will normally have set hard enough to withstand any erosion. This period may have to be varied to suit conditions arising from the type of cement used and the weather.

7.6.0 Masonry Work

7.6.1 General

The masonry work shall be so arranged that a layer of masonry once laid is not subjected to any disturbance either from the placement of subsequent layers or from any incidental traffic on the block from the time the mortar in the first layer has lost its plasticity(work-ability) to atleast 24 hours from its placement.

The details of all openings, block outs, measuring instruments and embedded parts and piping shall be ascertained and all fixtures positioned in the area before the masonry works is done in the area.

7.6.2 Face Masonry (Coursed Rubble Masonry)

The face masonry work shall be in parallel courses of about 300 mm in thickness. In each course, stones shall be laid header and stretcher fashion and joints shall break in courses above and below by atleast half the height of the course. The joints shall not be thicker than 12 mm for the upstream face with chiesel dressed stones and 20mm for downstream face with hammer dressed stones.

The face masonry work shall preferably be carried on simultaneously with the hearting masonry, in any case the difference in level between the highest point and the lowest point at any time in the block shall not be more than one and a half metre, with each succeeding course having a minimum offset of one and a half metres with respect to the course below.

The content of mortar in face stone masonry shall not be less than 40% of masonry.

7.6.3 Random Rubble Masonry (Uncoursed Rubble Masonry)

The stones shall be set on their flat beds as received from the quarry and without further dressing except knocking out weak corners and sharp edges. Spalls upto 200 mm size shall be used to wedge into thick mortar space and shall not exceed 10% of the total stones utilised. All stones, spalls etc., shall be washed with air water jet before use to ensure clean surface for mortar to adhere to and water shall be sprinkled before actually placing the stone in position in the work to prevent absorption of water from the mortar. The stones shall be carefully laid so as break joints as much as possible and solidity bedded with close joints. The mortar should be worked be a trowel to a quacky mass and the selected stones laid on flat bed and shaken to sink into mortar squeezing it out of the sides. The spalls shall be hammered down by a wooden mallet in the mortar filled in between the stones so as to reduce the thickness of the mortar joints. Additional mortar shall be used in the intervening spaces and well worked by the trowel and a light hand bar 12 mm dia and 0.6 metre long to mix up well with the bottom mortar and the stones vibrated to the extent necessary to bring up all excess mortar and entrapped air in the mortar. The content of mortar in random rubble masonry shall not be less than 40% of the masonry.

7.7.0 Weather Condition

Masonry work shall be temporarily suspended during excessively hot or rainy weather when conditions are such that the masonry can not be properly placed and cured.

Wherever necessary, exposed surfaces of fresh masonry shall be shaded from the direct rays of the sun and protected against premature setting of the mortar or drying by being cured under continuous sprays of water. All freshly placed masonry shall be covered and protected against surface wash.

7.8.0 Curing

Specifications for curing of masonry shall be same as for concrete as laid down in the relevant chapter of "Cement concrete".

7.9.0 Requirement of Impermeability and Permeability Testing Procedure for Masonry

Test holes for water testing shall be of 70 mm min. diameter, 4 to 6 metres deep core-drilled in the finished masonry at places shown after a minimum of 28 days hardening. The test holes shall be in two rows, the first row at 1½ m. from the upstream face of the dam and the second at a suitable location to be indicated. Atleast 2 holes shall be tested in each block. The pressure to be used for the test shall be equivalent to 1.75 times of the expected head of water at the elevation of bottom of hole. The labour and equipment shall be arranged by the Board and tests carried out by the officer authorised by the Executive Engineer. However, services of water and air shall have to be supplied by the contractor at no extra cost.

Water loss in any portion of the hole shall not be more than 0.25 litre per Sq. metre per minute in case of the first row of hole and 1.25 litres/Sq.metre/minute in the other when the head is applied for at least 10 minutes during each test subject to 10 m. being the minimum hydrostatic head to be applied. If the water loss test is done at pressures less than desired head, the water loss results should be interpreted assuming the variation of water loss with respect of pressure as linear.

If test holes in a block indicate water loss greater than acceptable, measures in the form of adequate core drilling and grouting shall be done as directed at the cost of contractor.

7.10.0 Measurement and Payment

7.10.1 General

The prices entered in the schedule for the incorporation of the various classes of masonry required by this section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work

including cement slurry with cost of cement except for any item specifically exempted therefrom and for which, in addition a specific payment item has been included in the schedule.

7.10.2 Measurement of the various classes of masonry for payment shall be made on the basis of the volume of the respective masonry work calculated as being contained within the relevant outlines shown on the drawings.

7.10.3 No allowance shall be made for the masonry backfill beyond the minimum lines of excavation shown on the drawings except where such payment is specifically authorised. Measurement of masonry shall be made without deductions for space occupied by electrical conduits, reinforcement.

7.10.4 Rates of various classifications of stone masonry in the schedule of bids are to be based on the assumption that in all types of masonry 150 kg of cement is used per cubic metre of finished masonry. If the contractor is required to use any different content of cement per cubic metre of masonry, the payment to contractor shall be adjusted upward or downward on the basis of such variation in cement content at the unit rate for the item "Variation in cement content in stone masonry from 150 kg per cum. of masonry". The cement content for the purpose of calculating variation in cement content shall be arrived by dividing total cement consumption in all types of masonry as recorded at the mixing point of mortar (approved for use by the Executive Engineer) by the total volume of finished masonry placed within the prescribed lines and grades and shall be deemed to cover all labour, material and equipment employed for it.

7.10.5 Payment for the various classes of masonry shall be made on the basis of the unit price per cum. entered for the respective items in the schedule.

SECTION-8

CEMENT CONCRETE

8 0 Cement Concrete

8.1.0 General

Concrete for the dam and appurtenant works shall be composed of cement, sand, coarse, aggregate, water and any other admixtures as specified, all well mixed and brought to the proper consistency. Tests shall be carried out on the concrete at specified intervals during the progress of work and the mixes modified as necessary in order to consistently secure the required strength work ability, density and impermeability together with the maximum practicable economy. It is contemplated that the concrete will range in character from a mass concrete with maximum aggregate of size 75 mm. and a cement content of approximately 200 kg/M^3 to a heavily reinforced concrete having 20 mm. maximum size of aggregate and a cement content of approximately 400 kg/M^3. The water-cement ratio for the concrete will be regulated by the requirements of strength, durability and workability. The concrete shall be of uniform consistency and quality throughout any pour and for similar parts of the same structure. However, the consistency composition shall be such that the concrete can be worked into all corners and angles of the forms and that the concrete surrounds completely the reinforcement and embedded metal without causing any segregation of the ingredients or collecting any free water taking into account the type and capacity of vibrating equipment used.

The control of concrete is based, besides other factors on maintaining a fairly uniform slump at the point of placement and on holding the water-cement ratio as closely as practicable to the standards determined for the purpose. Under no conditions shall the slump be greater than that required to provide proper placement and compaction of the fresh concrete within the forms.

The slump shall be measured in accordance with the standard methods prescribed in Appendix-G of IS.456 - 1966 as revised from time to time.

The allowable slump or consistency shall be as directed. The consistency of the concrete shall be varied only by increasing or by

decreasing the amount of cement paste in each batch and not by any change of the water-cement ratio established for each class of concrete.

8.2.0 Concrete Classification

Concrete classification is related to the specified 28 days compressive strength and shall conform with the requirements set out in Table 1 thereof. In case where approved pozzolan is used as part replacement of cement, the pozzolan concrete shall be designed to attain the same 365-days strength as would be attained at the end of 365 days by a corresponding neat cement concrete.

A minimum of three test specimens shall be made for each 120 cubic metre of each class of concrete for a given age. There shall be atleast three test specimens for each day of concreting even if only a few cubic metres of the particular concrete is manufactured in a day.

The tests shall satisfy the following criteria:

(i) The average strength of any three consecutive sample strengths shall be greater than the specified strength.

(ii) The overall coefficient of variation for any ten consecutive sample strength shall be less than 0.15.

(iii) Not more than ten percent of the specimen strengths shall be less than 85 percent of the specified strength.

Additional tests shall be carried out as and when directed.

8.2.1

Table-I

Concrete classifications & location of use.

Sl. No.	Classification of concrete(IS 456-1966)	Location	Details	
			Maximum aggregate size in mm.	Minimum compressive strength kg/M^2 for 15 cm.cube @ 28 days.
1	2	3	4	5
1.	C 1(M.150)	In foundation for filling crevices etc., if necessary.	40	150
2.	C 2(M.200)	In road bridges, slabs, beams all around galleries, & other opening in the Dam.	40	200

1	2	3	4	5
3.	C 3(M.250)	Spillway crest downstream of spillway, piers, bucket portion and training wall.	75	250
4.	C 4(M.250)	In block outs.	20	250

8.3.0 Concrete Materials

8.3.1 Cement

Cement shall, unless otherwise specified be ordinary portland cement conforming to the relevant clauses of the I.S. 269 - 1976 (Third revision) as revised from time to time.

Cement shall be used in approximately the same chronological order in which it is received from the factory.

Transportation units and storage bins for bulk cement shall be weather proof and shall be constructed so that there is no dead storage.

Cement delivered in bags shall be transported under completely weather-proof covers and stored in weather-proof structures with adequate provision for the prevention of absorption of moisture and stored in a manner permitting inspection and identification of each consignment. Stacking height of bagged cement shall not exceed 3 metres.

Cement that has been in storage for more than four months shall not be used without special inspection, testing and approval.

8.3.2 Water

The water used shall be clean and free from injurious amounts of deleterious substances such as but not limited to, silt sewage, oil, acid, alkali, salts and organic matter.

8.3.3 Sand

The term sand is used to designate fine aggregate with maximum size of particles 4.75 mm. The sand used shall be of coarse category conforming to the relevant specifications of the IS 515 - 1959 & I S. 383 - 1963 as revised from time to time. It shall be either natural river sand or manufactured stone sand or mixture of both in specified proportions. The sand shall be clean and gritty and composed of hard siliceous grains of a quality approved by the Executive Engineer. It shall be free from injurious amount of clay, soft particles, flaky

particles, vegetable of organic matter mica and other deleterious substances and shall not contain any salts.

(i) Natural Sand

Natural sand shall be obtained from an approved source. No sand affected by salty sea water shall be used. The sand shall be screened and thoroughly washed, preferably in flowing water so as to remove all earthy impurities and very small fines unless otherwise permitted by the Executive Engineer.

Natural sand shall be reasonably free from laterite and other softer grains and all source of sand showing appreciable percentage of these impurities shall be rejected.

The maximum percentage of deleterious substances in the natural sand as delivered to the mixer shall not exceed the following:-

Deleterious substance	Maximum permissible limit by weight
Materials finer than I.S.Sieve No.	3%
Shale	1%
Coal and lignite	1%
Clay lumps	1%
Cinders and clinkers	0.50%
Alkali mica and coated grain (deleterious)	2%

Note: The sum of percentage of all deleterious substance shall not exceed 5% by weight.

The presence of mica in the fine aggregate will reduce the compressive strength of concrete considerably. It is advisable to investigate the mica content of the fine aggregate and make suitable allowances for possible reduction of strength of concrete or mortar.

(ii) Manufactured Sand

Wherever natural sand conforming to specification requirements is not likely to be available within economic reach, resource has to be taken to manufactured stone sand of desired quality. The stone that will be used in crushing for getting fine aggregate shall conform in all respects to the stone specified for course aggregate.

The maximum percentage of deleterious substance in the manufactured sand as delivered to the mixer shall not exceed the following:-

Deleterious substance	Maximum permissible limit(by weight)
Material passing I.S. sieve 8.	3%
Coal and lignite	1%
Clay lumps	1%
Others	1%

Note: The sum of the percentage of all deleterious substance shall not exceed 5% by weight.

The natural and manufactured sand should be protected from being contaminated with dust, organic matter or other deleterious substances and should be as per specifications. If manufactured sand is not considered as per specifications, the same may be outright rejected by the Executive Engineer or the sand may be allowed to be used after required treatment. Varying amount of moisture in fine aggregate contributes to the lack of uniformity in concrete consistency. Efforts should be made to ensure uniform and stable moisture content in the aggregate as batched. Dry sand will always be preferred.

The sand will be well graded and when tested by standard sieves shall conform to the following limits of gradation. The gradation shown in the table are indicative only. The best gradation may be determined by the Executive Engineer after experiments and tests.

Sieve Size I.S.	Individual percentage retained	
	Natural sand	Manufactured sand
1	2	3
480	0-5	0-5
240	5-20	10-25
120	10-20	10-25
60	10-30	10-30
30	15-35	10-30
15	12-30	10-20
Pass	3-7	10-20
Max. F.M.	3.10	3.25
Min. F.M.	2.30	2.50

The grading of fine aggregate shall be so controlled that the fineness moduli of at least 9 out of 10 samples of fine aggregate delivered to the mixer shall not very more than 0.20 from the average of 10 samples tested.

8.3.4 Coarse Aggregate

The term coarse aggregate is used to designate aggregate that is reasonably well graded and ranging in size of particles from 4.75 mm. to 150 mm.or any size or range of sizes within such limits. The coarse aggregates shall conform to relevant specifications of I.S. 515 - 1957 (for natural and all manufactured aggregate) or of I.S. 383 - 1963(for natural aggregate as revised from time to time).

The aggregate shall be composed of clean hard durable pieces of stone, regular, rounded, in shape obtained naturally or by crushing from suitable stone approved by the Executive Engineer.

The coarse aggregate shall be free from objectionable quantities, of weed or other deleterious substances, the preparation of which in any size of coarse aggregate as delivered to the mixer shall not exceed the following values.

Permissible deleterious material in manufactured coarse aggregate:

Deleterious substance	Maximum permissible limits (by weight)
Material finer than I.S.8	1%
Coal and lignites	1%
Clay lumps	1%
Total soft, friable, elongated or laminated pieces	3%

Note:-- Total of all deleterious materials shall not exceed 5% by weight. Permissible deleterious materials in natural coarse aggregate.

Deleterious substances	Maximum permissible limits (by weight)
Material finer than IS-8	1%
Coal and lignite	1%
Clay lumps	1%
Soft fragments	3%

Note:- Total of all deleterious material shall not exceed 5% by weight. The aggregate shall be resistant to chemical or physical change such as cracking, swelling, softening, leeching, or other chemical alteration after its incorporation in concrete.

(i) Crushing and Grading

The aggregate should be crushed and the different sizes of the coarse aggregate shall be separated into nominal sizes as follows:-

Designation of size	Nominal size range
20 mm(¾") aggregate	(3/15" to ¾") 4.75 mm to 20 mm.
40 mm(1½")aggregate	(2/4" to 1½") 20 mm to 40 mm.
80 mm(3") aggregate	(1½" to 3") 40 mm to 80 mm.
150 mm(6") aggregate	(3" to 6") 80 mm to 150 mm.

(ii) Storage

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

The percentage of weight of the significant under size shall be less than 5% when tested on the designated test screens having opening 5/6 times the normal minimum size of material. No oversize (i.e. material that would be retained on the designated test screens having opening 7/6 times the normal sizes of the material) will be permitted. In addition to these requirements, coarse aggregates of all size shall further conform to the relevant I.S.S. 515 - 1959 or its revisions when tests for crushing, abrasion soundness and water absorption of coarse aggregates. Use of aggregates and sand containing excessive amount of zeolitas, secondary minerals and such other components which cause alkali reactivity of the aggregates and consequent reduction in durability in concrete is prohibited. The Executive Engineer may, however, allow use of such material either in part or in full keeping in view the extent of reactivity, the location, the nature of exposure and the structure.

8.3.5 Admixtures

Admixtures such as wetting agents air entraining agents etc. shall be used only under specific authorisation and wherever so permitted, the proportions and methods of use shall be as directed by Executive Engineer. Materials permitted as admixtures shall have

established merit for improving any specific quality of the concrete without having any deleterious effects.

8.4.0 Manufacture of Concrete

8.4.1 Production of Aggregates

Production of aggregate may include quarrying of the raw materials and processing viz. transporting, crushing, screening, and washing. Water used for washing aggregates shall be clean and free from alkali, salts and other impurities. After washing, fine aggregate must be stored in stockpiles with a free-draining base for atleast 3 days to ensure that sand delivered to the batching plant will have a reasonably uniform moisture content. The storage and handling shall be in such a manner as to prevent inter-mingling of various sizes of aggregates required separately for grading purposes. No foreign matter shall be allowed to be mixed up with the aggregates.

8.4.2 Batching

(i) The prescribed amount of the various materials for concrete, including water, cement, admixtures, the groupings of fine aggregate and each individual size of coarse aggregate shall be measured and controlled within the specified limits of accuracy. The amount of water, cement and aggregate shall be determined by weighing. In the case of fine aggregates, the surface moisture shall be determined in accordance with the method prescribed in Appendix-D of IS 456 - 1957 as revised from time to time. In the case of coarse aggregates, percentage of free water shall be determined by weighing a representative sample, then surface drying each particle individually with a clean piece of cloth and re-weighing.

(ii) The proportions of various materials shall be changed as directed in order to maintain the desired quality of the concrete. The batching equipment shall be constructed and operated so that the combined inaccuracies in feeding and measuring the materials will not exceed 1½ percent for water on cement and 2 percent for each size of aggregate.

(iii) The operating performance of each scale or other measuring device shall be checked by test weights, and the tests shall cover the ranges of measurements involved in the batching operations. Tests of equipment in operation shall be made atleast once every fortnight and adjustments, repairs or replacements made as necessary to meet the specified requirements for accuracy of measurement.

(iv) Aggregate shall not be batched for concrete or mortar when free water is dripping from the aggregate.

8.4.3 Mixing

(i) The concrete ingredients shall be mixed thoroughly in batch mixers of satisfactory type and size, which are so designed as to ensure uniform distribution of all the component materials through out the mass at the end of the mixing period. The plant shall be so designed and operated that all materials entering the mixer can be accurately proportioned and readily controlled. The entire batch within the mixer shall be discharged before re-charging. The volume of mixed materials per batch shall not exceed the rated capacity. A mixer will be considered unsatisfactory, if from three tests of any one batch a range in slump exceeding 25 mm. or a range in air content exceeding one percent is given between representative samples taken at different portions of the mixer discharge.

(ii) (a) For any one batch, the difference between unit weights of air-free mortar in samples taken from the front and end of the mixer discharges, when determined in accordance with the provisions of the mixer performance test, designation 26 in the Appendix of the seventh edition of the United States Bureau of Reclamation Concrete Manual, shall not exceed 1.6 percent of the mean value. The adequacy of mixing shall also be determined in accordance with "Methods of sampling Analysis of Concrete" as per I.S. 1199-1959 and its subsequent amendments. Excessive variation on the unit weight of air free mortar indicates that mixing time should be increased. Mixer efficiency tests shall be made at the start of a job and at such intervals as may be necessary to ensure compliance with the requirements for effective mixing. The minimum mixing time specified herein may be reduced if mixer efficiency tests confirm that the reduced time permits satisfactory mixing.

The first concrete batch at the start of the day's work shall be made richer by the addition of extra cement as directed.

(b) For any one batch the difference between the unit weights of coarse aggregate from concrete samples from the front and end of the mixer or mixer discharge, when determined in accordance with the above mentioned mixer performance test shall not exceed 10 percent of the mean value.

(iii) The mixing of each batch shall continue for not less than the period stated in the following tabulation after all materials are in the mixer, unless tests of mixer performance show that variation in these prescribed times is necessary or acceptable.

Capacity of mixer	Time of mixing	
	Natural aggregate	Manufactured aggregate
1. 1 cubic metre or less	1¼ minutes	1½ minutes
2. 2 cubic metres	1½ minutes	2 minutes
3. 3 cubic metres or larger	2 minutes	2½ minutes

Each mixer shall have a timing device for indicating the completion of the required mixing period.

The actual time of mixing shall be checked atleast twice during each shift and the timing device shall be adjusted if in error. The timing device shall be so interlocked with the discharge gate of the batch hopper that timing does not start until the discharge gate is fully closed and all ingredients are in the drum. A suitable record shall be kept of the average time consumed in charging, mixing and discharging a batch during each run.

The full contents of the drum shall be discharged quickly so as to avoid segregation.

The minimum mixing periods specified are conditional on the materials being fed into the mixer in a manner which will facilitate efficient mixing and on operation of the mixer at its designed speed. The following sequence of charging the mixer may be adopted.

(a) Five to ten percent of the total quantity of water required for mixing, adequate to wet the drum thoroughly, shall be introduced before the other ingredients in order to prevent any caking of the cement on the blades or sides of the mixer.

(b) All dry ingredients (cement and both fine and coarse aggregate) shall be simultaneously ribboned into the mixer in such a manner that the period of flow for each ingredient is about the same. Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly along with the dry ingredients.

(c) The remaining quantity of water shall be added after all the other ingredients are in the mixer.

(d) Portion of the coarse aggregate, however, may be added last, this facilitates the clearance of the chutes and removes any fine aggregate or cement adhering to the sides.

(iv) Excessive mixing requiring addition of water to preserve the required concrete consistency will not be permitted. Concrete which has been kept unused for more than 30 minutes after the addition of water shall be wasted unless the concrete is in such a condition that it can be subsequently vibrated in place and its use is specifically permitted.

(v) When the mixer is stopped, before placing again any ingredients in the mixer all hardened concrete or mortar shall be removed from the inner surface of the mixer.

(vi) The retempering of partially hardened concrete or mortar requiring renewed mixing, with or without the addition of cement, aggregate or water shall not be permitted.

8.5.0 Temperature of Concrete and Weather Conditions

The temperature of concrete at the time of placement shall not exceed 32^{o}. Concrete operations shall be temporarily suspended during excessively hot weather when the air temperature inside the forms exceeds $45^{o}C$ or when conditions are such that the concrete cannot be placed at the required temperature. Wherever necessary, exposed surfaces of fresh or green concrete shall be adequately shaded from the direct rays of the sun and protected against premature setting or drying by curing under continuous fine spray of water.

8.6.0 Transporting Concrete

8.6.1

(i) (a) Concrete shall be transported from the mixer to the placing position as rapidly as practicable by methods that will prevent segregation or loss of ingredients, or slump loss in excess of 25 mm. and or a loss in air content of more than one percent before the concrete is placed in the works. Whenever the length of haul from the mixing plant to the place of deposit is such that the concrete unduly compacts or segregates, suitable agitators shall be installed in the conveying system.

(b) Where the time of haul exceeds 20 minutes, mixed concrete shall be transported under cover and protected from evaporation.

(ii) Buckets used for conveying concrete shall be capable of prompt discharge of low-slump, lean-mix concrete in controlled quantities without splashing or segregation and shall be of such capacity that there is no splitting of batches in loading buckets. Buckets shall be of the bottom dump type permitting an even, controlled flow into the forms or hopper without undue splashing or segregation. Cars, trucks and skips shall be designed to facilitate uniform delivery rather than quick dumping.

(iii) Chutes used for conveying concrete shall be of such size and shape as to ensure a steady uniform flow of concrete in a compact mass without separation or loss of ingredients and shall be protected from wind and sun where necessary to prevent loss of slump by evaporation and shall be furnished with a discharge hopper. The free fall or drop of concrete shall be limited to 150 cm. The chute sections shall be made of, or lined with metal and all runs shall have approximately the same slopes not flatter than 1 vertical to 2½ horizontal. The required consistency of the concrete shall not be changed in order to

facilitate chuting. However, if it becomes necessary to change the consistency, the concrete mix shall be completely redesigned. Wherever there is a free fall within the conveying system, suitable baffleplates, splash boards, or down spouts shall be provided to prevent segregation, splashing or loss of ingredients. Whenever it is necessary to hold the discharge end of a chute more than 3 metres above the level of the fresh concrete, a flexible downspout shall be used to break the fail and confine the flow. The lower end of the spout shall be held close to the place of deposit. Wherever depositing is intermittent, a discharge hopper shall be provided. All chutes shall be thoroughly cleaned before and after each run. All wash water and debris shall be wasted outside the forms.

(iv) Equipment used for transporting concrete from the mixer to the forms shall be maintained free from deposits of stiff concrete and leakage of mortar. Batch containers transit mixers, chutes, concrete pumps, pipelines and discharge hoppers shall be thoroughly cleaned after each run and wash water and debris wasted outside the forms.

8.7.0 Preparation for Placing Concrete

8.7.1 Concrete shall not be placed until all form work required is completed, embedded parts, if any, installed and checked and surfaces prepared for placing. No concrete shall be deposited until the foundation has been inspected and approved.

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

8.7.2 Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed, shall be free from standing water, mud and debris. All surfaces of rock upon or against which concrete is to be placed shall, in addition to the fore-going requirements be cleaned and free from oil, lubricants, objectionable coatings and loose semi detached or unsound fragments. The surface of absorptive foundations upon or against which concrete is to be placed shall be moistened thoroughly and kept sufficiently wet for at least 24 hours immediately prior to placing so that moisture will not be drawn from the freshly placed concrete. The cleaning and roughening of the surfaces of rock shall be performed by the use of high velocity air water jets, wet sand blasting, stiff brooms, picks or by other effective means. The washing and scrubbing process shall be continued until the wash water collecting in puddles is clear and free from dirt. In the final cleaning process the wash water may have to be removed by sponges. If any drilled hole is left in the foundation surface which is no longer needed, the holes shall be cleaned with air water jetting and filled up completely with cement slurry.

8.7.3 Concrete/masonry surfaces upon or against which concrete is to be placed and to which the new concrete is to adhere and that it has become so rigid that the new concrete can not be incorporated by mere vibration integrally with that previously placed, are defined as construction joints.

The surfaces of construction joints shall be clean, rough and damp but free from standing pools of water when receiving the next lift. Clean up shall comprise removal of all laitance, loose or defective concrete, castings, sand, sealing compounds if used and other foreign materials, if necessary by scrapping,chipping or other suitable means.

The surfaces of construction joints shall be cleaned by use of a high pressure water jet or by wet sand blasting and then washed thoroughly. The water jetting, sand blasting and washing shall be performed at the last opportunity prior to the placing of concrete.

8.8.1 Placing and Compacting Concrete

After the surfaces have been cleaned and dampened as specified, surfaces of rock and construction joints shall be covered, wherever practicable with a layer of mortar approximately 15 mm to 20 mm thick. The mortar will have the same proportions of water, air entraining agent, cement and fine aggregate as the concrete mixture which is to be placed upon it. The water-cement ratio of the mortar is place shall not exceed that of the concrete to be placed upon it, and the consistency of the mortar shall be suitable for being spread uniformly and worked thoroughly into all irregularities of the surface.

8.8.2 In so far as it is practicable, concrete shall be placed directly in its final position and shall not be caused to flow in a manner to permit or cause segregation. Methods and equipment employed in placing concrete will ensure that aggregate is not separated from the concrete mass.

8.8.3 In placing mass concrete in a lift successive batching of concrete shall be placed in a systematic arrangement in order to avoid long exposure of parts of the live surface of a concrete layer.

In mass concrete placement, delays may occur resulting in cold joints within a lift. When placement is resumed while concrete is so green (and therefore capable of ready bonding) that it can be dug out with a hand pick, the usual contraction joint treatment will not be required if the surfaces are kept moist and the concrete placed against the surface is thoroughly and systematically, vibrated over the entire area adjacent to the older concrete. If the delay is short enough to permit penetration of the vibrator into the lower layer during routine vibration of successive layers, the vibration will assure necessary bonding.

If from any cause, the working surface is left exposed until it has hardened to a considerable extent, it shall be left to set and cure for not less than 56 hrs. or longer if necessary until a strength greater than 35.2 kg/Cm^2 (500 psi) has been attained, before completing the lift. The surface thus, interrupted shall be given a thorough clean up as for normal lift joint surface and the work shall be commenced with a mortar layer as specified.

In placing mass concrete, the exposed area of fresh concrete shall be maintained at the practical minimum by first building up the concrete in successive approximately horizontal layers to the full width of the block and to full height of the lift over a restricted area at the downstream end of the block and then continuing upstream in a similar progressive stages to the full area. The slope formed by the unconfined upstream edges of the successive layers of concrete shall be kept as steep as practicable in order to keep its area minimum. Concrete along these edges shall not be vibrated until adjacent concrete in the layer is placed, except that it shall be vibrated immediately when weather conditions are such that the concrete will harden to an extent the later vibration may not fully consolidate and integrate it with more recently placed adjacent concrete.

Re-tempering of concrete shall not be permitted. Any concrete which has become so stiff that proper placing without re-tempering can not be ensured, shall be wasted.

In formed work, structural concrete placements shall generally be started with an over-sanded mix containing 20 mm maximum size aggregate and an extra sack of cement per cubic metre and having a 125 mm slump placed several centimetres deep on the joints at the bottom of the form, concrete placement shall commence immediately thereafter.

8.8.4 If concrete is placed monolithically around opening having vertical dimensions greater than 0.6 metre, or if concrete in decks floor slabs, beams, girders, or other similar parts of a structure is placed monolithically with supporting concrete, the following instructions shall be strictly observed.

(i) Placing of concrete shall be delayed not less than one hour nor more than three hours at the top of openings and at the bottom of fillets under decks, floor slabs, beams, girders or other similar parts of structures when fillets are specified and at the bottom of such structures, members when fillets are not specified but in no case shall the placing be delayed so long that the vibrating unit will not of its own weight readily penetrate the concrete placed before the delay. When consolidating concrete placed after the delay, the vibrating until shall penetrate or vibrate the concrete placed before the delay.

(ii) The last 0.6 metre or more of concrete placed immediately before the delay shall be placed with as low slump as practicable and shall be thoroughly compacted.

(iii) The surfaces of concrete where delays are made shall be clean and free from loose and foreign materials when concrete placing is started after the delay.

(iv) Concrete placed over openings and in decks, floors, beams girders and other similar parts of structures shall be placed with as low slump as practicable.

(v) Concrete shall be compacted to maximum practicable density, in such a manner that is free from pockets of coarse aggregate and is in intimate contact with surface of forms and embedded/materials. Unless otherwise permitted, all concrete shall be compacted by mechanical vibrator.

(vi) Compaction of concrete shall wherever practicable be carried out by the use of immersion type vibrators. Concrete vibrators having vibrating heads of 100 millimetre or more in diameter shall be operated at speeds of at least 6000 revolutions per minute when immersed in the concrete.

Vibrators having vibrating heads less than 100 mm. in diameter shall be operated at speeds of at least 7,000 revolutions per minute in the concrete. Normally, form work shall be designed to provide for the insertion and operation of mechanical vibrators in the placed concrete. Form vibrators shall be used wherever internal vibration is not possible or would be inadequate.

In compacting each layer of concrete the vibrator shall be operated in as near vertical position and the vibrating head shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer. In the area where newly placed concrete in each layer joins previously placed concrete, more vibration than usual shall be performed the vibrator penetrating deeply at close intervals along these contacts. Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contact of the vibrating head with surface of the forms shall be avoided.

(vii) During placing and until curing is completed the concrete shall be protected against the harmful effect of exposure to sunlight, wind and rain as direct.

8.9.0 Form Work

8.9.1 General

(i) Forms shall be used wherever necessary to confine the concrete and shape it to the required lines, or to ensure against contamination of the concrete by material caving or sloughing from adjacent surface left by excavations or other features of the work. All exposed concrete surfaces having slopes of 2 horizontal to 1 vertical or greater shall be formed.

(ii) Form work may be of timber, steel of precast concrete panels or of such other suitable materials or combination of such materials. Form work shall be sub-stantially and rigidly constructed to the shapes, lines and dimensions required, efficiently propped and braced to prevent deformation due to placing, vibrating and compacting cc rete, other incidental loads or to the effect of weather. If settlement or deflection of forms under the load of fresh concrete is to be expected, allowance should be made in the original construction of the forms so that the finished lines and dimensions of the structure are in accordance with those specified on the drawings.

(iii) The surfaces of form work shall be made to produce surface finishes as specified and form work joints space be tight enough to prevent loss of liquid form concrete. Joints between the form work and existing concrete structures shall also be 'grout tight'. Form work shall be arranged to facilitate easing and removing of the various parts in correct sequence, without jarring or damaging the concrete. Fixing blocks belts or similar devices may be embedded in the concrete, provided they do not reduce the strength or effective cover of any part of the structure below the required standard but the use of through bolts shall be avoided wherever possible. Temporary opening shall be provided at all points necessary in the forms to facilitate clearing and inspection immediately before the placing of the concrete.

(iv) Forms shall overlap the hardened concrete in the lift previously placed by not more than 75 mm. and shall be tightened smogly against the hardened concrete so that when concrete placement is resumed, the forms will not spread and allow offsets or loss of mortar at construction joints. Additional bolts or form ties shall be used as necessary to hold forms tight against hardened concrete. Particular attention shall be paid in setting and tightening the forms for construction joints so as to get a smooth joint free from sharp deviations or projections.

(v) Moulding strips shall be placed in the corners of forms so as to produce chemfered edges as required on permanently exposed concrete surface.

8.9.2 Materials to be Used

(i) Materials used for form sheathing and lining shall conform with the following requirements:

Required finish	Timber sheathing or lining	Steel sheathing or lining
1	2	3
F 1	Any type and grade meeting the dimensional requirements of surface finish except that metal forms shall be used on surfaces of internal transverse and longitudinal joints in the dam.	Steel sheathing permitted, steel lining permitted except on surfaces of internal transverse and longitudinal joints in the dam where steel sheathing is required.
F 2	Common grade timber or plywood sheathing or lining.	Steel sheathing permitted, steel lining permitted if strongly supported.
F 3	For plane surfaces, common grade timber or better T & S or plywood.	Steel sheathing permitted, Steel lining not permitted.
F 4	For warped surfaces timber which is free from knots and other imperfections and which can be cut and bent accurately to the required curvatures without splintering or splitting.	Steel sheathing permitted. Steel lining not permitted.

* Steel sheathing denotes steel sheats not supported by a backing of timber boards. Steel lining denotes steel sheats supported by a backing of timber boards.

(ii) Timber sheathing or lining shall be of such kind and quality or shall be so treated or coated that there will be not chemical deterioration or discolouration of the formed concrete surfaces. The type and condition of form sheathing and lining and the ability of forms to withstand distortion caused by placement and vibration of the concrete, and the workmanship used in the form construction shall be such that the

formed surfaces will conform with applicable requirements of this specification pertaining to finish of formed surfaces.

Forms for concrete surfaces required to receive F2 and F3 finishes shall be constructed so as to produce uniform and consistent texture and pattern on the concrete faces. Metal patches on forms for these faces will not be permitted. The form sheathing or lining shall be so placed that all horizontal form marks are continuous across the entire surface. Where finish F2 is specified the sheathing or lining shall be placed so that the joint marks on the concrete surfaces will be in general alignment both horizontally and vertically and the form sheathing material used for such surfaces shall be restricted to one type in any one major feature of the work.

Forms for surfaces required to receive F4 finish shall be constructed so as to conform accurately to the required curvature of the sections. Where necessary to meet requirements for curvature the form sheathing shall be built up of laminated splices cut to make right, smooth form surface. The forms shall be so constructed that the joint marks on the concrete surface shall in general, follow the line of water flow. After the forms have been constructed, all surface imperfections shall be corrected, all the nails shall be hidden, and any roughness and all angles on the surface of the forms caused by matching the forms material shall be dressed to curvature.

If temperate hard wood is used as a form lining, it shall be continuously supported with timber or plywood.

(iii) Embedded ties for holding forms shall remain embedded and except where F1 finish is permitted, shall terminate not less than two diametres or twice the minimum dimension of the tie or ten millimetres, whichever is greater, in from the formed faces of the concrete. Where F1 finish is permitted, ties may be cut off flush with formed surface.

The ties shall be constructed so that removal of the ends or and fasteners can be accomplished without causing appreciable spalling at the faces of the concrete. Recesses resulting from removal of the ends of the form ties shall be filled in accordance with the provisions of section of repair of concrete.

8.9.3 Cleaning and Treatment of Forms

At the time concrete is placed in the forms, the surface of the forms shall be free from encrustations of mortar, grout or other foreign material. Before concrete is placed, the surfaces of the forms designated to produce F1, F2 and F4 finishes shall be oiled with a commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces. For timber forms, form oil should consist of pure

refined pale paraffin mineral oil or other approved form oil. For steel forms, form oil shall consist of refined mineral oil suitably compounded with one or ingredient which are appropriate for the purpose.

Care shall be taken to keep form oil out of contact with reinforcement.

8.9.4 Removal of forms

(i) Except as otherwise provided in this sub-clause forms shall be removed as soon as the concrete has hardened sufficiently to prevent damage by careful form removal, thus facilitating satisfactory progress with specified curing and earliest practicable repair of surface imperfections.

(ii) Forms on upper slopping faces of concrete, such as forms on the water sides of warped transitions, shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such slopping surfaces shall be performed at once and be followed immediately by the specified curing.

(iii) In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms for wall opening shall be loosened as soon as this can be accomplished without damage to the concrete.

(iv) Subject to approval, forms on concrete surface close to excavated rock surface may be left in place provided that the distance between the concrete surface and the rock is less than 400 mm. and that the forms are not exposed to view after completion of the works.

(v) Forms shall be removed with care so as to avoid injury to the concrete. Any concrete damage in form removal shall be repaired in accordance with the provisions of section of repair of concrete.

(vi) The following minimum intervals of time as per I.S.456 - 1978 will generally be allowed when using ordinary portland cement between placing concrete and striking form work but the period shall be modified in case of wet weather and also at the option of the Executive Engineer.

a)	Walls, columns and vertical faces of all structural members	24 to 48 hours.
b)	Slabs (Drop left under)	3 days.
c)	Beam soffits (Drops left under)	7 days.
d)	Removal of drops under	
	I Slabs spanning upto 4.5 m.	7 days.
	II Slabs spanning over 4.5 m.	14 days.
e)	Removal of drops under beams and arches.	
	I Spanning upto 6 m.	14 days.
	II Spanning over 6 m.	21 days.

8.10.0 Finishes and Finishing of Concrete Surface

8.10.1

(i) Allowable deviations from plump or level and from the alignment, profile, grades and dimensions shown on the drawings are defined as "tolerance" and are to be distinguished from the irregularities in finish as described herein. The tolerance in concrete construction are specified in the particular section.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawing or as hereinafter specified. In the event of finishing not being definitely specified herein or on the drawings the finished to be used shall be as directed. Finishing of concrete surfaces shall be performed only by skilled workmen.

Concrete surfaces will be tested where necessary to determine whether surface irregulation are within the limits hereinafter specified.

(ii) Surface irregularities are classified as "abrupt" or "gradual". Offset caused by displaced or misplaced from sheathing or lining or form sections or by loose knots or otherwise defective form timber will be considered as abrupt irregularities, and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be one and a half metres for testing of formed surfaces and three metres for testing unformed surfaces.

(iii) The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 & F4. Bag rubbing or sand blasting will not be required on formed surfaces. Grinding will not be required on formed surfaces other than that necessary for the repair of surface imperfections. Unless otherwise specified or indicated on the drawings, the classes of finish which will apply are as follows:-

(a) Finish F1

This finish applies to surfaces where roughness is not objectionable, such as those upon or against which fill material, masonry or concrete will be placed, the upstream face of the dam that will permanently be under water or surfaces that will otherwise be permanently concealed. The surface treatment shall be repair of defective concrete, correction of surface depressions deeper than 25 mm. and filling of tie rod holes. Form sheathing shall not leak mortar when the concrete is vibrated. Forms may be built with a minimum of refinement.

(b) Finish F2

This finish is required on all permanently exposed surfaces for which other finishes are not specified, such as in outlet works and open spillways, bridges and retaining walls not prominently exposed to public view and in the galleries and adits in the dam, except where F1 finishes are permitted. Forms shall be built in a workmanlike manner to the required dimensions and alignment, without conspicuous offsets of bulge surface irregularities shall not exceed 5 mm for abrupt irregularities and 10 mm. for gradual irregularities measured from a 1.5 m template.

(c) Finish F3

This finish is designated for surfaces of structures prominently exposed to public view where appearance is of special importance. This shall include parapets, railings and decorative features on the dam and on the bridge. To meet the requirements for the F3 finish, forms shall be built in a skillful, workmanlike manner, accurately to dimensions. There shall be no visible offsets, bulges or misalignment of the concrete. At construction joints the forms shall be tightly set and securely anchored close to the joint. Surface irregularities shall not exceed 3 mm. for abrupt irregularities and 5 mm. for gradual irregularities measured from a 1.5 m. template.

(d) Finish F4

This finish is required for formed concrete surfaces at the spillway crest, glacis and bucket and inside sluices where accurate alignment and eveness of surface are essential for prevention of destructive effects of water action. The forms must be strong and held rigidly and accurately to the prescribed alignment. For warped surfaces, the forms shall be built up in section cut to make right, smooth form surfaces after which the form surfaces are dressed and sanded to the required curvature.

When measured as described in this clause, gradal irregularities shall not exceed 5 mm. Abrupt irregularities will not be permitted. The formations of air holes on the surface of the concrete designated to receive finish shall be minimised and where such air holes are found, they shall be repaired in accordance with relevant section.

8.10.2 The classes of finish for unformed concrete surfaces are designated by the symbols U1,U2,U3 and U4. Unless otherwise specified or indicated on the drawings these classes of finish shall apply as follows:

(i) Finish U1

This finish applies to unformed surfaces that will be covered by fill material, masonry or concrete, or where a scruded surface finish meets the functional requirements. Finish U1 is also used as the first stage of finishes for U2 & U3. Finishing operations shall consist of sufficient levelling and screeding to produce even uniform surfaces. Surface irregularities measured as described in this section, shall not exceed 10 mm.

(ii) Finish U2

This is a floated finish and applies to all out door unformed surfaces not specified to receive finishes U1 or U3. It may be used for such surfaces as of spillways and aprons.

Finish U2 is also used as the second stage of finish for U3. Floating may be performed by use of hand or power driven equipment. Floating shall be started as soon as the screeded surface has stiffened sufficiently to prevent the formation of laitence, and shall be the minimum necessary to produce a surface that if free from screed marks and is uniform in texture. If finish U3 is to be applied floating shall be continued until a small amount of mortar without excess water is brought to the surface, so as to permit effective trowelling. Surface irregularities measured as described in this section shall be tolled down where shown on the drawing or as directed.

(iii) Finish U3

This is a trowelled finish and may be specified for tops of parapets prominently exposed to view, and conduit invert immediately downstream of regulating gates and valves. When the floated surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel trowelling shall be started. Steel trowelling shall be performed with firm pressure such as will flaten the sandy texture of the floated surface and produce a dence uniform surface free from blemishes and trowel marks. Surface irregularities, measured as described in relevant part of this section, shall not exceed 5 mm. Where a hard steel trowelled finish is specified, the regular U3 finish shall be trowelled again after the surface has nearly hardened using firm pressure and trowelling until the surface is hard and has a slightly glossy appearance.

(iv) Finish U4

This is a steel trowelled finish similar to finish U3 except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling or lining machines will be acceptable, provided the surface irregularities do not exceed the limits specified for finish U3.

8.10.3 Unformed surfaces which are nominally level shall be sloped for drainage as shown on the drawings or as directed. Unless the use of other slopes or level surface is indicated on the drawings, narrow surface such as tops of parapets, tops of walls and kerbs shall be slopped approximately one on per 30 cm of width, broader surface such as roadways, platform and decks, shall be slopped approximately half centimeter per 30 cm. of width.

8.11.0 Repairs of Concrete

8.11.1 Repairs of concrete shall be performed by skilled workers and in the presence of an experienced Engineer. The contractor shall correct all imperfections on the concrete surface as necessary to produce surfaces that conform with requirements of the section "Finishes and finishing of concrete surfaces" on formed concrete shall be completed as soon as practicable after removal of forms and within 24 hours after removal of forms. Concrete that is damaged from any cause and concrete that is honey combed, fractured or otherwise defective and concrete which because of excessive surface depressions must be excavated and built up to bring the surface to the prescribed lines, shall be removed and replaced by dry pack mortar or concrete as hereinafter specified. Where bulges and abrupt irregularities protrude outside the limits specified in the section "Finishes & finishing of concrete surfaces", the protrusions shall be reduced by bush hammering and grinding so that the surfaces are within the specified limits.

Before repairs are commenced, the methods proposed for the repair shall be approved by the Executive Engineer. Routine curing should be interrupted only in the area of repair operations.

8.11.2 Methods of Repairs

For new works four methods are used.

(i) Dry Pack Method

This method should be used for holes having a depth nearly equal to or greater than the least surface dimensions; for cone bolt she bolt and grout insert holes and narrow slots cut for the repair of cracks. Dry pack should not be used for relatively shallow depressions where lateral restraint can not be obtained; for filling in back of considerable lengths of exposed reinforcements; nor for filling holes which extend entirely through the wall, beam etc.

(ii) Concrete Replacement Method

Concrete replacement should be used when holes extend entirely through the concrete sections; when holes in unreinforced concrete are

more than 1000 sq. cm. in area and 100 cm or more in depth; and in hole in reinforced concrete are more than 500 Sq. cm. in area and deeper than the reinforcement steel.

(iii) Mortar Replacement Method

This should be used for holes too wide to dry pack and too shallow for concrete replacement, and for all comparatively shallow depressions, large and small, which extend more deeper than far side of the reinforcement bars nearest the surface.

(iv) Epoxies Method

A thermometting plastic known as epoxy can be used as a bonding medium wherever long time curing of conventional concrete can not be assured. Also epoxy mortars of fine sand well as plain epoxy are suitable for concrete repair work and should be used whenever very thin patches are to be placed for immediate re-use of the area is required or where moist curing can not be effectively accomplished. Preparation for epoxy bonded repairs should in general be identical to that for other concrete repairs except that every effort should be made to provide surfaces which are thoroughly dry. Drying of the immediate surface for at least 24 hours and warming to temperature between 65^{o} to $80^{o}F$ are essential for proper application of epoxy bonded repairs. Preparation for the use of epoxy mortars should include thorough cleaning and drying of the areas to be repaired. A wash of dilute 1:4 muriatic acid rising with clean water and subsequent drying is desirable where feasible. If acid wash is not feasible, preparation may be accomplished as for other concrete repairs with final clean up being by means of sand blast method, followed by air water jet washing and thorough drying. Epoxy repairs shall be carried out only by trained personnel.

8.11.3 Preparation of Concrete for Repair

All concrete of questionable quality should be removed. It is better to remove too much concrete than too little because effected concrete generally continues to disintegrate and while the work is being done it costs but little more to excavate to ample depth. Moistening, cleaning surface drying and complete curing are of utmost importance when making repairs which must be thoroughly bonded, water tight and permanent. Surfaces between trimmed holes should be kept continuously wet for several hours, preferably overnight prior to placing new concrete. Immediately before placement of the filling, the holes should be cleaned so as to leave a surface completely free of chipping dust, dried grout and all other foreign materials. A preliminary washing as soon as the chipping and trimming are completed

is desirable to remove loose materials. Final cleaning of the surfaces to which the new concrete is to be bonded should be done by wet sand blasting followed by washing with air water jet for thorough cleaning and drying with an air jet. Care should be taken to remove any loose materials embedded in the surface by chiesels during the trimming and to eliminate all shiny spots indicating free surface moistures. Cleaning of steel if necessary should be accomplished by sand blasting. The prepared surface shall be approved by the Executive Engineer.

(i) Dry Pack of Concrete

For this method of repair, the holes should be sharp and square at the surface edges but the corners within the holes should be rounded, especially when water tightness is required. The interior surfaces of holes left by cone bolts, she bolts etc., should be roughened to develop an effective bond. Other holes should be under cut slightly in several places around the perimeter. Holes for dry pack should have a minimum depth of 25 mm.

(ii) Concrete Replacement

Preparation for this method should be as follows:-

(a) Holes should have minimum depth of 100 mm in new concrete and the minimum area of repair should be 500 Sq. cm. for reinforcement and 1000 Sq. cm. for unreinforced concrete.

(b) The reinforcement bars should not be left partially embedded, there should be a clearance of atleast 25 mm around each exposed bar.

(c) The top edge of the holes at the face of the structure should be cut to a fairly horizontal line. If the shape of the defect makes it advisable, the top of the cut may be stepped down and continued on a horizontal line. The top of the hole should be cut to 1 to 3 upward slope from the back towards the face of the wall or a beam. It may be necessary to fill the hole from both sided, in which case the slope of the top of the cut should be modified accordingly.

(d) The bottom and sides of the hole should be cut sharp and approximately square with the face of the wall. When the hole goes entirely through concrete section spalling or feather edges shall be avoided by having chippers worked from both faces. All interior corners should be rounded to a minimum radius of 25 mm.

(iii) Mortar Replacement

When mortar gun is used with this method, comparatively shallow holes should be flared outwardly at about 1:1 slope to avoid inclusion

of rebound Corners within the holes should be rounded. Shallow imperfections in new concrete may be repaired by mortar replacement if the work is done promptly after removal of the forms and while the concrete is still green for instance, when it is considered necessary to repair the peeled areas resulting from surface materials sticking to steel forms and surface, may be filled using mortar guns without further trimming or cutting. Wherever hard placed mortar replacement is used, edges of chipped out areas should be squared with the surface leaving no feather edges.

(iv) Use of Dry Pack Mortar

The surface after preparing should be thoroughly brushed with a stiff mortar or grout barely wet enough to thoroughly wet the surface after which the dry pack material should be immediately packed into place before the bonding grout has dried. The mix of bonding grout is to be 1:1 cement and fine sand mixed to a consistency like thick cream. Under no circumstances should be bonding coat be wet enough or applied heavily enough to make the dry pack material more than very slightly rubbery. Dry pack is usually a mix (dry volume of weight) of one part of cement to 1½ parts of sand that will pass a No. 16 screen. A mortar patch is usually darker than the surrounding concrete unless special precautions are taken to match the colours. Where uniform colour is important white cement may be used in sufficient amount to produce uniform appearance. For packing cone bolt holes a leaner mix of 1:3 or 1:3½ will be sufficiently strong and will blend better with the colour of the wall. Only enough water should be used to produce a mortar which when used, will stick together on being moulded into a wall by slight pressure of hands and will not exclude water but will leave the hands damp. The proper amount of mixing water and proper consistency are those which will produce a filling which is at the point of rubbery when the material is solidly placed. Dry pack material should be placed and packed in layers having a compacted thickness of about 10 mm. The surface of each layer should be scratched to facilitate bonding with next layer. One layer may follow another immediately unless appreciable rubberiness develops in which case work on the repair should be delayed to 30 to 40 minutes. Under no circumstances should alternate layers of wet and dry materials be used. Each layer should be solidly compacted over its entire surface by use of a hard wood stick and hammer. Much of the tamping should be directed at a slight angle and towards the sides of the hole to assure maximum compaction in these areas. The holes should not be overfilled and finishing may usually be completed at once by laying the flat side of a hardwood place against the fill and striking it several good blows. If necessary, a few light strokes with a rag some time later may improve the appearance. Steel finishing tools should not be used and water must not be used to replacement of concrete.

8.11.4 Procedure of Replacement of Concrete Curing of Repairs etc.

All procedures for replacement of concrete, mortar replacement, use of apoxies and curing of repairs shall be according to the provisions laid down in Chapter-VII. Repair and Maintenance of concrete-Concrete Manual, the United States Bureau of Reclamation, Seventh edition 1963.

8.12.0 Curing of Concrete

8.12.1 All concrete shall be cured by water in accordance with the requirement of sub-clause (3) of this clause or Membrane curing in accordance with the requirements of sub-clause (4) of this clause. Concrete surfaces to be painted shall not be cured by membrane curing.

8.12.2 The unformed top surfaces of walls and piers shall be moistened by covering with water saturated material or by other effective means as soon as the concrete has hardened sufficiently to prevent damage by water. These surfaces and steeply slopping and vertical formed surfaces shall be kept completely and continuously moist, prior to and during from removal, by water applied on the unformed top surfaces and allowed to pass down between the forms and the formed concrete faces. This procedure shall be followed by the specified water curing and membrane curing.

8.12.3 Concrete cured with water shall be kept wet for at least 14 days immediately following placement of the concrete or until covered with fresh concrete by covering with water saturated material or by a system of perforated pipes, mechanical sprinklers or porous hoses or by any other suitable method, which will keep all the surfaces continuously (not periodically) wet. The period of 14 days specified above shall be increased to 21 days when pozzolan has been used in the concrete as part replacement of cement.

8.12.4 (i) Membrane curing shall be by application of a suitable type of white pigmented curing compound which forms a water retaining membrane on the surface of concrete, provided that on concrete surfaces which will be permanently exposed to view clear curing compound may be required. Curing compound shall be applied to the concrete surfaces by spraying on one coat to provide a continuous uniform membrane overall area, with a maximum coverage per gallon as prescribed by the manufacturer according to the roughness of the surface to be covered. If necessary to cover the surface adequately a second coat of curing compound shall be applied by spraying at right angles to the direction at which the first coat was applied. Mortar encrustations and fins on surface for which finish F4 is specified shall be removed prior to application of curing compound. Curing compound shall be applied to all areas of concrete surfaces except that those parts with surface imperfections shall be omitted until repaired.

(ii) When curing compound is to be used on unformed concrete surfaces, application of the compound shall commence immediately after the finishing operations are completed.

(iii) When curing compound is to be used on formed concrete surfaces, the surface shall be moistened with light spray of water immediately after the forms are removed, and shall be kept wet until the surfaces will not absorb more moisture. As soon as the surface film of moisture disappears but while the surface still has a damp appearance, the curing compound shall be applied. There must be ample coverage with the compound at edges, corners and rough spot of formed surfaces. After application of curing compound has been completed and the coating is dry to the touch, any required repair of concrete surfaces shall be performed. Each repair after being finished, shall be moistened and coated with curing compound in accordance with the foregoing requirements.

(iv) Traffic and other construction operations shall be such as to avoid damage to coatings of curing compound for a period of not less than 28 days after application of the curing compound. Where it is impossible because of construction operations to avoid traffic over surfaces coated with curing compound, the membrane shall be protected by a covering of sand or earth not less than 25 mm in thickness or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. Any sealing membrane that is damaged or that peels from concrete surfaces within 28 days after application, shall be repaired without delay.

(v) Curing compound if used, shall be of approved quality.

8.13.0 Requirement of Concrete Construction

8.13.1 General

All concrete construction shall conform to the permissible tolerance and technical provisions as described in this section and to the details requirements of the following paragraphs. All structures shall be built in a workman like manner and to the lines, grades and dimensions shown in the drawings or prescribed by the Executive Engineer. The location of all construction joints shall be subject to the approval of the Executive Engineer. The dimension of each structure shown on the drawings will be subject to such changes as may be found necessary by the Executive Engineer to adopt the structures to the conditions disclosed by the excavation.

8.13.2 Concrete in Shafts, Foundation Faults and Seams and Fissures

The item of the schedule for concrete in shafts in foundation faults and seams includes all concrete in shafts below the bottom of trenches required to be excavated for the correction of foundation defects as provided in section of "Excavation of foundation". The sound rock on the sides of the shafts shall be clean, solid, free from oil, mud and other objectionable coatings and shall be sufficiently rough to assure satisfactory bond with the concrete. All temporary timbering shall be removed from the shafts before or during the placing of the concrete in the shafts. The concrete shall be tamped and vibrated and special care shall be taken to fill all irregularities in the surface of the rock excavations.

8.13.3 Concrete in the Dam(Upto Crest Level Including Concrete in Bucket/Stilling Basin)

This item of the schedule for concrete in dam includes all concrete in the main structure of the dam between the normal upstream and downstream faces of the dam upto crest level including concrete in block outs but excludes concrete in spillway bridge, bridge piers (above crest level) elevator shaft (above crest level) training walls (above crest level) concrete in side walls, kerbs and parapets and concrete in shafts in foundation faults and seams. Concrete in upstream and downstream faces of the dam to a thickness to be prescribed by the Executive Engineer, may differ in mix proportions from the concrete in the interior of the dam and may contain more cement per unit volume of concrete. The concrete in the dam also includes the foundation of the trash rach structure river sluices and irrigation sluices. All concrete in the dam shall be placed in horizontal lifts not exceeding 1.5 metre in thickness. Each lift shall be placed in layers not exceeding 50 cm. in thickness and shall be placed and built upto the full height of the lift in accordance with the provisions of relevant part of this section.

The forms of surfaces between adjacent blocks may be removed as soon as the concrete has hardened sufficiently to prevent the surface damage. Except as provided below, the placing of concrete in the dam shall be so regulated that the maximum differential height between adjacent blocks shall not exceed 7.50 m.

The rate of placing concrete in any block of the dam shall be such that not more than one lift shall be placed in 72 hours. Every effort shall be made to obtain a regular, periodic placement of succesive lifts throughout the dam. All concrete in the dam shall be cooled as provided in the relevant part of this section. All outlets galleries and other sizeable openings within mass concrete shall be closed or bulk headed at the faces of the dam and other exposed surfaces from the time concrete is placed around the openings until the concrete surrounding the openings is completely cooled.

Plumb line walls shall be formed in the concrete where shown on the drawings or directed and plumb shall be maintained within 12 mm.

8.13.4 Concrete in Dam (Above Crest Level)

The item of schedule for concrete in dam includes all concrete above crest level in piers, abutments, elevator shaft, training walls, non-overflow portion of dam, power dam and blockouts.

8.13.5 Concrete in Spillway Bridge, Side Walls, Kerbs and Parapets

The item of the schedule for concrete in spillway bridge, kerbs and parapets include all concrete in the spillway bridge, kerbs and parapets in full length of the masonry dam and block outs.

Expansion joints shall be constructed as shown on the drawings or as directed.

Pre-moulded bitumenous fibre type expansion joint material shall be placed in the expansion joints.

Lighting recesses shall be constructed in the parapets as directed by the Executive Engineer. Open joints or false joints shall be constructed as shown on the drawings or as directed by the Executive Engineer. Preformed expansion joint filler shall be placed in the road way and side walks where shown on the drawings on as directed by the Executive Engineer.

8.13.6 Concrete in Blockouts

All concrete required to be placed in blockouts to permit the installation and adjustment of mechanical and other equipments shall be included in the respective concrete as described above. The concrete surfaces of the blockouts shall be chipped and roughened as described hereinafter before the concrete is placed in blockouts.

Exceptional care shall be taken in placing the concrete in blockouts in order to ensure satisfactory bond with the concrete previously placed and to secure complete contact with all metal work in the blockouts.

The roughening of the concrete surface of the blockouts shall be performed by chipping or sand blasting as approved by the Executive Engineer and in such a manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface. After being roughened the surface of the concrete shall be cleaned thoroughly of loose fragments, dirt and other objectionable substances and shall be sound and hard to ensure good mechanical bond between the existing and new concrete.

All concrete which is not hard, dense and durable shall be removed to the depth required to assure its surface satisfactory to the Executive Engineer.

8.14.0 Cooling of Concrete

Heat release during hydration of cement when large masses of concrete are being produced poses two different problems viz. (i) the thermal stability of concrete and (2) the cracking of concrete. The thermal stability is necessary for normal behaviour of the structure. So, suitable cooling system is to be adopted in the dam concreting in order to rapidly achieve thermal stability.

In order to control thermal instability arising out of the heat of hydration the placement temperature of concrete should be adopted as directed by the Executive Engineer.

8.15.0 Tolerance for Concrete Construction

8.15.1 General

(i) Permissible surface irregularities for the various classes of concrete surface finishes specified in the relevant portion of the section on "finishes and finishing of concrete surfaces" are defined as finishes and are to be distinguished from "Tolerances" as described in this section. Deviations from the established lines, grades and dimensions will be permitted to the extent set-forth in this clause, provided that lesser tolerances than that tolerances set-forth in this clause may be prescribed at site if such tolerances are considered to impair the structural action or operational action or operational function of the structure.

(ii) Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this clause.

(iii) Concrete work that exceeds the tolerance limits specified in this section shall be either remedied satisfactorily or removed.

8.15.2 Mass Concrete in Dams and Appurtenant Works

The following tolerances shall apply for concrete in dams and other larger mass concrete structures:-

i) (a)	Variation of the constructed linear outlines from established position in plan.	In 6 metres	12 mm
		In 12 metres	20 mm

(b)	Variations of dimension to individual structural features from established positions.	In 24 metres or more In burried construction	30 mm Twice the above amount.
ii)(a)	Variations from the plumb, from the specified batter or from the curved surfaces of all structures including the lines and surfaces of walls and vertical joints.	In 3 metres In 12 metres or more In burried construction	12 mm 30 mm Twice the above amount.
(b)	Variation from the level or from the grades indicated on the drawings.	In 3 metres In 9 metres or more In burried construction	6 mm 12 mm Twice the above amount.
iii)	Variations in cross sectional dimensions of columns, beams, buttresses,piers and similar members and variation in the thickness of slabs walls and similar members.	Minus Plus	6 mm 12 mm
iv)	Variation from plum and level for sills and side walls for radial gates and similar watertight joints.	Not greater than a rate of 3 mm in 3 metres.	

8.15.3 Placing Reinforcement Bars

The following tolerance shall apply for placing of reinforcement bars:-

i)	Variation of protective covering	With 50mm cover With 75mm cover & over	cover 6 mm cover 12 mm
ii)	Variation from indicated Spacing;	Provided that number of bars required by spacing is not varied	25 mm

8.16.0 Porous Concrete

Porous concrete shall be used at locations shown on the drawings or as directed. Porous concrete shall be composed of one part of cement to five and a half parts of aggregate by weight. The fines in the aggregate (viz. sand) may be permitted upto ten percent of the total aggregate. Only so much water shall be used in the concrete as is required to produce paste which will coat the particles and not fill the voids. In placing porous concrete, care shall be taken to ensure that it is not over tamped or compacted. The porous concrete as laid shall be pervious and free draining when it hardens. As soon as the concrete hardens (so that paste can not be washed away) it should be kept moist for a minimum of fourteen days. The compressive strength of porous concrete at 7 days as determined by test on 15 cm. by 30 cm. cylinders should not be less than 70 kg/Cm^2 and the porocity at 7 days be such that water shall pass through a slab of the concrete 30 cm. thick at a minimum rate of 500 litres/min./Sq.metres of the slab with a constant 10 cm. depth of water standing on the slab. The porous concrete blocks shall be laid as shown in the drawings or as directed by the Executive Engineer to form porous drains in the masonry dam.

8.17.0 Measurement & Payment

8.17.1 General

The prices entered in the schedule for the incorporation of the various classes of concrete, plain reinforced and porous required by this section shall be all inclusive constituting full compensation for mobilising, demobilishing and supplying all equipment, forms, materials, curing, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition a specific payment item has been included in the schedule.

8.17.2 Except as otherwise expressly provided for in the specifications, measurement of concrete for payment shall be made on the basis of the volume of concrete calculated as being contained within the concrete outlines shown on the relevant drawings.

Measurement for payment for the concrete laid in pockets in the foundation shall be made on the basis of the volume of pocket filled.

No measurements shall be made for the concrete backfill beyond the minimum lines of excavation shown on the drawings except where such payment is specifically authorised. Measurement of concrete shall be made after deducting the volume of all recesses, passageways, chambers, opening cavities and depression, embedded pipes and metal works but without deductions for round of bevelled edges or space occupied by electrical conduits and reinforcement.

8.17.3 The item of concrete in foundation faults seams and crevices including all concrete in the shafts below the bottom of trenches shall be measured on the basis of the volume of pocket.

8.17.4 The item of concrete upto crest level of the dam includes all concrete in the main structure of the dam contained between the normal upstream and downstream faces of the dam including concrete in block outs, trash rack, river sluices, irrigation sluices in bucket/stilling basin i.e. all concrete below the crest level of the dam. Measurement of all such concrete shall be made on the basis of the volume of concrete calculated as being contained within the concrete outlines shown on the relevant drawings.

8.17.5 Concrete above crest level of the dam shall include all concrete above crest level in dam i.e. in piers, elevator shafts, Training walls, non-overflor portion of the dam, power dam & blockouts etc. Measurement of all such concrete shall be made on the basis of the volume of concrete calculated as being contained within concrete outlines shown on the relevant drawings.

8.17.6 Concrete in spillway bridge, side walks, kerbs and parapets in full length of the masonry dam and block outs etc. shall be measured on the basis of volume of concrete calculated as being contained within the concrete outlines shown on the relevant drawings.

8.17.7 The item of porous concrete shall include all porous concrete laid in masonry dam, bucket/stilling basin and appurtenant works. Measurement of all such concrete shall be made on the basis of the volume of concrete calculated as being contained within concrete outlines shown on the relevant drawings.

8.17.8 The rates of various classification of concrete in the schedule of bids are to be based on the assumption that in all types of concrete 200 kg of cement is used per cum of finished concrete. If the contractor is required to use any different content of cement per cum of concrete, the payment to contractor shall be adjusted upward or downward on the basis of such variation in cement content at the unit rate for the item "variation in cement content in concrete from 200 kg per cum of concrete". The cement concrete for the purpose of calculating "variation in cement content" shall be arrived at by dividing total cement consumption in all types of concrete as recorded at the mixing point for concrete and mortar approved for placement (by the Executive Engineer) by the total volume of finished concrete placed within the prescribed lines and grades and deemed to cover all labour, material and equipment employed for it.

8,17.9 Payment for the various classes of concrete shall be made on the basis of unit price per cubic metre entered in respect of items in the schedule.

SECTION-9

CEMENT PLASTERING & CEMENT POINTING

9.0.0 Cement Plastering and Cement Pointing

9.1.0 General

The work of cement plastering will be required to be done in contraction joints in dam and appurtenant works. The work of cement pointing shall be required on the upstream face and down stream face of the masonry dam and on faces of appurtenant work.

9.2.0 Materials

Specification of cement, sand, water air entraining agents and other admixtures shall be in accordance with the provision in relevant portions of the section of "Masonry" under Masonry Dam.

9.3.0 Cement Plaster

9.3.1 Composition, batching, mixing and transportation of mortar for cement plaster shall conform to the provisions as contained in the relevant section of "Masonry" under Masonry Dam.

9.3.2 Surface Preparations

The joints of masonry where the plaster is to be applied shall be racked square for a minimum 25 mm depth at the appropriate time (between 12 & 24 hours after the masonry is laid when mortar is firm but not hard to the extent needing chieselling). Masonry surfaces shall be prepared and cleaned by removing loose particles, dust, adhering mortar, grease, oil, effloresence and other foreign matters by hard brooms, wire brush, air water-jet. Sand blasting may also be resorted to if required and directed by the Executive Engineer. The surface so prepared shall be kept wet for a minimum 24 hours preceding to plastering.

9.3.3 Plastering

The height of contraction joint on which plaster is to be applied shall be at least 2 metres on the higher of the two blocks. Masonry in the lower block shall not be raised unless the plaster on the higher block has set to an extent to avoid bonding. The plaster when applied

shall have a thickness of 20 mm. The mortar shall be applied by steel trowels into joints and the filling of joints ensured by pushing the edge of steel trowel into joints. Mortar shall then simultaneously be applied by steel trowels and roughly finished with steel trowels. The plaster surface will be furnished by wooden trowels giving neat lines in plumb and plan. Curing of cement plaster shall be in accordance with the provisions contained in relevant portion of the section of "Cement Concrete" under Masonry Dam.

9.4.0 Cement Pointing

9.4.1 Batching, mixing and transportation of mortar for cement pointing shall conform to the provisions contained in relevant section of"Masonry" under "Masonry Dam". The composition shall be 1 part cement to 2 parts of sand by weight.

9.4.2 Preparation

(i) Moistening, cleaning, surface drying and complete curing are of utmost importance for thorough bond and water-tightness. Surfaces with the joints should be kept continuously wet for several hours, preferably overnight; prior to packing of joints.

(ii) Immediately before placement of the filling the joints should be cleaned so as to leave a surface completely free of chipping dust,dried grout, mortar and all other foreign materials. A preliminary washing as soon as the chipping and trimming are completed is desirable to remove loose material. Final cleaning of surface to which the new mortar is to be bonded be done by an air-water jet followed by drying with an air jet. Care should be taken to remove any loose material embedded in the surface by chiesels during trimming and to eliminate all shiny spots indicating free surface moisture.

9.4.3 Pointing

Cement pointing shall be carried out in accordance with provisions contained in relevant parts of the section of "Masonry" under Masonry Dam.

9.5.0 Measurements and Payments

9.5.1 The prices entered in the schedule for the work required by this section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition, a specific payment item has been included in the schedule.

9.5.2 Measurements for cement plaster and cement pointing shall be made on the basis of surface area of plaster and pointing actually contained within the profile as shown in the drawings or as directed by the Executive Engineer.

9.5.3 The payment for various classes of cement plaster and cement pointing shall be made on the basis of unit price entered for the respective items in the schedule.

9.5.4 The rates of various classes of cement plaster in the schedule of bids are to be based on the assumption that in all types of cement plaster 11 kg of cement is used per Sq.metre of plaster. If the contractor is required to use any different content of cement per Sq.metre of cement plaster the payment to the contractor shall be adjusted upward or downward on the basis of such variation in cement content at the unit rate for the item "Variation in cement content in cement plaster from 11 kg per Sq.metre of plaster". The cement content for the purpose of calculating "variation in cement content" shall be arrived at by dividing total cement content in all types of plaster as recorded at the mixing point for mortar approved for placement (by the Executive Engineer) by the total area of the finished plaster placed within the prescribed lines and grades and deemed to cover all labour, material and equipment employed for it.

9.5.5 The rates of cement pointing in the schedule of bids is to be based on the assumption that in cement pointing 3 kg of cement is used per Sq.metre of pointing. If the contractor is required to use any different content of cement per sq.metre of cement pointing, the payment to the contractor shall be adjusted upward or downward on the basis of such variation in cement content at the unit rate for the item "variation of cement content in pointing from 3kg/Sqm. of pointing". The cement content for the purpose of calculating "variation in cement content" shall be arrived at by dividing total cement content in mortar as recorded at the mixing point for mortar approved for placement (by the Executive Engineer) by the total area of the finished pointing placed within in the prescribed lines and grades and deemed to cover all labour, material and equipment employed for it.

SECTION-10

REINFORCEMENT

10.0.0 Reinforcement

10.1.0 General

10.1.1 The contractor shall furnish, cut, bend and place steel reinforcement including rods of mild steel and or tor-steel as indicated in drawings or as directed by the Executive Engineer.

10.1.2 All steel used for reinforcement shall be clean, free from oil, grease, paints, dust, mortar, scales, kinks rust or any rolling defects or bends other than those required as per drawings or directions of the Executive Engineer.

10.2.0 Quality of Reinforcement

10.2.1 Reinforcement shall be any of the following:-

(i) Mild steel and high tensile steel bars and hard drawn steel wire conforming to IS: 432 - 1960 as revised from time to time.

(ii) Structural steel sections conforming to IS: 226 - 1955 as revised from time to time.

(iii) Cold twisted steel bars complying with the requirement of IS:1786 - 1966 as amended from time to time.

(iv) Such other reinforcement as may be proved suitable having regard to the yield point stress ductility, ultimate resistance to tension and other essential properties of the completed reinforcement as produced in readiness for reinforced concrete.

10.2.2 Bar stock shall be periodically tested for quality, from time to time during the progress of the work and when there is doubt that bar stock may not conform to the requirements of the specifications.

Bar stock not meeting the requirements of the specifications shall not be used in the work.

10.3.0 Cutting and Bending

10.3.1 Reinforcement bars shall be of the size prescribed and shall be cut to the lengths, bent to the shapes and fixed in position shown on the drawings or as directed by the Executive Engineer and shall conform to IS: 2502 - 1963 as revised from time to time.

10.3.2 Deformed bars shall not be resent after being bent and straightened unless initially bending and subsequent straightening and bending are carried out under proper approved supervision.

10.3.3 Reinforcement bars shall be bent cold. Bars shall not be cooled by quenching. Bars shall not be straightened or bent in a manner that will injure or weaken the material.

10.4.0 Jointing and Splicing

10.4.1 Joints or splices in reinforcement bars shall be made at the position shown on the drawings. Additional joints or splices may be permitted at positions other than those shown on the drawings provided that the positions of joints and splices in adjacent bars are staggered and are placed as approved.

10.4.2 Reinforcement bars 28 mm. in diametre and larger may be connected by butt welding provided that lapped splices will be permitted if found to be more practical than butt welding and if lapping does not encroach on cover limitations or hinder concrete or reinforcement placing.

10.4.3 Reinforcement bars 25 mm in diametre and less may be either lapped or butt welded, whichever is the most practicable.

10.4.4 Deformed bars shall not be lap welded at splices except where lap welding is shown on the drawings or otherwise specifically approved.

10.4.5 Butt welding or reinforcement bars shall be performed under cover from the weather and may be performed either by the gas-pressure or flash pressure welding process, or by the electric arc methods. The following requirements shall apply for all welding of reinforcement bars including butt welding and the preparation of welded reinforcement mats.

(i) The ends of the bars to be butt welded by gas-pressure or flash-pressure welding shall be squared off by an abrasive disc cutter. Any accumulation of dirt or oxide film formed after the cutting operation shall be removed by sand blasting or buffing prior to welding ends of bars to be joined by flash pressure welding shall be cleaned of all rust and projections on the end faces and for a distance of about 15 cm. from the ends, if necessary, to prevent arching. Care shall be taken in aligning and separating the ends of the bars shall be

matched accurately and shall be retained firmly in position during the welding operations. For pressure welding the bars shall be accurately held in position with the prescribed pressure applied prior to heating and during heating and welding.

(ii) Where bars are to be joined by electric arc welding, the weld metal shall be deposited in successive layers and each layer shall be thoroughly cleaned before the subsequent layer is deposited.

(iii) All structural welds shall have complete fusion and freedom from imperfections. Defective pressure welded joints shall be separated by flame cutting and re-welded.

Defective arc welds shall be chipped to sound metal and resulting cavities shall be filled in the same manner as the original grooves were filled or the bars shall be flame cut and re-welded.

(iv) Tack welding of reinforcement bars for fixing bars in place or for preparation of mats shall be carried out by competent operators using approved techniques. The work shall be so performed that there are no sharp discontinuities or loss of cross section in the joined bars at or adjacent to the weld.

(v) Only operators skilled in the type of welding procedures used for the welding of reinforcement bars shall be used for work. Before being permitted to weld bars on the job, each operator shall make four satisfactory test welds of the bars using the same bar material, end preparation, pressure, heating and upsetting as will be used for the actual reinforcement. The test bars shall not be less than 45 cm. long before welding. The bars when tested shall show a breaking strength of the metal in the bars. For the welding process and the operator to qualify all test welds must meet this requirement, the operator may be permitted to weld an additional set of bars and if these meet the requirements, the process and the operator will be qualified.

(vi) Welding materials and welding procedures and the workmanship of welding operators will be subject to inspection and approval at all times during the progress of the work.

10.4.6 The position and dimension of lapped splices will normally be shown on the reinforcement drawings. Where splices are required for the work, the following minimum overlap of spliced bars shall be used for the various sizes and grades shown. Hooks will not normally be prescribed for splices in structural grade deformed bars.

Lapped Splices

Diameter of bars in mm.	Grade of Bar	Minimum length of overlap in strength splices	
		For S120(M150) concrete.	S160(M200) concrete.
1	2	3	4
8.	M.S.Rounds	28 cm.	21 cm.
10	M.S.Rounds	47 cm.	35 cm.
12	Deformed ribbed bars	66 cm.	49 cm.
16	Deformed ribbed bars	88 cm.	65 cm.
20	Deformed ribbed bars	110 cm.	82 cm.
22	Deformed ribbed bars	110 cm.	83 cm.
25	Deformed ribbed bars	125 cm.	94 cm.
32	Deformed ribbed bars	160 cm.	120 cm.
36	Deformed ribbed bars	180 cm.	135 cm.
40	Deformed ribbed bars	200 cm.	150 cm.

10.4.7 Binding wire used shall be of soft annealed steel of 16 SWG and shall have an ultimate strength of not less than 5,600 kg. per square cm. and an yield point of not less than 3,850 kg. per square cm.

10.5.0 Measurement and Payment

10.5.1 The prices entered in the schedule for the work required by this section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which in addition a specific payment item has been included in the schedule.

10.5.2 Measurement of steel reinforcement shall be made for the weight of the steel reinforcement actually placed in position and only to the extent shown in the approved drawings and will include all laps and hooks as directed by the Executive Engineer if not shown in the drawing. The rate shall include the cost of

supplying binding wire, labour in making lap joints, tack welding, welded joints, ties and metal supports if any, of hauling, storing, sorting, cutting, bending cleaning, placing and securing and maintaining in position all reinforcement bars as shown on the drawings or as directed. No payment shall be made on account of wastage. The rate shall be inclusive for the wastage of the steel bars. Steel used for supports, spacers, ties, pins etc., will not be measured for payment. Wherever welding of reinforcement is done as per direction of the Executive Engineer it shall be payable at Rs. 15/- per splice for all types and sizes of bars which shall include cost of all materials and labour. The weight as specified by the manufacturer's sectional tables shall be taken as standard for purposes of computing total weight of steel used as reinforcement.

10.5.3 Payment for mild steel and Tor steel reinforcement shall be made on the basis of the unit price entered for the respective item in the schedule.

SECTION-11

TRANSVERSE CONTRACTION JOINTS

11.1.0 Transverse Contraction Joints

11.1.1 General

Vertical transverse contraction joints shall be provided in the dam (for convenience in construction and to provide for contraction of the concrete/masonry) as shown in the drawings. Unless otherwise directed, the joints shall be started from the foundation and shall extend through the full cross-section of the dam profile. The contraction joints in the concrete portion shall be smooth, as obtained with plane surfaces of form work. In case of masonry the edge of the block at the joint shall be built with selected stones and the surface plastered, 20 mm thick with cement mortar appropriate to the zone.

11.1.2 The joints shall be sealed at the upstream face by installing one line of copper or monel metal water stop (16 gauge) and one line of rubber water stop as shown on the drawings. The water-stops shall be shaped as shown in the drawings to provide for opening and closing of the joints on account of expansion or contraction and shall be jointed carefully together so as to form a continuous water tight diaphragm. Adequate provision shall be made to support and protect the water stops in position during the progress of work and adequate care taken while removing forms so that the bond between the seal and masonry or concrete is not broken.

The concrete surrounding the water stops shall closely follow the masonry in the block and at no time shall the top of the concrete be lower than the general elevation of the masonry in the lower of the two adjacent blocks by more than 1.5 m.

11.1.3 The asphalt seal plot provided between the two lines of water stops shall be filled with an approved 'H' grade asphalt or blown bitumen maxphalt R 85/25. The asphalt seal shall be poured in lifts corresponding to the concrete lift. After the seal is completed to the top it shall be capped as detailed in the drawings.

11.2.0 Water-stops

11.2.1 Metal Sealing Strips

(i) General

Metal seals or metal sealing strips of copper/monel shall be placed in joints in the dam and appurtenant structures where shown on the drawings and elsewhere as directed. The contractor shall furnish all materials for metal sealing strips, materials for brazing metal sealing strips and washers and nails for fastening and sealing strips to the forms. The details of the shape and of the placing of sealing strips will be as shown on the drawings or as directed by the Executive Engineer. The sealing strips shall be jointed carefully together by brazing so as to form continuous watertight diaphragms in the joints. Adequate provision shall be made to support and protect the sealing strips during the progress of the work. The contractor shall replace or repair to the satisfaction of the Executive Engineer any metal sealing strips punctured or damaged before final acceptance of the work.

(ii) Materials

Materials for metal sealing strips shall conform to the specifications mentioned herein-after unless otherwise approved in writing by the Executive Engineer. Metal seals or sealing strips shall be of Copper/monel as specified.

Monel is the trade name of a copper nickel alloy. Representative properties of Monel and Copper are given:-

		Monel	Copper
1.	Tensile strength (kg/cm^2)	4922.64	2194.09
2.	0.2% proof stress (kg/cm^2)	1969.06	1125.18
3.	Elongation percent.	35	55
4.	Hardness B.H.N. (max.)	135	50
5.	Fatigue limit (kg/cm^2)	2531.65	689.17
6.	Corrosion fatigue limit in well water (kg/cm^2)	1476.79	703.23
7.	Corrosion fatigue limit in saline water (kg/cm^2)	1969.06	703.23
8.	Coefficient of thermal expansion (25-100°C)	13.6x10-6	16.6x10-6

11.2.2 P.V.C. Water Stops

(i) General

P.V.C. water stops may be placed as and where directed by the Executive Engineer. The P.V.C. water stops will be of the size and shape as shown in the drawings.

P.V.C. for water stop shall conform to the following:-

Specifications for P.V.C. Seal Material

No.	Characteristics	Unit	Values
1.	Tensile strength	kg/cm^2	116 minimum.
2.	Ultimate elongation	%	300 minimum.
3.	Tear resistance	kg/cm^2	49
4.	Stiffness in flexture	kg/cm^2	24.6 minimum.
5.	Accelerated extraction		
(a)	Tensile strength	kg/cm^2	105 minimum.
(b)	Ultimate elongation	%	250 minimum.
6.	Effect of alkali 7 days		
(a)	Weight decrease	%	0.1 maximum.
(b)	Weight increase	%	0.25 maximum.
(c)	Hardness change	Point	$\pm$ 5
7.	Effect of alkali 28 days.		
(a)	Weight increase	%	0.40 maximum.
(b)	Weight decrease	%	0.30 maximum.
(c)	Dimension change	%	$\pm$ 1

(ii) All field connections shall be made as directed and the contractor shall take suitable precautions to support and to protect the water stops during the progress of the work and shall replace or repair at the contractor's expense any water stops which are damaged before final acceptance of the work.

11.2.3 Asphalt Seals

Asphalt seals in the contraction joints in the dam in square formed opening with 127 mm. side shall be provided as shown in the drawing. 12 mm. dia. steam heating pipes at galvanised iron seamless type are to be used in the square opening as per the drawing. The formed hole for asphalt fill shall be filled with 'H' grade asphalt or blown bitumen Maxphalt R 85/25.

11.3.0 Measurement and Payment

The prices entered in the schedule for the work required by this section shall be all inclusive constituting full compensation for mobilising, de-mobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition, a specific payment item has been included in the schedule. Except or otherwise expressly provided for the specifications, measurement of Copper or monel seals, PVC water stops and providing rectangular formed holes filled with asphalt provided with steam heating pipes shall be made on the basis of the linear length calculated as being contained within the profile of the dam and as shown on the relevant drawing.

Payment for copper or monel seals PVC water stops and rectangular formed holes shall be made on the basis of Unit price entered for the respective item in the schedule.

SECTION-12

MACHINERY AND METAL WORKS

12.0.0 Machinery and Metal Works

12.1.0 Installing Machinery, Equipment and other Metal Work

12.1.1 General

Except as otherwise provided, all metal work and machinery required to be installed under these specifications as parts of the completed dam and appurtenant works will be furnished by the Board. In general, the machinery and equipment furnished by the Board will have been assembled, marked and match marked to facilitate assembly in the field, will have been tested to determine that all parts function properly and will have been disassembled as required for transport. In general, all other metal work will be furnished fabricated in sections convenient for transport and marked. The contractor shall install or attach to or build into the structures and shall clean and paint all machinery, equipment and other metal work in work-man-like manner as here-in-after specified. Machinery and equipment, including all moving parts, shall be installed carefully and accurately, shall be tested for operation, and shall be adjusted so that all parts will move freely and will function properly to secure satisfactory operation, as determined by the Executive Engineer. In the installation of machinery, equipment and other metal work only mechanics skilled in their various trades shall be employed.

12.1.2 Repair of Damaged Parts

Damaged or defective parts shall not be installed. If any defects errors and inaccuracy are found in the machinery, equipment and other metal work furnished by the Board, the Executive Engineer will decide whether the parts will be returned to the manufacturer for correction or whether the defects, errors and inaccuracies shall be corrected in the field. The repair of damage which is due to the operation of the contractor and the correction of minor defects, errors and inaccuracies in the machinery, equipment and other metal work furnished by the Board which may be expected to occur in the ordinary commercial grade of shop work and manufacture of such materials as determined by the Executive Engineer shall be made by and at the expense of the contractor in a manner satisfactory to the Executive Engineer.

12.1.3 Installation Details

Special care shall be taken to ensure that all frames, guides and other fixed metal work are installed in exact position and alignment, that all machinery is in the proper position relative to the equipment which it will operate and that all parts are in exact alignment. Special care shall be taken in assembling all gearing to ensure that the gears will mesh properly so as to engage evenly over their full face width and will operate freely without binding and without excessive backlash. All couplings, and flange faces shall be cleaned thoroughly of all dirt and burrs before connection to ensure tight fit and true alignment. The finished surface of all flange joints shall be coated with joint compound furnished by the contractor and satisfactory to the Executive Engineer and unless otherwise specified gaskets shall be placed in flange joints. All flange bolts shall be tightened until it is assured positively that there will be no leakage. Metal work to be embedded in concrete shall be placed accurately and shall be supported in correct position of alignment and grade while the concrete is being placed and until it has set. Anchor bolts shall be installed when the concrete is placed unless otherwise directed. Where it is impracticable to place anchor bolts or anchors for the installation of ladders, stairways or other comparatively light metal work before the concrete is placed, holes shall be drilled in the concrete after the concrete has set thoroughly and compound lead and metal alloy expansion anchors and bolts shall be installed as directed. The surfaces of all metal work to be in contact with or embedded in concrete or cement grout shall be cleaned of all rust, dirt, grease, loose scale and other foreign substances, immediately before the concrete or grout is placed and the cleaning of such metal work shall be in accordance with provisions contained hereafter. Machinery and equipment bases and all machinery and equipment units not mounted on bases shall be levelled carefully and adjusted to correct alignment and grade. Unless otherwise specified, after the machinery and equipment has been located properly it shall be secured rigidly in place using permanent steel shims and if required by these specifications, all spaces under machinery and equipment bases and supports shall be filled completely with cement grout. All shims shall be furnished by and at the expense of the contractor.

12.1.4 Grouting

Grout for machinery, equipment and other metal works shall be mixed in the proportions and to the consistency prescribed by the Executive Engineer. The cost of all works and materials in connection with the grouting operations shall be included in the prices in the schedule of bids for "Contact grouting including cost of cement". Before placing grout, the surfaces of existing concrete on which grout will be placed shall be roughened and shall be cleaned of all laitance, loose or defective concrete, coatings, and other foreign

material by effective means followed by thorough washing. Such surfaces shall be kept moist for at least 24 hours immediately prior to the placing of the grout.

12.1.5 Servicing and Testing

After each complete unit of machinery has been installed and connected to the equipment that it is to operate, the machinery and equipment shall be serviced and tested. The servicing shall consist of cleaning, lubricating and adjusting all parts of the machinery and equipment. All parts shall be cleaned thoroughly, bearing shall be lubricated properly and the gear housing shall be filled with suitable gear oil or as directed. If required by the Executive Engineer, the contractor shall furnish thoroughly all bearings, reservoirs, and gear housings with kerosene before the bearings, reservoirs and gear housings are filled with oil. All lubricating oil and grease will be furnished by the contractor. After each unit of machinery and equipment has been serviced to the satisfaction of the Executive Engineer, it shall be given an operating test and adjustments shall be made until the operation of the unit is satisfactory to the Executive Engineer. All tests shall be witnessed by a representative of the Board.

12.1.6 Payment

Except as otherwise provided in these specifications, payment for installing the various items of machinery including motors and limit switches which are definite parts of the machinery mechanisms, equipment and other metal work will be made at the applicable rate in schedule of bids for installing the various items of machinery, equipment and other metal work which shall include the cost of transporting, hauling, assembling, erecting, servicing, adjusting, cleaning and repair of painting and galvanising on all machinery, equipment and other metal work, of drilling holes, of making all connections to machinery, equipment and other metal work, of making required test and of maintaining the machinery, equipment and other metal work in position and proper operating condition until final acceptance and taking over by the Board. The weights of machinery, equipment and other metal work as given in the schedule of bids and elsewhere are approximate or estimated weights only. The unit prices for installing metal work and machinery shall include the cost of making minor changes and the cost of correcting minor errors and inaccuracies in the various parts as may be expected to occur in the ordinary commercial grade of shop work and manufacture of such materials and as determined by the Executive Engineer.

12.2.0 Erecting Structural Steel

12.2.1 General

All structural steel work which is to be furnished by the Board will be furnished completely fabricated in sections convenient for transport and with a supply of rivets and permanent bolts for field erection. Erection in the field of all steel shall be by bolting, rivetting and arc welding, or by any combination of these and the contractor shall be prepared to perform all classes of work. Only expert riveters and qualified welding operators shall be employed to perform the rivetting and welding and if required by the Executive Engineer each such riveter and welding operator shall submit satisfactory evidence of his ability or take a qualifying test before being allowed to perform the work.

12.2.2 Assembling

All parts shall be accurately assembled and erected as shown on the drawings, manufacturers approved erection drawings or as directed by the Executive Engineer and all match marks of the manufacturer or fabricator shall be followed carefully. Members shall not be overstressed during the process of erection, and hammering that will injure or distort the members shall not be permitted. Bearing surfaces and surfaces to be in permanent contact shall be carefully cleaned before the members are assembled or erected. In bolted connection the bolts shall be drawn tight and where required by the Executive Engineer, the threads shall be burred so that the nuts cannot become loosened. Where fitted bolted connections are shown on the drawings or required by the Executive Engineer, the bolt holes shall be reamed in the field to provide a tight drive fit. Where rivetting is required, the field connections and splices of all gates and all members carrying erection stresses shall have not less than of the holes fitted with bolts and cyliderical erection pins (half bolts and half pins) before being riveted. The diameter of the fitting up bolts shall be the same as the nominal diameter of the rivets or field bolts, and cylindrical erection pins shall be one millimetre larger in diameter than the nominal diameter of the rivets, provided that cylindrical erection pins used in erecting all structural steel gates and frames shall be of the same diameter as the rivet or bolt holes. Erection bolts and pins shall be furnished by the contractor. Corrections of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets shall be considered a legitimate part of erection. For the purpose of determining what constitute a reasonable amount of reaming it shall be considered that where any rivet or bolt hole is not more than three millimetre off in concentricity in the two or more members after the connection is temporarily assembled, the same is minor error in shop works, any holes more than three millimetre off in concentricity after the

connection is temporarily assembled shall be reported immediately to the Executive Engineer and his approval of the method of correction shall be obtained. Cutting of members with a cutting torch will not be permitted unless approved by the Executive Engineer.

12.2.3 Riveting

Riveting shall be done with pneumatic riveters and pneumatic buckets shall be used wherever possible. All connections shall be accurately and securely fitted up before the rivets are driven. Drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. All unfair holes shall be reamed or drilled. An unfair hole will be considered as one in which a cold rivet of the size specified will not enter with light tapping after light drifting has been resorted to. Rivets shall be heated to a light cherry red colour, and shall be driven while hot. They shall not be over-heated or burned. When driven, the rivets shall completely fill the holes and shall firmly grip the connected parts together. The rivet heads shall be of the same shape and size as the heads of shop rivets, full and symmetrical, concentric with the shank, and shall have full bearing on the on the member. Recupping or caulking of rivets will not be permitted. Loose burned, or otherwise defective rivets shall be removed. In removing rivets the surrounding metal shall not be injured and if necessary, rivets shall be drilled out. Field rivets shall not be painted until they have been inspected and accepted by the Executive Engineer.

12.2.4 Welding

All welding shall be done by the electric arc method, using a process which will exclude the atmosphere from the molten metal, except otherwise where specifically permitted by the Executive Engineer. All welding rods required shall be furnished by the contractor. Welding rods shall be of the heavily coated type designed for all position welding and the size type and manufacture of the rods shall be subject to the approval of the Executive Engineer. Welds shall be made as specified on the drawings and in accordance with the welding symbols of the Indian Standard Institution (IS-813). Welding except for penstock liners and where otherwise specifically stated, shall be done in accordance with the latest applicable code of practice of Indian Standard Institution. All butt weld shall have completely penetration. Peeling of multiple layer welds will not be required, except as otherwise noted for penstock liners. Stud anchors and stud bolts shall be end-welded with automatic end-welding guns.

12.3.0 Cleaning and Painting Metal Work

12.3.1 General

The contractor shall furnish and prepare and apply all material for cleaning, painting and coating of metal work as hereinafter specified. All metal surfaces, either unpainted, or shop-painted, shall be cleaned, painted, repaired or re-coated as hereinafter specified. The cost of furnishing, preparing and applying all material which are required for cleaning painting or coating operations including supply of all labour, tools and equipment shall be included in the prices in the schedule of bids for installing or furnishing and installing the various items of metal work.

12.3.2 Cleaning Surfaces

Surfaces shall be cleaned and prepared in accordance with the method to be used for each items of metal work which is indicated in the painting schedule. Weld spatter or any other objectional surface irregularities shall be removed by any suitable means before cleaning. The following methods shall be applied.

Method-(A)

All oil, grease and dirt shall be removed from the surface by the use of clean mineral spirits, xylol, or white gasoline and clean wiping material.

Method-(B)

All oil, grease rust preventive compound and dirt shall be removed from the surfaces by the use of clean mineral spirits, xylol, or white gasoline and clean wiping material. Following the solvent cleaning, all loose rust, loose mill scale and other foreign substances shall be removed by scraping, chipping, blasting or other effective means.

Method-(C)

All oil, grease and dirt shall be removed from the surfaces by the use of clean mineral spirits, xylol, or white gasoline, and clean wiping material except that for surfaces which require coal tar coating, the cleaning solvent shall be xylol. Following the solvent cleaning, the surface to be painted shall be cleaned of all rust mill scale, and other tightly adhering objectionable substances by sand blasting or grit blasting as directed by the Executive Engineer to uniform bright base metal.

Any grit or dust from the cleaning operation shall be completely removed from surface by brushing, air blowing, suction or other effective means before the surfaces are painted.

In the event of rust forms or the surface become otherwise contaminated in the interval between cleaning and painting, recleaning will be required. Surfaces of stainless steel, nickel, bronze and machined surfaces adjacent to metal work being cleaned or painted, shall be protected by masking tape or by other suitable means during the cleaning and painting operations.

12.3.3 Repair of Shop Coat

Metal work which has been shop painted shall be handled with care so as to preserve the shop coat in the best practicable condition. Before proceeding with any painting operation the contractor shall clean the base metal and repaint all areas of shop paint which are defective or damaged. Paint applied to such areas shall be of the same type as used for the original shop coat unless otherwise directed. The cleaning and painting of damaged areas shall be at the contractor's expense.

12.3.4 Application Procedures

Paint and coating materials shall be applied in accordance with this sub-paragraph and the painting schedule. All paint and coating material shall be in a thoroughly mixed condition at the time of application and shall not be thinned except where hereinafter specifically provided, Any warming of the paint shall be performed by means of a hot water bath, and except as specifically provided, the paint shall not be heated to a temperature higher than thirty eight degrees centigrade. Surfaces shall be free from moisture at the time of painting. The first coat shall be applied immediately after cleaning when paint is applied by spraying, suitable means shall be provided to prevent segregation during the painting operations. Effective means shall be provided for removing all free oil and moisture from the air supply lines of all spraying and blasting equipment. Each coat of paint shall be done to completion and shall be free from runs and sags. Except, as otherwise specifically provided, each coat shall be allowed to dry or harden before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after installation (except inaccessible surfaces of metal work or machinery which have been shop coated with priming paint) shall be completely painted as scheduled prior to installation. Coverage rates and application procedures for particular types of materials shall be as follows:-

(i) Coal tar primer and coal tar enamel for the plate steel liners as specified shall be applied in accordance with applicable Indian

Standards and the following specifications. Where there is conflict, the specifications given below will apply:-

(a) The application of coal tar primer and enamel and related operations shall be performed under experienced supervision by workmen skilled in the trade. The contractor's equipment for blasting and priming and for application of the enamel shall be so designed and manufactured and shall be in such condition as to enable compliance with the specification requirements.

(b) The surface shall be dry at the time the coal tar primer is applied.

(c) The primer shall be applied by hand brushing, air gun spraying or spraying and brushing. Spray gun apparatus if used, shall include an air separator that will remove all oil and free moisture from the air supply.

(d) The use of coal tar primer that becomes fouled with foreign substances or has thickened through evaporation of the solvent oil will not be permitted.

(e) After application the coal tar priming coat shall be uniform, free from floods, rains, sags, dips, holidays or bare spots. Any bare spots or holidays shall be recoated with an additional application of primer. All runs, sags, floods or dips shall be removed by scraping and cleaning and the cleaned area retouched or if considered necessary such defects shall be remedied by re-blasting and re-priming.

(f) In cold weather when the temperature of the steel is below seven degree centigrade or at any time when moisture collects on the steel, the steel shall be warmed to a temperature of approximately thirty degrees to thirty-eight degrees centigrade for sufficient time to dry the metal prior to priming. To facilitate spraying and spreading, the primer may be heated and maintained during the application to a temperature of not more than thirtyeight degrees centigrade.

(g) The minimum and maximum allowable drying time of the coal tar primer between, application of primer and application of coal tar enamel shall be 24 hours and 72 hours. If the enamel is not applied within the maximum time after priming, the surface shall be reprimed with an additional light coat of primer or if considered necessary the entire prime coat shall be removed by reblasting and the surfaces reprimed.

(h) At all time during cold weather when liner temperature is below seven degrees centigrade or during rainy or foggy weather when moisture tends to collect on cold liner, enamelling shall be proceeded by warming the liners.

(i) Warming shall be done by a method which will heat liner uniformly without injury to primer. Steel temperature of liner shall not exceed fifty two degrees centigrade.

(j) The primed surface to be enamelled shall be dry and clean at the time the enamel is applied no enamel shall be applied during cold weather, rain or fog unless the liners are preheated and protected from weather.

(k) All surfaces shall be coated by applying the enamel with daubers. The final brush strokes of enamel shall be made in the direction of flow and at right angles to the previous coat. All brush strokes shall overlap and form a continuous coating. Twentyfour hours drying time shall be allowed between coats.

(l) Hand enamelling daubers shall be of size best adopted for the work. Daubers shall be of size best adopted for the work. Daubers shall be made of the best grade of fibre set in solid hardwood handles. Mops, sweeps or knot daubers shall not be used.

(m) Where overhead enamelling is necessary inside of liner or specials, the invert and sides of the liner shall be protected from drippings and splashings of enamel by tarpaulins or heavy tar paper laid in the liner.

(n) The contractor shall at all times use every precautions to prevent damage to protective coating on the liners. Heavy tarpaper shall be laid and maintained in the bottom of the liner through its entire length as long as there is need of passage through liners. This shall apply to all surfaces whether bare, primed or enamelled. Any damage to the protective coating from any cause during progress of painting shall be repaired by the contractor at his expense.

(o) The coal tar primer shall be applied at a coverage rate of approximately at 10 square metre per litre, and the five coats of coal tar enamel (cold applied) shall be applied at a coverage rate of approximately 9 square metre per litre per coat.

(ii) Alkyd priming paint for use under machinery paint, and aluminium paint (except for aluminium finish paint in the special aluminium paint system) shall be applied by brushing at a coverage rate of approximately 10 square metres per litre. An additional priming coat shall be applied by brushing over all irregularities such as rivets, welds, bolts seams etc., without thinning before the application of the machinery paint, acid resisting paint or aluminium paint.

(iii) Machinery paint shall be applied by brushing or spraying coverage rate or approximately 15 square metres per litre per coat without thinning.

(iv) Aluminium paint (except for the aluminium finish in the special aluminium paint system) shall be applied by brushing or spraying at a coverage rate of approximately 8 square metre per litre per coat. The mixing of about 200 grms of aluminium paste per litre of varnish shall be performed in the field. Only enough paint for each day shall be prepared at one time.

(v) Rust preventive compound shall be applied by any convenient method which will ensure complete coverage with a heavy uniform coating.

12.3.5 Painting Schedule

Cleaning and painting shall be in accordance with the following schedule:

Sl. No.	Item	Method of surface preparation	Painting or coating material	Number of coats	Remarks
1	2	3	4	5	6
1.	Penstock liners and valve casing.				
	a) Interior surface	C	Coalter primer Coaltar Enamel	1 2	
	b) Exterior surfaces to be exposed to concrete sheltered areas.	B	Red lead priming paint type IV Phenolic resin aluminium	1 2	
	c) Exterior surface to be encased in concrete.	A	No painting or coating required.		

1		3	4	5	6
2.	Exterior surface of valve.	C	Red lead priming	1	
		(For unprinted surfaces)	Aluminium paint	2	
		B(For damaged areas of shop coated surfaces)	Aluminium paint Aluminium paint Aluminium paint	2 2	
		A(For undamaged areas of shop coated surfaces)	Aluminium paint	2	
3.	Service rate hoist, emergency gate hoist.	B(For damaged areas of shop coated surfaces)	Same as original shop coat or Alkyd priming, paint whichever is directed	1	
			Machinery paint	2	
		A(For undamaged areas of shop coated surfaces)			
4.	Metal work that will be subject to normal interior & exterior atmospheric exposure such as structural steel work embedded metal frames, metal stairways, metal handrails & ladder rungs etc., but not including items otherwise scheduled.	B	Alkyd priming paint	1	
			Machinery paint or aluminium paint whichever is directed.	2	

1	2	3	4	5	6
5.	Metal workshop coated with the Alkyd priming paint or the manufacturers standard shop coat, that will be subjected to normal interior & exterior exposure as operating mechanisms, hoists, gearboxes oil tanks, etc. but not including items otherwise scheduled.	B(For damaged areas of shop coated surfaces) A(For undamaged areas of shop coat surfaces)	Same as original shop coat or alkyd priming paint whichever is directed. Machinery paint or aluminium paint whichever is directed.	1 2	
6.	Galvanised surfaces required to be painted for decorative purpose(Where and as indicated on the drawings or where directed by the Executive Engineer.	A(followed by an etching solution of 5 percent muriatio or acetic acid or by any good quality galvanising etching solution rinsed thoroughly with clear water and dried.	Alkyd priming paint Machinery paint or aluminium paint whichever is directed.	1 2	
7.	Machined surface exposed which are to be in rolling or sliding contact and which will not be lubricated.	A	Gasoline soluble rust preventive compound.	2	
8.	Metal surface to be embedded in concrete.	A	No painting is required.		

12.3.6 Inspection of Materials

All paint and coating material shall be made available for sampling at least 30 days prior to and no paint or coating materials shall be used until they have been tested or/and approved by the Executive Engineer. In so far as practicable, as determined by the Executive Engineer, the contractor shall make arrangements with the Board for inspection of paint materials at the supplying point. The contractor shall provide facilities and assistance as required for procuring representative test samples which will be taken by the Board representative. Test samples shall be 10 kilogrammes of coal tar enamel, one litre each of all liquid materials and representative sample of all other materials proposed to be used. With each set of samples of coal tar enamel and coal tar primer for enamel, the contractor shall furnish the detailed information regarding specifications.

12.3.7 Paint Materials

All paints, such as cold-applied coal tar paint, coal tar primer and cold applied coal tar enamel, alkyd priming paint, rust preventive compound, machinery paints, and aluminium paint shall conform to applicable U.S.Federal Specifications or Indian Standard Specifications and shall be test in accordance with the applicable A.S.T.M. provisions. If desired by the Executive Engineer, the contractor shall be required to furnish necessary test reports from the Government test house for the paint materials submitted for approval of the Executive Engineer.

12.4.0 Requisition of Stores

All materials and equipment to be furnished by Board as provided in subsequent paragraphs shall be delivered to the contractor at site of works. The handling and storing of materials shall be done by the contractor as per provisions contained in special conditions and as directed by the Executive Engineer. On arrival of each consignment at site of storage these will be checked by the contractor in presence of the Executive Engineer and shortages or damages, if any shall be intimated to the Executive Engineer simultaneously.

12.5.0 Erection Supervision

The erection of various equipments detailed in subsequent paragraphs will be carried as per erection drawings of the manufacturers or the Board and as directed by the Executive Engineer. In case of complicated equipment such as valves, hoists, and controls the Board may also obtain the services of erection Engineer of the manufacturers who

will advice and supervise the erection work under the direction of Executive Engineer for:-

(i) Handling and transportation of equipment at site;

(ii) Assembly, erection and installation of equipment;

(iii) Field painting and

(iv) Testing of equipment.

The contractor shall work in full cooperation and collaboration with such erection Engineer provided by the Board.

12.6.0 Contractor shall adhere to the tolerances specified in the maker's drawing or drawings supplied by the Executive Engineer in respect of each individual part of any assembly.

12.7.0 Penstock Liners and Accessories

12.7.1 General

The contractor shall furnish and install penstock liners complete with all fabricated steel supporting frames, bolts, anchor plates and other items required for the installation works, as shown on the drawings or as directed by the Executive Engineer. The total number of liners may be increased or decreased but the contractor shall be entitled to no additional compensation above the unit prices per kg. for the applicable item in schedule of bids for such increase or decrease in the number of liners. The number, diameter length, thickness and location of the penstock liners shall be as per the final designs and the contractor shall not be entitled to any additional compensation above the unit prices for these items in schedule of bids.

12.7.2 Materials

All materials used in the manufacture and fabrication shall conform to applicable officially recognised standard specifications of the country. Such standard specifications shall, however, be approved by the Executive Engineer. Applicable Indian or American standard specifications are, however mentioned for general guidance.

Steel plates for liners and stiffeners, therefor, shall be the weldable boiler plates according to Indian Railway specifications or high tensile structural steel according to Indian Standard specifications IS: 961 and its amendments or weldable quality plates according to IS: 226 and amendments or as directed by the Executive Engineer.

Forged steel shall conform to the A.S.T.M. designation A 105-46 Grade-I, shall be suitable for welding and shall not have carbon content in excess of 0.35 percent.

Cast steel shall be in accordance with Indian Standard Specification on IS: 1030 and its amendment or Indian Railways Specification M2-48 Grade-I. All castings shall be annealed as required therein. Radiographic, Gamma rays, magnaflux or other non-destructive tests, shall not be ordinarily required but for the purpose of examination of repairs to defects, the Board may require the contractor to make such tests to determine the suitability of the repairs.

Flex packing for expansion joints shall conform in all respects to the U.S. Federal Specifications H.H.P. 10-68.

Gasket material shall conform to the requirements of the U.S. Federal specifications H.H.P. 151-B.

The contractor shall furnish to the Executive Engineer copies of specifications for materials and equipment purchased by contractor for use in fabrication of liners. All such orders shall quote the requirements of these specifications. Test specimens for physical tests of metal shall be supplied by the contractor, plainly marked to indicate the materials they represent and shall be properly boxed and transported at the contractor's expense. The cost of making the tests shall be borne by the contractor. Acceptance of articles, material and supplies shall in no way relieve the contractor of the responsibility for furnishing articles, material and supplies which meet the requirements of these specifications.

12.7.3 Manufacture

Before beginning manufacture of any parts of the liners the contractor shall submit to the Executive Engineer for approval four copies of shop drawings showing the details of all parts. The shop drawings shall show clearly the layout of the plates and the details of the joints and connections of the plate, steel and liners. Any manufacturing done by the contractor before approval of the drawings, shall be at his risk. The Executive Engineer shall have the right to require the contractor to make any changes in the drawings which may be necessary, in the opinion of the Executive Engineer to make the finished articles to conform to the requirements of these specifications, without additional cost to the Board. Approval by the Executive Engineer of the contractor's drawings shall not be held to relieve the contractor of any part of the contractor's responsibility to meet all of the requirements of these specifications or of the responsibility for the correctness of the contractor's drawings.

The contractor shall furnish 6 complete sets of all final drawings of details and of erection diagrams showing all changes and revisions up to the time the fabrication is completed.

Where finished surfaces are specified or required for parts shown on the drawings, the type of finish, where not otherwise specified shall be most suitable for the part to which it applies and shall be smooth or average as defined hereinafter. Smooth surfaces shall be practically free from tool marks while slight tool marks shall be allowed on average surface. In general a smooth finish shall be required for all surfaces in sliding contact and an average finish for surfaces in permanent contact, where a tight joint is necessary.

The liners shall be welded in accordance with the provisions contained in this section subject to the following conditions:-

(i) The process and equipment used, the rates of deposit of weld metal, and the range of voltage and current shall be subject to the approval of the Executive Engineer. The ends of the liner with the exception of the closing sections, will have been bevelled or grooved to permit depositing the weld metal.Cracked or broken tack welds and those of poor quality shall be chipped out before the final weld is made.

(ii) All welding shall be in accordance with the requirements of Indian Standard Specifications (IS:812 to 819, 1179, 1181-82, 1261, 1278,1323, 1395 and 1442 and their amendments). Where the weld metal is deposited in successive layers, each layer shall be thoroughly cleaned before the subsequent layer is deposited. Whenever possible joints shall be welded in the flat position, unless otherwise directed by the Executive Engineer. Welded beads on the interior surfaces of the liner shall not project more than 3 mm. above the surface of the liner. Welded joints shall be reasonably free from ~~craters~~, depressions and other irregularities.

After welding is completed all weld spatters shall be removed. Radiographic examination of welds will be required for the longitudinal welds of the liners. Where the requirements of the standard specifications conflict with these specifications and drawings the requirements of these specifications and drawings shall govern.

(iii) All welds shall have complete penetration and freedom from imperfections and all defective welds shall be repaired to the satisfaction of the Executive Engineer. Defects in the welds shall be chipped or flame gouged until sound metal is reached on all sides, and the resulting cavity shall be filled by the same procedure as the original grooves, were filled.

(iv) The contractor shall furnish at his own cost for testing two welded plates 450 mm. wide and 600 mm. long, and 13 mm thick. The process of welding these shall be the same as that to be used on the job. The Board shall prepare test specimens from these test plates and will test the specimens. The Executive Engineer may require the contractor to make changes in his welding programme, if found necessary as a result of these tests.

(v) Qualification of Welders

All welders assigned to manual welding shall have successfully passed the test conducted by the fabricator or as prescribed for welder qualification as per IS: 2825-1969-code for unfired pressure vessels. In the opinion of the Executive Engineer work of any welding operator becomes questionable, such operator shall be required to pass another qualification test to the satisfaction of the Executive Engineer.

12.7.4 Radiographic and Ultrasonic Examination of Welds

As soon as possible after being welded, all shop welded longitudinal joints in the liners shall be radiographed for the entire length of the joints. The film used in making the radiographs shall be of the slow burning type. The radiographs shall be made in strict accordance with the requirements contained herein and the Indian Standard specification IS: 1182 and its amendments.

Before making the radiographs of the welds, the contractor shall place suitable indentification markers adjacent to the welds, which markers shall be designed and located so that the damages will appear on the radiographs. The markers shall be painted, stamped or fastened to the liners, as directed by the Executive Engineer and shall not be removed until all of the welds have been accepted. All radiographs shall be delivered to the Executive Engineer, who shall judge the acceptability of all welded joints. Defects in welds, as shown by the radiographs, shall be chipped or falme gauged to sound metal and the resulting cavities shall be rewelded. Welds that have been repaired shall be rewelded. Welds that have been repaired shall be radiographed. The method of radiographing the welds and the apparatus, equipments and the technique used in the making the tests shall be subject to the approval of the Executive Engineer. The contractor shall provide all equipment, apparatus, supplies and labour required for the liner sections showing the location of each radiograph for each welded joint. All radiographs shall become the property of the Board. All circumferential field joints shall be subjected to hundred percent Ultrasonic examination. Any defects in the welds shall be ractified and re-examined by Ultrasonic test. The cost of radiographic as well as Ultrasonic examination shall be borne by the contractor.

12.7.5 Fabrication

Fabrication of the penstock liners and accessories shall be in accordance with these specification and drawings and with the requirements of applicable Indian Standard Specification, and section-V of the latest edition of the A.P.I.-A.S.M.E. Code for the "Design, construction, inspection, and repair of Unfired pressure vessels for petroleum Liquids and Gases", sponsored by the American Petroleum Institute and the American Society of Mechanical Engineers. Where provisions of the codes conflict with provisions of these specifications, and the drawings, the provisions of these specifications and the drawings shall govern.

Each liner course unless otherwise shown shall be made from not more than two plates, and shall be not less than 1.5 metre in length. The longitudinal seams of a joining course of the liner section shall be located approximately 45° from the vertical centre line and shall be staggered. Plates for the liners shall be bent or rolled to true requried sections. Correction of shape by blows will not be permitted. The liner section shall be completely fabricated and butt-welded. All points on each end of each liner section shall lie in a plane normal to the longitudinal axis of the section within a maximum deviation of one and half millimetre on the either side of such plane. The edges of each fabricated liner section shall be prepared for field butt-welded joints where required. Particular care shall be exercised in matching the edges of the adjoining plates and courses to ensure that at all shop-butt-welded, longitudinal and circumferential joints, the inner surfaces of the plates are in continuity within a maximum offset at any point of one and half millimetre. Bends shall be made with equal deflection angles. Piezometer connections shall be provided for penstock liner. The manholes welding necks, and all nozzles shall be of good weldable quality steel and of forged steel, shall be shaped properly to the slope of the liners, where necessary, and shall be located and welded to the liners. The stiffener rings shall calibriated from not more than six circumferential sections. The sections of the stiffeners shall be joined by butt-welds and the stiffeners shall be attached to the liners so that the plane of the stiffeners will be normal to the liner axis.

12.7.6 Stress Relieving

Upon certification that the radiograph inspection and the density, bending and strength tests had shown the welding to be satisfactory, each fabricated section of the liner will be subjected to thermal treatment in the stress relieving furnace for the elimination of stresses developed during bending and welding. In the stress relieving operations, the liners will be heated uniformly, the temperature being gradually increased to approximately $620^{\circ}C$ which will be maintained for one hour per 25 mm of liner shall thickness. The furnace shall then be cooled

to 260°C during three hours period after which liner sections will be removed from the furnace. The holes etc., to be drilled in any liner section shall be drilled after stress relieving.

The stress relieving will only be required if liners are fabricated from mild steel plates of thickness more than 40 mm as specified in A.S.T.M.Code. For liners fabricated from high tensile steel, stress relieving will not be required.

12.7.7 Shop Cleaning and Painting

Shop painting of liner will not be required, however, all metal surface shall be cleaned of weld spatter before shipment. All finished surfaces of metal work including screw threads that will be exposed to the atomosphere during transport, or while awaiting installation shall be coated with a gasoline soluble rust preventive compound.

12.7.8 Marking

Each completed liner section shall be marked to show its location in the finished assembly. Each section shall be marked to show the vertical centre line, the direction of flow and a serial number with the marks for the vertical centre line planned on the outside of the liner at the top and on the inside at the bottom at each end. The contractor shall indicate the location of each section of liner and appurtenant parts in the completed assembly on the drawing as per requirement of this section.

12.7.9 Hydrostatic Test

All lengths of liners to be furnished including bends shall be given hydrostatic pressure tests in contractors premises satisfactory to the Executive Engineer Hydrostatic test pressure shall be computed from the following formula:-

$$P = \frac{0.8 \times Yp \times t}{R}$$ in which

P = test pressure in kgms. per square centimetres.

t = minimum thickness, in centimetres of plate in liner length tested,

R = minimum internal radius, in centimetre of section being tested,

Yp = yield point stress of the liner material in kg/cm^2.

Each liner length shall be filled completely with water and the pressure slowly and uniformly increased until the required test pressure is reached. The test pressure shall be applied and released three successive times and after each application shall be held at the times and after each application shall be held at the required pressure until all welded joints and can be examined. Any defects in welds or plates disclosed by the hydrostatic pressure test shall be repaired by the contractor to the satisfaction of the Executive Engineer and all repaired lengths shall be retested hydrostatically after all repairs have been made. After erection of penstock liners at site, each penstock shall be subjected to hydrostatic test in the manner specified above and defects ractified to the satisfaction of the Executive Engineer. Repair and re-testing shall be done by the contractor and at his cost. The contractor shall furnish all labour, materials, supplies and equipment including test heads, required for making the test. No separate payment shall be admissible for testing of liners in contractor premises and the cost involved shall be deemed to be included in the item of "Hydrostatic testing of penstock" of the schedule. Measurements for payment of Hydrostatic testing of penstock shall be done for length of penstocks actually erected and tested at site. Payment for such tests of penstocks erected shall be made as per item "Hydrostatic testing of penstocks" in the schedule of bids.

12.7.10 Installation

The liners complete with the manhole covers nozzles, piezometers, plugs, filling line connections drains, flanges and stiffener rings, will be furnished by the contractor in accordance with specifications given above. The contractor shall install all required anchor bolts at the level established, as working bases for the installation of the liner. The liner sections shall be located or placed in position in accordance with the erection diagrams and shall be accurately aligned to grade before the joints are welded and the sections embedded in concrete. The contractor shall provide and attach necessary permanent structural steel supports to the liner sections. The contractor shall, in addition provide and install all temporary supports, blocking cables, anchors or expansion spiders required to hold the liners in position or to prevent distortion while the liners are being welded or being embedded in concrete. When assembled and ready for welding the distance between the ends of adjoining sections which are to be connected together with butt-welds shall not be greater than six millimetres and not less than three millimetres unless otherwise directed. Care shall be taken to avoid excessive growth of shrinkage in length. All welding and repairing of defective welds shall be performed in accordance with the provisions in the relevant portion of this section. After the girth joints have been welded and repaired to the satisfaction of the Executive Engineer, the sections shall be cleaned and encased in concrete. Any temporary timber supports used for the liners, shall be removed before the concrete is placed.

Penstock Accessories

The contractor shall provide following penstock accessories as per specifications detailed below:

(i) Stiffener Rings

These shall be fabricated in not more than four circumferential sections but welded together and properly filled and welded to the pipe such that the planes of rings shall be normal to the axis of the penstock.

(ii) Flanges, Manholes percolation rings, phezometric connections, nozzles and plugs:-

These shall be installed on a penstock as directed by the Executive Engineer. Nozzles mantriles etc. shall be shaped properly to the curvature of the pipe at the location of these attachments.

12.7.11 Painting

The liners shall be painted as specified in the "painting" schedule given before in this section.

12.7.12 Payment

The weight of penstock liners, steel stiffeners and backing strip as fabricated for the work and approved by the Executive Engineer for placement shall constitute the weight for the item "furnishing and installing liner for penstock". Payment for "furnishing and installing liners for penstock" will be made at the unit price per kgm., for the item in the schedule of bids, which unit price shall include furnishing, installing and painting liners.

12.8.0 Metal Pipes Fittings and Valves

The contractor will furnish all metal pipes, fittings and valves, floor drains, area drains, joint materials and all other accessories and appurtenances required for permanent installation, as parts of permanent piping to be attached to or built in the Rajghat Dam, pressure shaft, and other appurtenant work being carried out under the contract, and other permanent piping not otherwise specifically provided for in the schedule of bids and specifications. The pipes fittings, valves and accessories and appurtenance shall be installed and tested by the contractor as directed. All pipes after being cut and before being threaded or fitted to welding fittings shall be reamed and all burrs shall be removed. The thread shall be cut full, shall be free from

torn or ragged surfaces, and the joints shall be made up so that no threads are exposed on chromium plated pipe and not more than three threads are exposed on other threaded pipe after installation screw threads only. Screw joints shall be made metal to metal and caulking of screwed joints to stop or prevent leakage will not be permitted. The pipe ends and all socket fittings shall be cleaned thoroughly and shall be free of foreign matter before assembly prior to welding operations.

Flanged joints shall be made up with undamaged gaskets and all bolts shall be drawn tight. Cast iron bell and spigot pipes will be furnished in standard lengths and shall be cut where required, by the contractor. The spigot ends of cast iron pipes and fittings shall be placed concentrically on the bells, and the joints shall be packed with oakum or similar material and shall be thoroughly caulked with suitable caulking tools so as to leave 50 mm. in the bell of cast iron water pipes for lead or mortar. Joints not to be embedded in concrete shall be poured full of molten lead in one operation. The lead shall be retained in the joints by suitable joint runners and after the lead has cooled sufficiently it shall be filled completely with lead if so specified or with mortar from the concrete in which the pipes are placed. Metal pipe and fittings to be embedded in concrete shall be held firmly in position and protected from damage while the concrete is being placed. Care shall be taken to prevent the pipe from becoming clogged during the progress of the work and should any pipe become either partially or wholly clogged before final acceptance of the work, it shall be cleaned out in a manner satisfactory to the Executive Engineer or shall be replaced by and at the expense of the contractor. Open ends of pipes shall be plugged or otherwise suitably closed where and as directed. All exposed piping from the roughed in piping to the plumbing fixtures shall be installed in accordance with good standard plumbing practice. The metal pipes, fittings and valves shall conform to the following Indian Standard Specifications:

1.	Sheet metal, rain water pipes, gutters, fittings and accessories.	: I.S.1728	and their amendments
2.	Gate, globe, and check valves for water & oil	: I.S. 778	
3.	Cast iron, rain water pipes fittings.	: I.S. 780	
4.	Sluice valves.	: I.S.1230	
5.	Centrifugally-spun pressure pipes.	: I.S.1536	
6.	Vertically spun cast iron pipes.	: I.S.1537	
7.	Cast iron fittings for pressure pipes.	: I.S.1938	
8.	Steel tubes and pipes	: I.S.1161	

All portions of all piping system which will not be embedded in concrete, except air vent piping not subjected to pressure all vent line, all portions of all pressure piping system for oil, air and water supply and all portions of other piping system which will be operated under a pressure exceeding 2 kg. per square cm. as determined by the Executive Engineer shall be tested by the contractor as directed. All portions of drain line which will not be embedded in concrete and which will not be operated under pressure shall be subjected to a test pressure of not less than 1 kg. per square centimetre and not more than 1.5 kg. per square centimetre as directed. Tests of drainage system shall be made by hydrostatic pressure on air pressure as directed. Except as otherwise provided in these specification all pressure piping systems for oil, air and water supply shall be tested by the contractor to a hydrostatic pressure of not less than 7 kg. per square centimetre and not more than 25 kg. per square centimetre as directed. The methods used shall be satisfactory to the Executive Engineer. The piping for all oil system shall be thoroughly cleaned by an approved method after testing as directed. The contractor shall furnish all materials, supplies, labour and equipment required for making the tests. All leakage and other defects in the work which may be disclosed by the test or at any time prior to acceptance by the Board shall be corrected by the contractor to the satisfaction of the Executive Engineer. Pipes and fitting to be placed in concrete shall not be painted but shall be thoroughly cleaned of all excessive rust, dirt and grease immediately before being embedded in the concrete. After being installed and tested, if testing is required all exposed piping shall be painted. Except as otherwise provided in these specifications, payment for furnishing and installing, including painting metal pipes, fittings and valves will be made at the applicable unit prices per kg. in the schedule of bids for "furnishing and installing pipes, fittings and valves" "providing and fixing mild steel ventilation pipe including cost of pipe".

12.9.0 Furnishing and Laying Ground Wires and Ground Rods of Copper

A net of copper conductors clamped or welded at each intersection and fastened to anchored copper ground rods shall be furnished and installed as directed by the Executive Engineer. Bare copper conductor shall be installed leading from the mat into and throughout the dam and appurtenant works and other works as required by the Executive Engineer. Risers from these conductors and from the mat shall be furnished and installed as directed by the Executive Engineer so that connections may be made for grounding all electrical apparatus. The contractor will be required to make the complete installation of the ground cables.The various parts of the grounding system shall be located in the structures as directed.

12.9.1 Measurements and Payments

The price entered in the schedule for the item is inclusive of all compensation for mobilising, de-mobilising, supply of equipments, materials, labour, supervision, cleaning of site, over-breakage done (without permission of Executive Engineer) filling of over-breakage by approved materials, clearance of silt deposited and all incidental work except for any item specifically exempted therefrom and for which in addition a specific payment item has been included in the schedule of item.

Payments for furnishing and installing ground wires and ground rods will be made at unit price per kg. for the particular item under the schedule of bids. Payments for drilling holes for placing ground rods to anchor the mats to the rock foundation shall be made as per item "wet percussion drilling" under the schedule of bids. Payments for grouting of rods into the holes shall be made at unit price under the item "contact grouting including cost of cement" under the schedule of bids.

12.10.0 Drilling Grout Holes Through Plate Steel Including Provision of Fillets, Threading, Plugging, Welding and Finishing Holes Drilled Through Plate Steel

12.10.1 General

Drilling through plate erected in works will be required in places as indicated in drawings or as directed by the Executive Engineer.

12.10.2 Finishing

The drill hole after it has served the purpose shall be finished after providing fillets, threading, plugging, welding as indicated in drawings or as directed by the Executive Engineer. These works shall be carried out as per specifications contained in the relevant parts of this section.

12.10.3 Measurement and Payment

(i) The prices entered in the schedule for the work required herein shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition, a specific payment item has been included in the schedule.

(ii) Measurement for the work shall be made on the basis of the number of holes actually drilled as required in drawings or as directed by the Executive Engineer and shall be paid at unit price entered for the item in the schedule.

EARTH DAM SPECIFICATIONS

PREAMBLE TO SPECIFICATIONS

The prices entered in the schedule for incorporation of various items of work of Earth Dam required under this document shall be all inclusive, constituting full compensation for mobilising, demobilising and supplying all equipments, material, labour, supervision and all incidental work except for any item specifically exempted therefrom and for which, in addition or specific payment of item has been included in the schedule.

Payment for all items of works of Earth Dam shall be made on the basis of the unit price entered for the particular item in the schedule.

Notwithstanding any provision to the contrary contained in this document, the contractor shall be allowed to use suitable material obtained from excavation of stripping, cut off trench, filter and toe drain free of cost in the execution of works under this contract. No deduction for use of such material shall be made for the over all measurement of respective items of work. The decision of the Executive Engineer regarding suitability of excavated material shall be final and binding on the contractor. The disposal of all unused excavated material shall be governed by the related provision of this document.

EARTH DAM : SPECIFICATION

A. General Specification

1.1.1 Bench Marks: Before starting any work, the contractor shall erect a permanent bench mark, reference line and check profiles at convenient positions approved by the Executive Engineer. The bench mark shall be 20 cm x 20 cm x 60 cm (9" x 9" x 24") with 40 cm (1 ft. 3 inches) embedded underground and 20 cm (9 inches) above the ground. The top surface of the bench mark shall be horizontal and plain. The words "B.M." with R.L. shall be conspicuously carved and painted on the bench mark. The reference line shall comprise of a base line properly dagbelled on the ground with number of masonry pillars suitably spaced. The check profiles as shall be of such materials and shall be located at such places as to ensure execution of all slopes, steps and elevation, to the profile or profiles indicated in the approved drawings or as directed by the Executive Engineer or the Assistant Engineer Incharge acting on behalf of Executive Engineer.

1.1.2 The Assistant Engineer on behalf of the Executive Engineer shall himself lay out all important levels, all control points with respect to this bench mark and reference line and corelate all levels and locations with this bench mark and the reference line. Important levels shall be checked up by the Executive Engineer. All assistance shall be given for the same by the contractor.

1.1.3 In the case of spread out works several bench marks, reference lines and check profiles as may be necessary shall be constructed by the contractor as directed by the Executive Engineer.

1.1.4 All materials and labour for setting out works including construction of bench marks, reference lines, check profiles and surveys required for setting out works, as may be required at the various stages of the construction works, shall be supplied or made by the contractor at the contractors cost.

1.1.5 Cross Section: Immediately prior to the beginning of the work, cross sections of the existing ground level at every fifteen metres, normal to the axis of the dam shall be taken over base and seating of

the dam for sufficient distance outside limits. Levels on these cross section will be taken at 5 metres intervals.

1.1.6 These cross sections shall be taken and plotted in ink by the departmental agency in presence of the contractor or his authorised agent, if he so desires and shall be binding on the parties after they are signed, both by the contractor and the Executive Engineer. These cross sections shall form the basis of all future measurements and payments on the area.

1.1.7 Payments: No payment shall be made to the contractor for this item. The rate for individual items of work under the contract shall include the cost of setting out works and all other items as indicated above.

2. Preparation of Work Areas

2.1 Clearing & grubbing operations shall be performed in excavation areas, embankment areas, borrow areas including a 6 M wide strip measured beyond and contiguous to the limit-lines of the areas. These sites should be cleared of all trees, stumps, roots, rubbish, bushes and other objectionable materials. Such materials from clearing operations shall be burnt, removed from the site of work or otherwise disposed off as approved. All the materials to be burnt shall be piled neatly and when in a suitable condition, shall be burnt completely. Piling for burning shall be done in such a manner and in such location as to cause least fire risk. The burning shall be so thorough that all the materials are reduced to ashes. Special precautions shall be taken to prevent fire from spreading to the areas beyond limits of the areas specified and suitable equipment and supplies for preventing and suppressing fires shall be available at all times.

No trees shall be cut from outside areas designated unless instructed in writing by the Executive Engineer and all trees designated outside of the areas actually occupied by the Dam shall be protected carefully from the damage.

2.1.1 Payments: No separate payment will be made for this item and the same will be included in the item of works in schedule of quantities and bids.

2.2 Care & Diversion

The contractor shall construct and maintain all temporary bunds in the existing nala on upstream & downstream of dam alignment to make the work area clear of water. The contractor shall pump out all water from this work area and shall keep the foundation free from water while excavating and preparing the foundation etc. The contractor shall be

entitled to no claim for damages or additional compensation or payment for water leaking through under or around temporary bunds.

2.2.1 Payment: No separate payment shall be made for construction of temporary bunds and dewatering and the same shall be included in the corresponding items of work in schedule of quantities and bids.

B. Detail Specification of Earth Dam

3. Stripping

3.1 Stripping shall have to be done at two places;

i) Under the dam seat

ii) Under clay blanket on upstream of dam.

The entire areas of embankment including a 3 M wide strip beyond and contiguous with the areas of embankment proper as shown in the drawings shall be stripped to a sufficient depth, as directed, to remove all unsuitable materials. The unsuitable materials shall include all debris, top soil, vegetable matter including roots, loose rock, mounds of earth & boulders, organic silt, swamp materials and other perishable or objectionable materials that are unsuitable for use in permanent construction or that might interfere with the proper bonding of the embankment with the foundation, or the proper compaction of the materials in the embankment, or that may be otherwise objectionable. The stripping shall be kept in advance of other items of works to ensure that no undesirable material will get mixed with approved embankment material and to enable proper inspection and measurement. Materials from stripping operation shall be disposed off beyond 60 m from the toe of the dam in such a way as not to detract from the finished appearance of the project nor interfere with the accessibility of the structure for operation where required. The waste piles shall be levelled and trimmed to reasonably regular lines. The useful material obtained during excavation shall be suitably utilised either immediately or after stock piling as per specification of the item described later and directed by the Executive Engineer.

3.2 Measurements & Payments: a) Immediately prior to the beginning of the work, after the jungle and silt clearance has been done, accurate cross section of the existing ground level at every 15 M interval or closer where necessary and normal to the axis of the dam shall be taken over the area to be excavated and for sufficient distance outside the limits of excavation levels on these cross sections will be taken at 5 metres. Final sections along the same lines after the benching or stripping is completed shall be taken. Volume shall then be computed for materials excavated and recorded.

b) The payment for the work shall be on measurement for the actual work recorded in cubic metre units. It shall include all items like excavations, dressing of the benches and foundations, rehandling and removal of material from the sites including all leads & lifts etc., as described in the schedule of quantities and bids.

4. Cut Off Trench

4.1 Excavation of Cut Off Trench Under Dam Embankment

The cut off trench as shown in the drawings shall be excavated in the foundation to the established lines and grades. The alignment and cross section shown in the drawings will be subject to such changes as may be found necessary by conditions disclosed by the excavations. Accurate trimming of the slopes of the excavation will not be required, but excavation shall conform as closely as practicable to the established lines and grades.

4.1.2 Where excavation of cut off trench extends below rock such blasting procedure shall be adopted in order to prevent excessive damage to the blasted surface. When the excavation reaches within about 90 cms. of the final levels, no blasting may be permitted, if in the opinion of the Executive Engineer such blasting will shatter and disturb the rock below foundation. No blasting shall be carried out within 20 m of the area already grouted. In such cases rock excavation should be completed by chiselling and wedging etc.

4.2 Material Excavated from the Cut Off Trench

This material, if suitable, shall be used in the embankment or upstream blanket either immediately or after stock piling as convenient. The suitability or otherwise of the material and zone of the embankment in which it is to be placed will be determined by the field laboratory and prescribed by the Executive Engineer. Material excavated from cut off trench shall not be placed in the embankment till the foundation for the embankment has been cleared, stripped and prepared as specified and adequate arrangement made for watering and rolling the layers of earth fill in the embankment. This material shall be subject to the same degree of embankment control as for the material obtained from the borrow pits. Excavated materials which are unsuitable for use or are in excess of dam embankment requirements or other earth work requirements shall be wasted as directed by the Executive Engineer. Waste piles shall be located immediately beyond the disposal of stripped material where they shall not interfere harmfully with the natural flow of stream, with the operation of the reservoir or with the flow of water to or from the spillway or outlet works and where they will neither detract from the appearance of the completed project, nor interfere with the accessibility of the

structure for operation. Where required the waste piles shall be levelled and trimmed to reasonably regular lines.

4.3 Removal of Water from Foundation Excavation

The method of removal of water from foundation excavation shall be efficient and effective. Where the excavation for cut off trench in the foundation extends below the water table, the portion below the water table shall be dewatered in advance of excavation.

The dewatering shall be accomplished in a manner that will prevent loss of fines from the foundations, will maintain stability of the excavated slopes and bottom of cut off trench and will result in all construction operations being performed in dry conditions. The use of sufficient number of properly screened wells or other equivalent methods as approved for dewatering shall be adopted. The seepage along the bottom of the cut off trench shall also be controlled, which may require supplementing the dewatering systems by pipe drains leading to sumps from which water shall be pumped. Such pipe drains shall be of uniform diameter for each run and shall be provided with grout connections and returns at 15.25 M (50') intervals and shall be embedded in reasonably well graded gravel or like material.

During placing and compacting of the impervious materials in the cut off trench the water level at every point in the cut off trench shall be maintained below the bottom of the earthfill until the compacted fill in the cut off trench at that point has reached a depth of 3 M (10') after which water level shall be maintained atleast 1.5 M (5') below the top of compacted fill. When the fill has been constructed to an elevation which will permit the dewatering systems to maintain water level at or below the designated elevations as determined by the Executive Engineer to pipe drains including surrounding gravel shall be filled with grout composed of water and cement or clay.

4.4 Back Filling of Cut Off Trench

Cut off trench shall be backfilled with impervious material of the same specifications and in the same manner as for the impervious hearting zone of the embankment of the dam. Cut off trench shall be filled back by the impervious earth placed in the continuous approximately horizontal layers not more than 15 cm (6") in thickness after being rolled under optimum moisture contents. Higher thickness of layers may also be permitted, if suitable compaction unit such as vibratory compactor are used to give the required density under optimum moisture content. The extent of thickness of layers shall be determined in the field by laboratory test. Watering of Earth Work and its compaction shall have to be arranged by the contractor.

4.5 Measurements & Payments

(a) For this purpose grid levels at the ground at 5 m or closer intervals will be taken after stripping and before commencement of the cut off trench and after the final excavation of the cut off trench. Payments will be based on the contents of the cut off finally approved on excavated sections. The classifications of various geological strata and classification of soils shall be recorded as the excavation progresses and payment made at the rate of each classification in accordance with the description given in the schedule of quantities. For wet excavation and dewatering, no seperate payment will be made and the same will be included in the respective items in the schedule of quantities and bids. Similarly rate will include all leads & lifts of disposal & shoring wherever necessary.

(b) Payments for the back-filling of the cut off trench shall be made in the way as for the impervious clay core of the embankment of the dam.

Payment shall be made as per actual measurements of work done at unit rate of one cum and shall include all items of work including excavation of earth and its transportation, breaking clods, picking of roots, levelling and laying, watering & compaction. It shall include also all leads & lifts of earth. No extra payment for dewatering shall be made and same will be included in respective items of schedule of quantities and bids. For running and completed works payments will be made as explained in foregoing paras 7.12.

5. Foundation Grouting

5.1 Scope: This specification covers to construction of the grout cut off curtain below the core of the earth dam.

5.2 General Programme: The curtain will in general be formed by grouting from a single row of holes, but in places double row may be required.

5.3 Grout Materials: Grout for injunction under pressure into rock shall consist of cement, bentonits, water & in special circumstances sand.

Cement used in grouting shall be of good quality portland cement conforming to IS-1489-1967. It shall not contain particles more than half percent coarser than 200 mesh.

Water for mixing shall be clean, fresh and free from injurious amount of oil, acid, alkali,. salts, silts, organic material and other deleterious substances.

1 Kg. of 200 mesh bentonite per bag of cement shall be used with cement as admixture.

Sand, if used in grout mixture, shall conform to the requirements of IS specifications for sand for concrete with the limitation that sizes above No.120 Indian Standard Sieve size shall be excluded.

Grout Mixtures: Grout to be used shall normally be a water . cement and bentonite mixture. The ratio of water to cement will be varied to meet the characteristics of each hole as revealed by the grouting operations. As a general rule, initially the grout shall be fairly thin (in relation to thicker mixes which may be used) so that characteristics of the foundation rock could be estimated without chances of loosing the hole. Grout mix used shall be tested at frequent intervals to ensure that the material are uniform in quality. Grout shall be used within an hour and retampering shall not be permitted. Grout mix left unused after an hour, or at the end of days work shall be rejected.

5.4 Casing Pipe: Grouting may be started before excavating the trench to the final finished surface by providing a packer at the point of final finished surface of the trench. In case of the hole in the portion above the final finish surface does not stand a casing pipe may be used.

5.5 Drilling: Holes shall be set out and drilled at locations and to depths as shown in the drawings, or as required at site conditions. Use of percussion type of drill shall be permitted. The minimum diameter of each grout holes shall not be less than that produced by the commercial standard Ex. size drill bit i.e. approximately 38 mm.

Holes shall be drilled vertically or at an inclination to the verticles as shown on drawings, or as required by site conditions. Exploratory holes shall not deviate from the required direction by more than one percent of the length of the hole, as measured at the point of maximum penetration. All measurements relating to the depth of hole shall be made from the ground collar of the holes. An accurate log of all drill holes shall be maintained.

All holes remaining open on completion of work shall be backfilled with grout.

5.6 Pressure Testing of Holes: During the drilling of holes or after drilling is completed or during or after grouting any or all of the holes shall be water pressure tested.

The procedure for water Pressure testing shall be as specified herein. If a hole is drilled to full depth. The section of the hole to be tested shall be isolated by sealing it off with special double packers

attached to a perforated steel pipe and lowered into the hole. If stage drilling method is used, a single packer shall be used to isolate the section to be tested. Water shall then be pumped into the test section under pressure and for periods specified herein.

A record of the time, pressure and quantities of water used for testing a section of hole shall be maintained, before use and shall be periodically tested for accuracy and satisfactory operation.

The existing water level in the hole to be tested shall be established and recorded before commencement of pressure testing.

The pressure test shall be performed in one continuous operation using the following steps of pressure and times:

Step No.			Pressure (P)		Elapsed time in Minutes
1	P_1	=	1/3	P_3	5
2	P_2	=	2/3	P_3	5
3	P_3	=	Prescribed grouting pressure		10
4	P_4	=	2/3	P_3	5
5	P_5	=	1/3	P_3	5

The pressure for step number three shall be equal to the grouting pressure for the stage.

In some cases after steps 4 and 5, the hole valve shall be closed and the pressure drop observed and recorded for a maximum period of 3 minutes in each instance.

The general requirements for grouting described herein shall be followed through all grouting work unless otherwise directed.

Drilling and grouting holes for curtain grouting shall be done using the split spacing method. Primary holes shall be drilled and grouted before the secondary holes are drilled and grouted and the tertiary holes shall be taken up last.

Packer grouting shall be performed by attaching a packer to the end of a grout supply pipe into the drill hole until it reaches the nearest part of the farthest stage to be grouted at a specified pressure, setting the packer & grouting the stage beyond the packer at the required pressure, allowing the packer to remain in place until there is no back pressure, withdrawing the grout supply pipe to the nearest part of the next stage required & grouting the whole in successive stages as required. In stage grouting the hole will be drilled to a limited depth, pressure tested and then grouted at that depth. After the hole has refused grouting (to the extent specified hereinafter) it shall be flushed out before the grout in the hole has set sufficiently to require redrilling. After the grout surrounding the grouting hole has set, the hole shall be water pressure tested and may be re-grouted, if considered necessary. Thereafter successively deeper stages shall be drilled, grouted and tested at increasing pressure, until the required depth of the hole is completely drilled and grouted. Each stage shall during these operations be isolated from the previous stage by a packer provided at the bottom of the previous stage.

The packers used shall be so designed that they can be expanded to seal the drill hole at the specified elevations and when expanded shall be capable of withstanding, without leakage water pressure equal to the maximum grout pressure to be used.

The depth of each stage shall be 4 to 6 m. but may vary as required by site conditions.

If the conditions at site so indicate, the operations shall be so arranged that the grouting of 4 (or less as required) primary and secondary holes on either side of the hole being grouted shall have been completed upto the next upper stage in advance.

The maximum grouting pressure will be equal to 0.20 Kg./cm^2 per metre depth of packer (0.87 psi per ft.) or grouted zone or as specified in drawing measured on the back pressure gauge located at the header. In no case the pressure be such as will cause upheavel of the bed rock. Sensitive upheavel indicators shall be installed at suitable locations, and shall be carefully watched for any indication or uplift during water pressure testing and grouting operations. Higher grout pressure may be used in final sealing.

Bottom of these upheavel indicator installations shall extend 6 m or more below the deepest grouting and shall in no case be less than 3 m deeper than the bedding plane to which the grout holes in its vicinity extend.

The pumping rate will normally be governed by the required pressure. If it is found, impossible to reach this pressure while

pumping a certain type of grout mixture at the maximum speed of the pump, the speed of the pump shall be reduced, and if the desired pressure still cannot be reached, the grout mixture shall be changed or pumping discontinued.

Under no conditions shall the pressure or rate of pumping be increased suddenly, as either may produce an effect which would promote stoppage or opening of cracks of seams.

Grout mixes usually shall range between 10:1 and 9.5:1 by volume. Grouting of all holes shall, however, commence with relatively thin mix. The specified pressure shall be maintained for a minimum period of 5 minutes with this mixture, if such pressure is attainable. The length of time for which this cement ratio is used after the initial 5 minutes period shall be determined according to the characteristics of the hole. For instance, if the hole takes grout freely at this water cement ratio and the pressure specified cannot be built up or maintained or if the grout appears in other holes drilled in the area or in cracks in the bed rock surface, it shall not be used longer than for a period of 10 to 15 minutes, after which the water cement ratio shall be gradually decreased.

If it is found that the hole will take grout at the rate of the maximum capacity of the grout pump and no decrease in the rate of grout intake is observed while pumping a mixture having a water cement ratio of 0.5 or that no resistance can be built by reducing the pump speed, the grouting of the hole shall be continued for a maximum of 1 hour at minimum pump speed. If the rate of grout take still does not decrease the grouting of that hole shall be discontinued for a minimum of 2 hours to allow the grout to attain initial set. Thereafter, the hole shall be cleaned and after a period of 6 hours grouting shall be resumed. If it is found that certain holes cannot be effectively grouted with water cement mixture due to very large cavities or extensive grout take, sand grout mixture may be used when directed.

The amount of sand used in the mix. will be increased progressively until the maximum amount which the equipment will handle successfully has been reached. If the desired results are not obtained with this mix. grouting will be discontinued. In such event the hole shall be cleaned, the grout allowed to set, and additional drilling and grouting shall then be done in this hole or in the adjacent areas, as directed until the desired pressure is built up.

If necessary to relieve premature stoppage, periodic applications of water under pressure may be made, however, no prolonged application of water shall be allowed. If during the grouting of any hole, grout is found to flow from adjacent grout holes in sufficient quantity to interfere seriously with the grouting operation or to cause appreciable loss of grout, such holes may be capped temporarily. Where such

capping is not essential ungrouted holes shall be left open to facilitate the escape of air and water as the grout is forced into adjacent holes. Before the grout has set, the grout pumps shall be connected to adjacent capped holes and to other holes from which grout flow was observed and grouting completed at a pressure specified in this section.

The grouting of any hole shall be continued until grout intake connection takes grout at the rate less than 2 litres per minute of grout mixture in ten minutes at the maximum pressure used for grouting. After grouting of any hole is finished, the pressure existing in the hole shall be maintained by means of a valve until the grout has set to the extent that it will be retained in the hole.

The following requirements shall also be met during grouting:

(1) Drilling, washing, pressure testing or grouting shall not be performed within a distance of 12 m or such other distance as may be considered suitable for the site condition, from a hole being pressure tested or grouted, unless at least one grout hole in between these holes, has been completely grouted and a period of 6 hours has elapsed since the completion of such grouting.

(2) On steeply sloping ground, grouting shall invariably proceed from the lower elevation to the higher.

The arrangement of the grouting equipment shall be such as to provide a continuous circulation of grout throughout the system and to permit accurate pressure control by operation of a valve on the grout return line, regardless of how small grout take may be. Pressure gauges and adequate valves will be required at the pump and at each hole to ensure required control bye pass and shut off. The equipment and lines shall be prevented from becoming, fouled by constant circulation of grout and by the periodic flushing out of the system with water. Slushing shall be done with the grout intake valve closed, the water supply valve open, and the pump running at full speed.

5.7 Regrouting: The effectiveness of the grouting work shall be checked as work progresses, by tests performed in a series of vertical and/or inclined holes drilled along the grout curtain every 15 m. or so. Pressure tests in these holes, and core recovery, may indicate parts of the foundation already grouted require additional grouting. In such event additional holes shall be drilled and grouted as and when required.

5.8 Protection of Work & Cleaning: During drilling, testing and grouting operations, the rock surface in the grouting area and the surrounding 10 m wide strip shall be kept free and clean of oil, grease, drill cutting, muck, grout cement, excess water or any kind of waste.

To prevent surface leakages of grout all joints shall be properly closed by caulking with lead wool.

The appearance of grout from any of the cracks, openings cavities or drilled holes of any type in the grouting area shall be carefully watched and shall be recorded and immediately reported.

At all times during the process of the work all open drill holes, cleaned out faults, cavities and larger cracks in the bad rock or concrete surface shall be protected from becoming plugged or filled with oil, grease, drill cuttings, muck, grout cement or any kind of waste.

5.9 Technical Field Records: The contractor shall assist in maintaining an accurate and up-to-date technical field records of all surface testing, grouting and control operations and observations required to be performed in connection with this work, for each hole in a chronological order in the proforma given in Appendix-I.

5.10 Measurements & Payments:

a) Items of works to be executed in accordance with specifications given in para 5.0 to 5.9 and to be paid to the contractor are divided suitably as noted in the schedule of quantities & bids.

b) Rates quoted vide schedule of bids above should take into account the following:

i) Equipment: No equipment or machinery required for the due performance of the contractor, shall ordinarily be supplied to the contractor by the Board, unless specified to the contrary.

ii) Cement: Cement required for the above item shall be supplied by the Board from stores at Rajghat. Cost of cement shall be recovered at the issue rates. The tendered rates offered by the contractor for this work shall be inclusive of all leads & lifts of material.

Water: Water for drilling and grouting operation shall have to be arranged by the contractor. The rates tendered for these items shall be inclusive of water charges.

iii) Working hours, departmental instructions, supply of cement for construction purposes shall be regulated by the time schedule contemplated in the contract document and signed by both parties at the time of signing of the agreement. The work shall be carried out in the business like manner during the currency of the time schedule and the contract.

iv) Re-drilling required because of contractors failure to clear out a hole before the grout has set shall be performed by the contractor at his own expense, but when the grout has been allowed to set by the direction of Executive Engineer, the required redrilling shall be paid at the "Re-drilling" rate quoted by the contractor.

Drilling shall be measured in meters from the grout coller of hole. Payment for drilling will be made at his tendered rate which shall be inclusive of cleaning, washing & water pressure testing.

Grouting shall be paid at the tendered rates on total consumption of the hole in Kgs. of cement. Unit rate of grouting shall be inclusive of water pressure testing during and after grouting wherever necessary.

Re-drilling wherever necessary shall be measured in meter and paid at the tendered rates.

6. Borrow Areas

6.1 All materials required for the construction of impervious, semipervious or pervious zones of embankment and backfill for cut off trench which are not available from cut off trench excavation or other required excavation shall be obtained from designated borrow areas as shown in drawings or as designated by the field laboratory.

The limits of each borrow areas to be used in the various zones of embankment shall be flagged in the field and material from each borrow area shall be placed only in the zones for which it has been specified.

The depth of cut in all borrow areas will be designated by the Executive Engineer and the cuts shall be made to such designated depths only. Shallow cuts will be permitted in the borrow area, if unstratified material with uniform moisture contents are encountered. Each designated borrow area shall be fully exploited before switching over to the next designated borrow pits. Haphazard exploitation of borrow area shall not be permitted. The type of equipment used and the operations in the excavation of materials in borrow areas shall be such as will produce the required uniformity of mixture of materials for the embankment.

Borrow pits shall not be opened within a distance of ten times the height of the dam embankment from the upstream and downstream toes. Borrow pits shall be operated so as not to impair the usefulness or mar the appearance of any part of the work or any other property. The surface of wasted materials shall be left in a reasonably smooth and even condition.

6.2 Preparation of Borrow Areas: All areas required for borrowing earth for embankment shall be cleared off all trees and sumps, roots, bushes, rubbish and other objectionable material. Particular care shall be taken to exclude all organic matter from the material to be placed in the dam embankment. All cleared organic materials shall be completely burnt to ashes or disposed off as directed. The cleared areas shall be maintained free of vegetable growth during the progress of the work.

6.3 Stripping of Borrow Areas: Borrow area shall be stripped of top soil, sod and any other matter which is unsuitable for the purpose for which the borrow area is to be excavated. Stripping operations shall be limited only to designated borrow areas. Materials from stripping shall be disposed off in exhausted borrow areas or in the approved adjacent areas, as directed.

6.4 Borrow Areas Watering: Borrow area watering will be done by the contractor wherever necessary and in the manner considered necessary by the Executive Engineer.

The initial moisture content of material in the borrow areas shall be estimated with the help of laboratory tests. The optimum moisture content for the material in the particular borrow areas shall be obtained from the field laboratory. From the optimum moisture content and initial moisture content the amount of additional water required shall be decided. The required additional moisture, so decided shall be introduced into the borrow areas by watering well in advance of the excavation to ensure uniformity of moisture content. If in any location of a borrow area before or during excavation, there is excessive moisture, steps shall be taken to reduce the moisture to secure the material with moisture content closest to the optimum by excavating drainage ditches by allowing adequate time for drying or by any other means. To avoid formation of pools in the borrow areas during excavation, operations, drainage ditches from borrow areas to the outlets shall be excavated wherever necessary.

6.5 Payments: No payments will be made for any of the above works as these will be covered in the overall rate of earth work in the dam embankment.

7. Dam Embankment

7.1 General: Certain instruments for measuring the performance of the dam during construction and afterwards are proposed to be installed by the department at locations as specified in the drawing or as decided by the Executive Engineer. The contractor shall extend necessary facilities for the installation and observation of these instruments. The

contractor shall allow time in his placement schedule for installation and observations of instruments and for necessary soil tests near the installed instruments and no compensation for hindrance in placements on this accounts shall be allowed.

The embankment shall be constructed to the lines and grades shown in the drawings. The dam embankment is divided into zones within which fill materials having different characteristics are to be placed. Placement of fill within these zones as shown in the drawings shall be performed in an orderly sequence and in an efficient and workmanlike manner, so as to produce within each zone, fills having such qualities of density, strength and permeability as will ensure the highest practicable degree of stability and performance of the whole dam embankment.

No bushes, roots, sods or other perishable or unsuitable materials shall be placed in the embankment. The suitability of each part of the foundation for placing embankment materials thereon and of all material for use in embankment construction will be determined by the field laboratory.

The difference in elevations between core and shell zones of the dam embankment at any cross section above the embankment foundation shall not exceed 0.6 m (2 ft.) unless specifically authorised by the Executive Engineer. The embankment for each zone shall be maintained in continuous and approximately horizontal layers in these reach programmed for construction in that season. The dam may be constructed in discontinuous portions or reaches,provided that the slopes of the bonding surface parallel to dam axis between the previously completed portions of the dam embankment and the materials to be placed in each zone shall not be steeper than 3 to 1 in the core, and 2-1/2 to 1 in the other zones.

7.2 Preparation of Foundation:

a) Rock foundations;

b) Soil foundations; and

c) River bed sand foundations

Foundation preparation shall be done subsequent to stripping and excavation, if any. No material shall be placed in any section of the earthfill portion of the dam embankment until the foundation for that section has been dewatered, suitably prepared and has been approved by the Executive Engineer. All portions of excavations made for test pits or other sub-surface investigations and all other existing cavities found within the area to be covered by earthfill or of core and shell zones, which extend below the established lines of excavation for embankment foundation, shall be filled with earthfill of the corresponding zone

of the embankment. All test pits within a distance of 10 times the height of dam embankment from the upstream toe shall be filled by impervious material.

Surface of masonry walls against which the fill is to be placed shall be cleaned and moistened prior to placing the earthfill. The foundation immediately adjacent to the masonry structures shall be thoroughly cleared off loose materials and moistened.

a) Rock Foundation: The treatment of the rock surface under the dam shall be so done as to ensure a tight bond between the impervious core and foundation, for which the following procedure shall be followed:

1) Before the grout curtain is installed, the area of the rock surface which is to be in contact with the impervious core of the dam shall be exposed with rough excavation. Hard rock projections and over-hangs shall be removed. If blasting is to be restored to, care shall be taken to avoid objectionable shocks to foundation rock and abutments. As far as possible the whole contact area of foundation rock and abutments after rough excavation shall be exposed at one time to enable examination of rock surface characteristics and planning the method of treatment.

2) Cleaning and Shovelling: After the grouting operations are over, the rock surface shall be thoroughly cleaned. Pockets of sand and gravel and other soils shall be removed by hand shovelling and soft erodable seams and localised decomposition cleared out as deep as possible. Loose rock shall be removed by wedging and hand picking. Layers of grout spilled from grouting operation shall be chipped out and removed. Finally, the hand cleaned surface shall be thoroughly washed with powerful water jets to remove the fines which would have worked into the seams of the rock and obtain a clean surface. Compressed air jets shall be used as a final step in the clean up operation.

3) Sealing Cracks: Deep pot holes or pockets shall be filled with hand compacted soil or concrete. If the rock surface in the bottom and sides of pot holes is cracked, the crack should be sealed with cement grout. If the rock surface contains too many closely spaced pot holes, the entire rock surface shall be covered with concrete. A clay paste may be used in the smaller cracks. All the cracks and joints and shear seams or other incompetent materials that are exposed in the cut off trench shall be scoped out to the greatest depth practicable (not less than twice their width at the surface) with the aid of trowels, bars and cleaned with air water jets and then filled with slush grout. Slush grout shall consist of cement and sand thoroughly mixed in a proportion 1 part of cement to 2 parts of sand by volume with sufficient water to produce a highly plastic and buttery mix.

Foundation rock which is fairly impervious but has a very rugged surface shall be treated by laying core material at a moisture content slightly above the optimum, in thin layers and compacted with mechanical equipment/small tempers to ensure that all irregular depressions in the rock surface have been filled with soil to create an effective/ complete bond.

The moisture content and the layer thickness shall be specified by the field laboratory. Any open crack in the rock surface shall be sealed with cement grout by appropriate means. Fault zones or larger cracks shall be dug out to a depth as determined by the Executive Engineer and backfilled with concrete.

(b) Soil Foundation: Soil foundations shall be scarified and loosened by means of a plough, ripper or other methods to a depth of about 15 cms. to 20 cms. to the satisfaction of the Executive Engineer. Roots or other debris turned up during scarifying shall be removed from the entire foundation area for the fill. It shall then be moistened to slightly above the optimum moisture and compacted by required number of passes of the compaction equipment to the same percentage of compaction as the core. The purpose of higher than optimum moisture is to ensure forcing of the soil into any unseen soft zones just below the surface. The first few lifts of fill for the embankment shall be carefully placed, for the surface will still be rather irregular. If possible heavy rubber tyred rollers should be used for compaction because they will follow the irregular surface and not bridge over small low areas as other types of rolling equipment will do. Layers 10 cms. to 15 cms. thick with moisture content 1 to 2 percent above optimum moisture content must be used to ensure uniform compaction and a satisfactory intimate bond between the foundation soil and the fill materials especially under the central core. The layers shall be composed off the most impervious materials, under the central core zone.

(c) Sand Foundation: The foundation sand shall be tested for its natural relative density. In reaches where the relative density is less than 70% the foundation sand shall be densified by any of the approved methods to obtain a minimum relative density of 70%. Until the foundation has been tested and the relative density found to exceed 70% earth fill shall not be allowed to be placed. This is necessary to minimise the effects of any structural re-adjustments in a loose foundation.

7.3 Earth Fill Materials: The materials for the respective zones of embankment shall be obtained from borrow areas designated by the field laboratory, which also will specify the depth of cut in the borrow areas required for obtaining the desired gradation in the materials. In general, all material from a particular borrow area shall be a mixture of materials obtained for the full depth of cut. Where in a borrow area the sub-stratum occurs in well defined layers differing considerably in

mechanical analysis, so that mixture is not suitable for any particular zone, the materials shall be excavated layer wise by scrapers or other suitable means and the materials placed in the zone for which it satisfied the requirements. Materials shall be placed between the centre and slopes of embankment and the coarsed material shall be placed near the outer slopes of the embankment. The intermediate layer shall be the S.C. layer (less coarser) and is a part of shell material. This shall be laid in the transition between clay core and shell material. (This material is available in borrow areas of shell material).

Chemical and physical tests of soils in embankment shall be carried out to ensure that the soil does not contain (a) soluble lime contents (b) soluble salt contents or cohesionless fines, in quantities harmful to the embankments.

7.4 Placing Earthfill: The distribution and gradation of the materials throughout the earthfill shall be as shown on the drawings or as directed. The fills shall be free from lenses, pockets, streaks or layers of materials differing substantially in texture or gradation from the surrounding materials. The combined excavation and placing operations shall be such that the materials when compacted in the earthfill will be blended sufficiently to produce the best practicable degree of compaction and stability. Successive loads of materials shall be dumped on the earthfill so as to produce the best practicable distribution of the material. The various zones shall be clearly delineated on the embankment and the materials from the borrow areas placed accordingly.

The clay blanket shall be laid in a manner similar to clay core and compacted to same degree of compaction at optimum moisture content.

Particular care shall be taken to ensure that materials are not so placed as will be conducive to the formation of intermittent relatively impervious blankets in the shell zones, which will interfere with the satisfactory drainage.

No stone, cobbles or rock fragments having maximum dimensions of more than 10 cms. (4") shall be placed in the earthfill (casing only). Such stones and cobbles shall be removed either at the borrow pit or after being transported to the embankment but before the materials in the earthfill are rolled and compacted. Such stone and cobbles shall be used in the rip-rap or rock toe of the dam embankment, if suitable or wasted as directed. The materials shall be placed in the earthfill in continuous horizontal layers not more than 15 cms. (6") in thickness after being rolled as herein specified. Higher thickness of layers may also be permitted, if suitable compaction units such as vibratory compactors are used to give required density under optimum moisture content, but

in no case the compacted thickness of the layer shall exceed 25 cms. The extent of thickness of layer shall be determined in the field by laboratory test. During construction, a small transverse slope from centre towards edges should be given to avoid pools of water forming due to rains. If in the opinion of the Executive Engineer the surface of prepared foundation or the rolled surface of any layer of earhtfill is too dry or smooth to bond properly with the layer of materials to be placed thereon, it shall be moistened or worked with 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 earthfill material is placed. If the rolled surface of any earthfill is found to be too wet for proper compaction of the layer of earthfill material to be placed thereon, it shall be raked up and allowed to dry, or be worked with harrow, scarifier or any other suitable equipment to reduce the moisture content to the required amount, and then it shall be compacted before the next succeeding layer of earthfill material is placed. When compacting the soil against steep rock abutment or walls of masonry or concrete structures, the construction surface of embankment shall be sloped away from the rock or masonry or concrete structures, for a distance of 2.5 M to 3.5 M at an inclination of 6:1 or steeper. If the foundation surface is too irregular to allow the use of large roller directly against a structure or rock outcrop, the roller shall be used to compact the soil as close to the structure or the outcrop as possible and the portion of the embankment directly against the rock or the structure shall be compacted with pneumatic hand tempers in thin layers. The moisture content of the earthfill placed against the rock or the structure shall be slightly above the optimum, to allow it to be compacted into all irregularities of the rock and this shall be determined by the field laboratory. In placing the earthfill on rock foundation, the foundation shall first be prepared as detailed earlier. Care shall be taken in placing the first layer of the fill that no damage is caused by the hauling machinery which will get concealed by the spread layer of the fill. Sheep foot rollers shall not be employed for compaction till the thickness of the layers compacted by other means is greater by 30 cms. (12") than the depth of the foot of the roller drum. The soil for the first layer shall be at a moisture content sufficient to enable satisfactory bonding of the fill with the rock surface.

7.5 Weather Conditions: Embankment materials shall be placed only when the weather conditions are satisfactory to permit accurate control of the moisture content in the embankment materials During monsoons before stopping work on embankment, for any continuous spell, the top surface shall be graded and rolled with a smooth wheeled roller to facilitate run off. The contractor shall provide suitable protection works to protect the slopes from erosion from rain waters. No payment whatsoever will be made for providing such protection works. Prior to resuming work, the top surface shall be scarified and moistened or allowed to dry as necessary and approved by the Executive Engineer for resumption.

7.6 Moisture Control: The water content of the earthfill material prior to and during compaction shall be distributed uniformly throughout each layer of materials and it shall be between -2 to +1 of the optimum moisture content for casing material and between 0 to +2 for hearting material. Moisture determination of soils as well as needle moisture determination of soil shall be carried out as per designation E-9 and E-22 of USBR/Earth Manual 1968.

Laboratory investigations may impose some restrictions on the lower limits of the practicable moisture contents on the basis of studies on consolidation/characteristics of soils in embankment. Hereinafter the term range of optimum practicable moisture content shall refer to the value as described above. As far as practicable, the material shall be brought to the proper moisture content in the borrow area before excavation. If additional moisture is required, it shall be added by sprinkling water before rolling of a layer. If the moisture is greater than required, the material shall be spread and allowed to dry before starting rolling. Moisture control shall be strictly adhered to. The moisture content shall be relatively uniform throughout the layer of material. If necessary, ploughing, disking, harrowing or blending with other materials may have to be resorted to, obtain uniform moisture distribution. If the moisture content is more or less than the range of optimum practicable moisture content, or if it is not uniformly distributed throughout the layer, rolling and adding of further layer shall be stopped. Further work shall be started again only when the above conditions are satisfied.

7.7 Compaction and Watering: Contractor shall have to do watering of earth work and its compaction.

Compaction Equipment: While the specification below provide that equipment of a particular type & size is to be furnished and used, it is contended that the contractor shall use the improved compaction equipment as may be most suited to the prevailing site conditions and the programme of construction. The broad details of the equipments are given below:

Tamping Roller: Tamping rollers used for compacting earthfill shall conform to the following requirements:

1. Roller Drums: Double drum sheep foot rollers shall be used for compaction, each drum of a roller shall have an outside diameter not less than 142.25 cms. (56 inches) and shall not be less than 122 cms. (48 inches) in length. The space between two adjacent drums when on level surface shall not be less than 30 cms. (12 inches) and not more than 38 cms (15 inches). Each drum shall be free to pivot about an axis parallel to the direction of travel.

2. Tamping Feet: The total number of feet per drum shall be 88. At least one tamping foot shall be provided for 867 cm^2 (150 Sq. inches) of the drum surface area. The length of each tamping foot from the outside surface of the drum shall be maintained at not less than 18 cms (7 inches). The cross sectional area/bearing surface area of each tamping foot shall not be less than 25.80 Sq.cm. (4 Sq. inches), nor more than 64.5 Sq.cm. (10 Sq. inches) at plain normal to the axis of shank 15 cm. (6") from surface.

3. Roller Weight: The weight of the roller when fully loaded shall not be less than 7091 Kgs. (15,500 lbs) and the ground pressure when fully loaded shall not be less than 40 Kg. required to obtain the desired compaction. Tractor used for pulling rollers shall be 50 H.P. to 65 H.P. Power to pull the rollers satisfactorily at a speed of 4 Kms. per hour when the drums are fully loaded with wet sand ballast. During operation of rolling, the spaces between the tamping foot shall be kept clear of materials sticking to the drum which could impair the effectiveness of the tamping rollers.

7.8 Rolling: When each layer of material has been conditioned so as to have the proper moisture content uniformly distributed throughout the material, it shall be compacted by passing the tamping roller. The exact number of passes shall be designated by the field laboratory after necessary test. The layers shall be compacted in strips overlaping not less than 0.6 M. The rollers or loaded vehicle shall travel in a direction parallel to the axis of the dam. Turns shall be made carefully to ensure uniform compaction. Rollers shall always be pulled. Density tests shall be made after rolling. Dry density attained shall satisfy the compaction standards specified in "Criteria for control of compacted Dam Embankment" of U.S. Bureau of Reclamation). (Table 4, page 275 of Earth manual of bureau of Reclamation).

7.9 Tamping: Rollers will not be permitted to operate within 1.0 meter of concrete and masonry structures. In location where compaction of the earthfill material by means of roller is impracticable or undesirable, the earthfill shall be specially compacted as specified herein at the following locations:

i) Portions of the earthfill in dam embankment adjacent to masonry structures and embankment foundations designated on the drawing as specially compacted earthfill;

ii) Earthfill in dam embankment adjacent to steep abutments & location of instruments; and

iii) Earthfill at locations specially designated.

Earthfill shall be spread in layers of not more than 10 cms. in thickness when loose and shall be moistened to have the required moisture content as specified when each layer of material has been conditioned to have the required moisture content, it shall be compacted to the specified density by special rollers, mechanical tampers or by other approved methods; and all equipment and methods used shall be subject to approval based on evidence of actual performance and field compaction tests. The moisture control and compaction shall be equivalent to that obtained in the earthfill actually placed in the dam embankment in accordance with the specifications.

Watering: Watering of earthwork for consolidation shall be carried out by the contractor. He will use his own storage, pumping equipment and lay suitable pipe lines of adequate capacity on upstream & down stream of the dam. Tee-Connections will be provided at regular intervals in the main pipe line to connect to the off-take lines having valves to control the flow through rubber hoses. The whole system will be such and so laid out that regular flow of water is ensured on the dam at all times. The pipe lines will be required to be raised as and when required with the raising of the earthwork on the dam.

Measurement & Payment: No separate payment for watering of earth and its compaction shall be made to the contractor. The rate of earthwork tendered for filling of cut-off trench with impervious material, clay core, shell material & clay-blanket shall be inclusive of watering and compaction charges.

7.10 Dressing Slopes: The outside slopes of the embankment shall neatly dressed to lines and grades as placement of fill progresses. Compaction shall extend over the full width of the embankment and material in earth slopes shall be compacted as for the rest of structure. To ensure proper compaction on the edge, the cross section of the filling during construction shall be kept suitably wider and the cross section dressed to the designed requirement after compaction, for which no extra payment will be made and the cost of the same shall be included by the contractor in the per cubic meter rate of completed item of earth work as dealt with later under measurements and payments.

All humps and hallows varying more than 15 cm. (6") from the neat lines of the embankment shall be regarded. Material used to fill depression shall be thoroughly compacted and bonded to the original surface. Slopes shall be maintained until final completion and acceptance. Any material that is lost by rains, weathering or other cause shall be replaced by the contractor at his cost.

7.11 Settlement Allowance: In the earthfill embankment settlement allowance 2% shall be provided. The base width of the dam will not be

increased to maintain the design slopes indicated in the drawings for the additional height as settlement allowance, but the following procedure will be adopted:

Settlement allowance will be calculated at various levels where the slope is to be changed and the elevations including settlement allowance will be derived, the embankment widths at the designed levels remaining same. The edges of widths at the designed levels remaining same. The edges of embankment at the increased elevation (including settlement), when joined with the point where the slope has changed earlier below shall given the slope to be adopted for construction.

If the embankment is raised in more than one season provision for settlement shall be made in the last season's construction by slight steepening of slopes near the top.

7.12(a) Measurements & Payments of Earth Work on Dam & Clay Blanket: The work shall be measured on the basis of the cross sections. Initial cross sections for this will be the ones taken after stripping and in accordance with para 7.2. The cross sections will be taken at an interval of 15 M (50 ft.) or at closer distances as found necessary. The gross quantity of hearting, casing, clay blanket etc., as the case may be will be based on these cross sections in which also will be indicated the separate zones of hearting, casing clay blanket, filter material, pitching etc., for facility of arriving at the correct quantity of hearting, casing etc., that went into the embankment. The lines demarcating the zones on the cross sections shall conform to respective typical sections, except where departures from these are specially permitted by the Executive Engineer. Running measurements for any subsequent bill will be the overall sectional measurements minus the sectional running measurements upto the previous running bill & so on.

(b) Running measurements for clay core and shell material will be paid at 90% of the tendered rate upto 50% of the quantities given in the schedule of quantities & bids. The quantities in excess of 50% & upto 75% will be paid at 95% of the tendered rate. Quantities in excess of 75% will be paid at full tendered rates on the total quantities arrived at on the cross sectional areas as per sub paragraph (a) above. For clay blanket running measurements will be paid @ 95% of the tendered rate.

(c) Final measurements will be recorded on cross sectional basis. Foundation plan with relevant cross sections of the dam showing dimensions and levels shall be prepared and got signed by the contractor, in token of the acceptance first before commencement of stripping and again after completion of stripping of dam seat. The final measurements will be based on the accepted foundation plan and relevant cross section and

completed section of the dam at the time of taking final cross section. The quantities arrived at shall be paid at full tendered rate.

(d) The contractor shall be allowed to utilise the suitable material obtained from the items of excavation such as stripping, toe drain, cut off trench, foundations etc., in the dam section free of cost. Overall section of the components of the dam shall be measured and paid at the tendered rates.

(e) Cross sections referred to in above sub-para will be taken after the top most earth layer is duly compacted at optimum moisture content in accordance with paras 7.7 of the specifications. Any over section over and above stipulations in para 7.1 will be ignored and not paid for. Similarly while making running payment suitable deduction will also be made for loose, undressed, uncompacted material on the slope.

(f) In order that proper compaction can be done upto the edges of the designed section duly increased for settlement and shrinkage as stipulated above, section will be further widened by 45 cm (18 inches). Subsequently after compaction it will be dressed by trimming the slopes to proper sections so that the surface on the slopes is also as firm and compact as the top of the embankment. Necessary extra quantities required to be handled for this purpose shall not be paid for extra and is to be included in the rate of earth work for the dam embankment. as already stipulated in para 7.1.

(g) Apart from the items described in the schedule of quantities, rate payable for this item will also cover construction, maintenance and removal of all additional haul roads (other than shown on the map which shall be maintained by the Board) and ramps, lighting of work areas during dumping & compaction and removal of all roots, vegetation and other unsuitable and objectionable materials either at the borrow areas or at the embankment and unless there is anything specified to the contrary. No separate payment for treatment to the foundation as described in para 7.2 if required shall be made to the contractor.

The rate for earth work on dam (hearting & casing) shall include treat of foundation, laying of layers in uniform thickness, removal of roots & vegetation, breaking clods and dressing, watering & compaction with all leads and lifts.

Payment of final bill shall be made at full tendered rate of earth work for clay core and shell material and clay blanket on the quantities worked out as above.

7.13 Toe Drains: Pitched toe drains with filter will be provided throughout the length of dam at the downstream toe of earth dam as

indicated in the drawings and as per the details shown therein. Trench drain with fibretex or its equivalent material shall be provided where the depth of water below FRL exceeds 15 m. The layers of horizontal filter under the casing portion of dam shall be extended in the toe drains to specified thickness. The filter shall be watered & tamped with hand tampers.

The useful excavated material out of the toe drain shall be suitably utilised on the dam as directed by the Executive Engineer.

Measurements & Payments:

Payment will be made on sectional measurements of various item of work involved on the rates tendered by the contractor in the schedule of quantities and bids, which will be inclusive of all leads and lifts of material. Rate for laying of filter shall include watering and compaction charges also. Payment for fibre-tex or its equivalent material shall be made in square meters at his tendered rates with all leads and lifts.

8.0 Filter and Rip-Rap

8.1 Base Filter Blankets: Where indicated in the drawings, filter blankets shall be laid on the base under the downstream portion of the earth embankment. The number of layers in filter blanket and thickness of each layer shall be as specified in the drawing. Filter shall be placed and tamped into place in such a manner that mixing of filter with foundation or backfill materials will not occur.

The filter material shall consist of clean, sound & well graded crusher broken aggregate. The material shall be free from debris, brush wood, vegetable matter, decomposed rock and other deleterious matter. The gradation of each filter layer shall meet the following requirements with respect to the material to be protected and also with respect to the adjacent filter layers.

i) $\frac{\text{D-15 of the filter}}{\text{D-15 of the base material}}$ = 5 to 40

Provided the filter does not contain more than 5 per cent of material finer than 0.074 mm. (No. 200 sieve).

ii) $\frac{\text{D-15 of the filter}}{\text{D-85 of base material}}$ = 5 or less

iii) The grain size curve of the filter shall be roughly parallel to that of the base material. In the above D-15 is the size at which 15 per cent of the total soil particles are smaller, the percentage

being by weight as determined by mechanical analysis. The D-85 size is that at which 85 percent of the total soil particles are smaller.. It shall be laid in single layer or in layers as per the drawing. If more than one filter layer is required, the same criteria shall be followed. The finer filter is considered as the base material for selection of the gradation of the coarser filter.

iv) In order to prevent segregation and bridging of large particles/the maximum/particles size shall not exceed 75 mm.

Normally the percent of filter material retained on the sieves designated below shall be as follows:

Sieve Size	%age Retained
75 mm	Nil
40 mm	10
20 mm	15
10 mm	25
4.75 mm	20
2.36 mm	15
1.18 mm	10
600 micron	5

The above gradation is based to suit the requirement of the base material i.e. S.C. soil predominantly available in the borrow area. However, the final requirement for grading of the filter shall be established by the field laboratory on the basis of mechanical analysis of adjacent materials. Mechanical analysis shall be performed on samples, which have been compacted by the methods equivalent to compaction by rollers so that individual particles of decomposed rock are broken to their final condition in the embankment.

The material brought by the contractor to the site shall be subjected to the aforesaid tests in the laboratories at the project site. The result shall be final and binding and all material not conforming to the requirement so determined shall not be permitted for use on the said works.

8.2 Placing: The foundation shall be cleared, stripped as specified in paras 2.1 and 2.2 and S.C. layers of specified thickness as shown

in the drawing shall be laid wherever there is clay in the dam seat, before laying the base filter.

The filter material (mixed gradation) shall be deposited in horizontal layers of thickness not more than 15 cm. (6") after compaction by approved type of compactors.

The thickness of filter layer shall be increased to 30.48 cm. (12"), if compaction is performed by treads of crawler type tractors, surface vibrators, or similar equipment. Thickness of layers shall however, not be more than the penetrating depths of the vibrator, if compaction is performed by internal vibrator. During or immediately prior to compaction the material in each layer shall be thoroughly wetted. The relative density of the compacted material shall be not less than 70% as determined by the Standard U.S. Bureau of Reclamation relative density tests for cohesionless free drainage soils.

The relative density may also be computed using the max. and min. density as follows:

$$D_d = \frac{Y_d \text{ max.}}{Y_d} \times \frac{(Y_d - Y_d \text{ min.})}{(Y_d \text{ max.} - Y_d \text{ min.})} \times 100$$

Where Y_d max. = Maximum dry density of soil as obtained by the laboratory procedure,

Y_d min. = Minimum dry density of soil as obtained by the laboratory procedure, and

Y_d = the dry density at which the soil is to be placed or the inplace dry density.

Extreme care shall be taken in placing material in the filter zone as to obtain a fill free from lenses, layers and streaks of segregated materials.

After completion of the filter blanket, the earthfill material shall be placed in 10 cms. (4") layers and tamped by hand at optimum moisture or compacted by smooth rollers or power compactors as directed by Executive Engineer. Sheep foot rollers shall not be used till earth work has been laid and compacted to a thickness of 60 cms. (24") over the filter blanket. However, the compaction of earthfill in the initial 60 cms. (24") thickness shall be subject to the same quality control regarding to moisture content and dry density as for the rest of the embankment.

8.3 Chimney Filter

Vertical filter of the dimension specified in drawings shall be constructed on the downstream face of impervious core. The thickness of chiney filter shall be as shown in the drawings. Materials used shall be clean, sound and durable and shall be free from silt, roots, brush and other impurities. Filter materials shall be laid in 30 cm. layers and shall be compacted by pneumatic tyred rollers or other approved equipment. Materials for filter shall be compacted to obtain a minimum relative density of 70%. The filter shall satisfy the filter criteria. The gradation of the filter materials shall be the same as in para 8.1 for base filter blankets.

8.3.1(a) Payments:

Measurements and payments of filter blanket will be based on the cross section measurements at its tendered rates as stipulated in the schedule of quantities and bids. The rate shall include shuttering required for vertical filter, S.C. layer, if provided shall be paid under the item of casing or shell material. The rate shall be inclusive of all leads & lifts of material. Watering and compaction of the filter material shall be done by the contractor and rate tendered for laying of filter shall include charges for watering & compaction.

8.4 Rip-rap on the Upstream Slope of Embankment

Rip-rap shall be hand placed on the upstream slope of the dam embankment. The thickness of rip-rap layer shall be as indicated in the drawings. The thickness shall be measured normal to slope of the embankment. The stones shall be placed in two layers with header stones extending through both the layers and spaced at 1.5 m centre to centre.

The rip-rap material shall consist of the most durable rock fragments of approved quality selected for the purpose. The quality of individual rock fragments shall be dense, sound and resistant to abrasion, and shall be free from cracks, seams, shale partings, conglomerate bands and other defects that would tend to increase unduly their susceptibility to destruction by water and weathering action. The shape of the individual rock fragment shall be angular; fragments having thickness less than 50% of their maximum dimensions shall not be used as rip-rap. The individual stone (for at least 50% of the surface) laid in rip-rap should weight atleast 75 kg. These stones shall be evenly distributed over the paved area. No stone shall have any dimension less than 10 cms. The stones shall be placed on edge with the longer dimension normal to the slope. Rock fragments and spalls shall be tightly driven into the interstics to wedge the rip-rap in place and close direct opening underlying slope. Stones shall be laid in a compact manner beginning at the bottom of the slope.

Rip-rap shall be placed alongwith the fill so that a minimum of breakdown will occur during placing and spreading.

8.4.1 Graded Filter Underneath Rip-rap

Graded filters shall be constructed underneath the rip-rap on the upstream of embankment as indicated in the drawings.

The graded filter shall consist of sand and crushed stone as shown in the drawings. Sand used shall be clean, sound and durable and shall be free from silt, roots, brush wood and other impurities. Sand used in the filter shall be of size passing 5 mm screen. Crushed stone used for filter shall consist of rock fragments reasonably well graded upto 15 cms. in maximum dimension. The filter shall satisfy the filter criteria as given in 8.1.

8.4.2 Placing Filter

Before the first layer of filter material is placed, the embankment shall be trimmed neatly to the slope and grades indicated on the drawings. The filter material shall be placed in layers of uniform thickness and core shall be taken to avoid segregation of coarse and fine material in each layer, formation of pockets and mixing of material from one layer with material of another layer or earthfill.

Filter materials after laying shall compacted to 70% relative density by watering and compacting with hand rammers or other suitable mechanical equipments. Water and compaction of filter layer as specified above shall be done by the contractor.

8.4.2.1 Measurements & Payments

Payment will be made at tendered rate inclusive of all leads and lifts for various items under this para in accordance with above para and with description given in the schedule of quantities and bids. Measurements shall be taken by measuring independently surface area of the slope and multiplying the same by thickness of various layers of pitching and filters as directed by the Executive Engineer. The rate for laying filter shall include charges for watering and compaction of filter layers.

9. Inspection and Tests

The Executive Engineer shall maintain and exercise thorough check on the quality of fill material delivered to the dam and shall arrange to obtain the data and in situ properties of the materials after compaction for comparison with designed assumptions. To achieve these objectives, a programme of fill testing and inspection shall be planned to effect quality control.

9.1 Scope of Testing and Inspection Required

Field control of fill materials will require visual and laboratory checks. The checks on the effectiveness of placement and compaction procedures will require to be made by field density tests at prescribed intervals. The control shall be both the method type and/or on an end result basis.

9.1.1 Before Compaction

Materials delivered to the fill shall be visually examined and their properties estimated by way of inspection. These checks shall include:

a) Borrow Areas

(i) Excavation of borrow areas shall be limited in extent and depth as indicated on plans.

(ii) Estimation of moisture content of materials by visual examination and feel.

(iii) Samples shall be taken for laboratory analysis in case the soil is of different characteristics.

These inspection checks shall be supplemented by sampling the materials at prescribed minimum intervals and by testing the samples in the laboratory for gradation and moisture content.

b) Embankment

(i) Water content tests shall be carried out in the laboratory while placing the fill materials.

(ii) Moisture content shall be controlled by adding water or aerating the soil according to laboratory tests.

(iii) It shall be ensured that the methods of dumping, spreading and moisture conditions are such that which results in reducing segregation and/or variation of moisture content to a minimum.

9.1.2 During Compaction

It is intended that the checks on operations during compaction shall varify:-

(i) That the layer thickness of the material is as specified.

(ii) That the fill is compacted by the specified number of passes of the specified machinery.

(iii) That no excessive rutting, weaving or a scaling of the fill occurs during compaction.

9.1.3 After Compaction

The condition of the fill after compaction shall be observed and recorded particularly with respect of rutting or weaving, However, the properties of materials after compaction shall be determined primarily by fill density tests. Routing tests on samples taken from constructed embankments shall include; besides density tests, grain size distribution atterberg limits, permeability, shear and consolidation characteristics.

9.2 Frequency of Testing

It will be necessary to carry out sampling and testing of materials before and after compaction at sufficient frequencies so that effective checks on the fill operation is maintained. The testing frequencies proposed should correspond to the frequencies shown in Table-I. However, the actual frequencies shall be adjusted to suit the nature and variability of materials placed and the rate of fill placement.

Testing shall be performed at higher rates then these given in Table-I, during initial Stages of placing each zone in order to establish control and testing techniques. Also testing shall be conducted at higher rates in case of special problems of control caused by such factors as material variation, equipment performance and of weather.

In addition, these tests shall be made;

1. In areas where the degree of compaction, if doubtful.

2. In areas where embankment operations are concentrated.

3. For "record" tests at the locations of all embedded instruments.

Locations of insufficient compaction shall cover the following or any other areas so determined by the Executive Engineer.

1. The junction between areas of mechanical tamping and rolled embankment along abutments or cut off walls.

2. Areas where rollers turn during rolling operations.

3. Areas where too thick a layer is being compacted.

4. Areas where improper water content exists in a material.

5. Areas where less than specified number of roller passes were made.

6. Areas where dirt-clogged rollers are being used to compact the materials.

7. Areas where oversized rock which has been over-looked is contained in the fill.

8. Areas where materials have been placed when they contained minor amounts of frost, or at nearly freezing temperatures.

9. Areas that were compacted by rollers that have possibly lost part of their ballast.

10. Areas containing materials differing substantially from the average.

9.3 Record and Reports

Record of borrow area materials and embankment placing operations be maintained in order to have a continuous check on the suitability and availability of fill materials and quality of the fill. Thus, it will be possible to have complete description of materials in any portion of the embankments. The records shall be maintained on the form specified in Annexure.

Annexure indicates, the criteria for control of compaction of dam embankment.

9.3.1 Field Test Data

Records of field test data results should be presented in the form of statistical analysis sheets and summary sheets in order to provide control required for enforcement of statistical requirements of the specifications.

The test data summary sheets and inspection reports be used to form the basis of construction control report, which should be issued from the site at fornightly intervals during construction season. The report would contain narrative accounts of the progress and problems of fill construction, statistical analysis of test data and photographs of the fill operations.

9.4 Embankment Test Section

Placement of compaction methods specified will have to be verified by test embankment section to be built prior to starting of fill operations or at an early stage of dam construction. The initial stage of dam construction itself could be made to serve the purpose of test embankments. The test sections referred herein shall be used to establish:

a) Layer thickness of fill materials.
b) Optimum practicable moisture content.
c) Number of passes of sheep foot roller, or weight of vibratory rollers vis-a-vis number of passes for effective compaction.

When an appreciable change in material occurs, additional test sections shall be made during construction. The procedure for construction of test embankment section is as follows:

(a) Select a location on the embankment where un-interupted placing operations are being performed. This area 15 m. by 30 m.(about 50 ft. x 100 ft.) should be carefully marked and referenced so that its limits will be easily recognised. In order to expedite the determination of moisture content to be used, more than one test section may be established on the embankment at the same time.

(b) During construction of the test section which will most probably continue for several shifts, a complete record of the procedure should be kept. This record should include the number of layers placed, the spread thickness of each layer, the moisture content, at which the materials were rolled, the designation (No.1, No.2 etc.) of the rollers used, the condition of the rollers (clean or dirty), the action of the materials being rolled (such as wavy under the rollers, the amount of penetration of the roller teeth after different number of roller trips etc.) and the borrow pit location from which the materials came.

(c) Check the rollers to make certain that they meet all the requirements of the specifications.

(d) Determine the required spread thickness of layer that will compact to the specified thickness after rolling specified number of times and maintain this thickness as long as number of roller passes is kept the same.

(e) Using the available data from borrow pit investigations of the materials to be used in the test section the optimum moisture content as determined by laboratory tests will be known and 3 percent less than this moisture content should be used in the first 3 or 4 layers rolled.

(f) After 3 or 4 layers have been placed at 3 percent less than the laboratory optimum moisture content, field density test should be made throughout the section. These tests should be made for at least each 93 Sq.metres (1000 Sq.feet) of test section area, and should be so distributed over the area that they will detect the effects of different compaction conditions encountered during construction. For example, if the section is located near an abutment, certain parts of the area will receive more compaction from track travel than others; hence some tests should be made in the portion compacted only by the rollers and so reported.

(g) The next step is to compact another 3 or 4 layers at the moisture content slightly higher (1 percent or 2 percent) than the moisture content previously used, maintaining the same rolled thickness of layer and number of roller passes, as in above. Field density tests are again made over the test section.

(h) If the resulting field dry densities (of material passing the No.4 sieve) from (g) above shown an increase with increase of moisture, again by another 1 percent or 2 percent, repeat the test. If an increase in moisture results in a decrease in field density then place the next layers slightly dry of the original moisture content used and repeat the test. This procedure is nothing more than developing on the embankment a moisture density relation or compaction curve for a certain roller, thickness of layer, and a given number of roller trips. If special studies during investigation have indicated that the material being tested should be placed within certain moisture limits, or if the moisture limits to be used have been specified, the procedure outlined above should include tests at these moisture contents or at moisture contents both greater and smaller than the specified limits.

(i) The roller compaction curve is now compared with the standard laboratory compaction curve. If the field density of materials passing the No.4 sieve (from the roller curve) is greater than the standard compaction density at the specified moisture content, the test section should be continued decreasing the number of roller trips while maintaining the specific desirable moisture content until the most economical compactive effort is determined. When the roller trips are decreased, the required spread thickness of layer that will compact to the specified thickness of compacted material should reckoned.

(j) All works connected with the embankment test section will be done departmentally and the contractor shall allow this to be done without let or hindrance.

10. Protection Works

10.1 The face of the earth dam opposite the river and the side slopes (upstream & downstream) for same length beyond the permanent pitching on the upstream side slope shall have to be protected every year from floods. The contractor shall have to submit his detailed proposal well in advance by 15th of March every year for providing the protection works, which may normally comprise off any established river protection scheme for approval of the Chief Engineer. These protection work will have to be completed at site by 31st of May every year failing which the contractor shall be fully responsible for the damages to the earth

dam. Further, the contractor shall not be relieved of his responsibility regarding adequacy of his proposal by virtue of the fact that the same has been approved by the Chief Engineer and that he shall be fully responsible for the damage that may take place on earth dam consequent to improper functioning of the protection work/failure(partial or full) and that he shall bear full cost of restoration of earth dam.

The protection work shall have to be dismantled every year after the monsoon before resuming fresh work.

10.2 Payment

Intermediate payment of "providing & dismantling of protection work" shall be made as hereinafter provided subject to the condition that protection works are executed during the various years of construction in accordance with the approved proposals as required in the foregoing paras.

Payment for this item shall be made to the contractor as follows:-

After Ist monsoon	- 20% of the tendered amount.
After 2nd monsoon	- 40% of the tendered amount.
After 3rd monsoon	- 20% of the tendered amount.

Balance 20% of the tendered amount will be paid after completion of the total work.

Table-I

TESTING FREQUENCY

Sl.No.	Material	Volume or Time between Tests						Remarks
		Before Compaction			After Compaction			
		Gradation	Moisture Content	Field Density	Permeability	Triaxial shear Tests	Consolidation Tests	
1	2	3	4	5	6	7	8	9
1.	Impervious/ Semipervious.	3000 m^3 or per shift.	3000 m^3 or per shift.	1000 m^3 or per shift.	20,000 m^3 or once in ten days.	20,000 m^3 or once in ten days.	30,000 m^3 or once in fortnight.	
2.	Filters.	5000 m^3	-	10000 m^3	-	-	-	

Annexure-II

Criteria for Control of Compacted Dam Embankment

Type of Material	Percentage of No.4 fraction by dry weight of total material.	Percentages based on minus No.4 fraction					
		50 feet or less in height			Greater than 50 feet high		
		Minimum acceptable density	Desirable average density	Moisture limits Wo-Wf	Minimum acceptable density	Desirable average density	Moisture limits Wo-Wf
1	2	3	4	5	6	7	8
Cohesive Soils Controlled by the proctor test	0-25	D = 95	D = 98	-2 to + 2	D = 98	D = 100	2 to 0
	26-50	D = 92.5	D = 95		D = 95	D = 98	(Note 2)
	More than 50(Note I)	D = 90	D = 93		D = 93	D = 95	
Cohesion less soils controlled by the relative density test	Fine sands with 0-25	Dd= 75	Dd= 90	Soils should be very wet.	Dd= 75	D = 90	Soils should be very wet.
	Medium sands with 0-25 coarse sands and gravels with 0-100	Dd= 70	Dd= 85		Dd= 70	D = 85	
		Dd= 65	Dd= 80		Dd= 65	D = 80	

Wo-Wf Is the difference between optimum water content and fill water content in per cent of dry weight of

D Is fill dry density divided by Proctor maximum dry density in per cent.

Dd Is relative density as defined in section 14, Chapter 1.

1 Cohesive soils containing more than 50 per cent gravel sizes should be tested for permeability of the total material if used as a water barrier.

2 For high earth dams special instruction on placement moisture limits will ordinarily be prepared.

PRESSURE GROUTING RECORD

Hole No.
Co-ordinates:
Diameter :
Elevations :
Natural Ground:
Top of Hole :

Grout Cap
Width :
Depth :
Casing Pipe :
Depth :
Diameter :

Uplift Gauges
Bottom Elevation:
Top Elevation :
(Space for sketch)

Hole Log		Type of Grouting.	Stages of Grouting.	Date	Time	Water Pressure test			Pressure grouting			Uplift		Extent of leakage from surface joints & fissures.	Leakage from nearby holes Hole No.
Particulars.	Log					Pressure	Intake Litres/ minutes.	Grout mix by volume.	Pressure	Intake litres/ minutes.	Cement consumed.	Obs. point No.1	Obs. point No.2		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Notes:
1. Sketch on the top right hand corner shall show the location of the hole being grout together with location and condition of nearby holes. Holes that have been drilled will be indicated by 'D' suffixed with the number showing the depth of the hole, such as 'D-25'. The hole has been grouted will be indicated by the letter 'G' in similar manner. Position of upheavel indicators shall also be shown.
2. Columns 1 and 2 will also show the ground water table level.
3. Columns 5 and 6 will record the date & time of any significant event in the operation. The change in pressures and intake in the water pressure test, and each change in grout mix., pressure or intake in the grouting operation will be recorded.
4. The rate of intake in column 11 shall be recorded at every 15 minutes interval.
5. Cement consumption in column 12 shall be recorded for each pressure of grout mix. change.
6. Column 13 & 14 will show readings of uplift observation points at the beginning of the operations and at every noticeable change.
7. Under "Remarks" in column 18 shall be recorded any change or incident affecting the grouting operation, such as "Tight Hole" Leaks caulbed" , "Hole No.....capped" "grout pump down", grouting suspended due to _____, hole completed and so forth.

TECHNICAL SPECIFICATION OF FIBRETEX S-300

Material.	98% Polyproplene 2 % Polyester.
Weight.	Approx. 300 g./Cm^2
	0.9
Colours.	Usually grey.
Tensile strength. KN/M ASTMD-1682(grab test)	Min 29.0 Lengthwise Min 42.5 cross wise.
Elongation at burst.	40-70%
Pore size of material.	20/60 Microns.
Permeability of water.	Approx. 19 Lits. per second/ Cm^2. measured at 10 Cm. water column.
Effect of acids alkalies etc.	Excellent resistance to most acids and alkalis.Not attacked by mildew.

Errata to Tender Document
Lot No.III

Page / Clause No.	
	Earnest money deposit of Rs. five lacs be replaced by Rs.3.5 lacs (Rupees Three Lacs & Fifty thousands).
7 / 9(c)	Replace "all" by "any of the"
8 / 11	Pre tender conference will be at 3 PM
11 / 8	Delete para 3 from top which reads as under: "If the tender is made by a firm in a partnership, it shall be signed by the proprietor above his full name and the full name of his firm with his current business address."
12/9	Replace 5 lacs by 3.5 lacs in Earnest Money deposit.
12 / 9	Delete "Promisory note"- and stock certificates of Central Govt. or State Govt." If it appears on this page.
12 / 9	Replace "all"by" any of the " in deposits receipts of all scheduled banks.
13 / 12	Add "ninety" before days "in second line.
14 / 1(i)	Second line read Division No.III in place of Division No.V.
15 / (K)	Replace "proceeding" by "preceding".
18 / 9	Ist. line - Replace " advances " by " advanced ".
31 / 37	Last line - Replace " decrease " by decrees".
37 / 51	8th line - Replace - "on" by "an" before appropriate extension.
39 / Para 2	Ist. line - Replace "arbitrator" by "arbitration".
47 / Para 1	3rd line "Contractors" be replaced by "Contractor". The word "Confrance" where ever used should be read as "Conference"

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