

**GOVERNMENT OF INDIA
MINISTRY OF IRRIGATION**

**REPORT
OF
COMMITTEE ON COST CONTROL
OF
RIVER VALLEY PROJECTS**

VOLUME-IV

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REPORT OF
THE COMMITTEE ON COST CONTROL
OF
RIVER VALLEY PROJECTS

VOLUME IV

SPECIFICATIONS
EARTH DAM AND MASONRY DAM
MADHYA PRADESH

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 inherent 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.

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SPECIFICATIONS
EARTH DAM
(MADHYA PRADESH)

1.1 SETTING OUT WORKS

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 inch) embedded under ground and 20 cm (9") above ground. The words "B.M." with R.L. shall be conspicuously carved and painted on the bench mark. The reference line shall comprise of the base line properly dogbelled on the ground with the 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 elevations, do the profile or profiles indicated in the approved drawings. All measurements shall be with reference to the reference line or the masonry pillars along with reference line.

The Sub-Divisional Officer on behalf of the Executive Engineer shall himself lay out all important levels and all control points with respect to bench mark and reference line and correlate all levels and locations with bench mark and the reference line. Important levels shall be checked by the Executive Engineer. All assistance shall be given for the same by the contractor.

In the case of spread out works, several bench marks, reference lines and reference pillars may be necessary and shall be constructed before the work is taken up as directed by the Engineer-in-Charge.

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

1.1.2 Basis of Measurement and Payment

No separate payment shall be made to the contractor for the above work. The rate for individual items of work under contract shall include the cost of setting out works as indicated above.

1.2 PREPARATION OF WORK AND BORROW AREAS

1.2.1 Clearing and 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 line 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 of as approved. All the materials 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 the least fire risk. All the burning shall be so through that the materials are reduced to ashes. Special precautions shall be taken to prevent fire from spreading to the areas beyond limits of the cleared areas and suitable equipment

and supplies shall be available at all times for use for preventing and suppressing fires. The cleared areas shall be maintained free of vegetable growth during the progress of the Works.

1.2.2 Basis of Measurement and Payment

No separate payment shall be made to the contractor for this item. The rate for items under the contract shall include the cost of clearing grubbing and preparation of work and borrow areas.

1.3 STRIPPING AND BENCHING

1.3.1 Stripping shall have to be done at two places. (i) under dam seat (ii) under clay blanket on upstream of dam.

All dam and embankment areas including a 300 M (10 ft.) wide strip beyond and contiguous to the areas of dam and embankment proper as shown on the drawings shall be stripped or benched. Stripping shall to a sufficient depth to remove all materials not suitable as foundation for the embankment. The unsuitable material to be removed shall include loose rock, vegetable matter including roots, top soil, sod, organic silt, swamp material and other perishable or other objectionable material 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 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 gets mixed up with approved embankment material. At locations where a river or stream crosses the dam or embankment site, loose sand and gravel and loose boulders shall also be removed as directed. Stripped materials shall be disposed of in a manner as may be directed by the Engineer-in-Charge and 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.

1.3.2 Measurements and Payment

(a) Immediately prior to the beginning of the work, after the jungle and silt clearance has been done, accurate cross sections of the existing ground level at every 15 M (50 ft) interval or closer where necessary and normal to the axis of the dam shall be taken over the area to be excavated and sufficient distance outside the limits of excavation, levels on these cross sections shall be taken at 3 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 the measurement for the actual work recorded in cubic metre units. It shall include all items like excavation, dressing of benches and foundations, rehandling and removal of materials from site.

1.4 RECORDING OF CROSS SECTIONS

1.4.1 After clearing etc., and stripping where necessary and prior to the beginning of the work, starting cross sections of existing ground at every 15 metres intervals or closer, depending on the nature of ground, normal to axis of dam shall be taken up to sufficient distance outside the limits of work. The levels on these cross sections shall be taken at 3 metres intervals and entered in ink in the measurement book by the department 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 Engineer-in-Charge. These cross sections shall form the basis of all future measurements and payments. The starting cross sections shall also be plotted on tracing cloth signed by the contractor and the Engineer-in-Charge and sent in original to the Executive Engineer's office for record after keeping blue print copies for the work at site.

1.4.2 Basis for Measurement and Payment

No separate payment shall be made to the contractor for this item. The rate for items under contract shall include the cost of labour and other materials required for taking cross section.

1.5 EXCAVATION OF CUT OFF TRENCH UNDER DAM EMBANKMENT

1.5.1 A cut off trench as shown in the drawings shall be excavated in the foundation of the dam at the location indicated. This trench shall be excavated to a depth of 60 cm. (2 ft.) to 120 cm. (4 ft.) into the rock (depending upon the permeability of the rock) or into other impervious stratum as may be approved by the Engineer-in-Charge. Accurate trimming of the slopes of the excavation will not be required, but the cutting will in general follow lines as specified in drawings. The area to be excavated shall be dewatered. The water level shall be maintained below the level of excavation in the area and none of the excavation shall be performed in standing water. The dewatering shall be accomplished in a manner that will prevent loss of fines from the foundation, will maintain stability of the excavated slopes and bottom of cut off trench and will result in all constructions operation being performed in dry condition.

1.5.2 No trench excavation shall be started until the whole base of the dam or atleast the substantial part of it is cleared, grubbed, benched or stripped as required by specifications so that suitable material out of trench excavation can be directly utilised for forming the bank.

1.5.3 No blasting of rock would be permitted for the excavation in hard rock when the excavation in hard rock reaches within about 90 cm. (3') of final levels, if in the opinion of the Engineer-in-Charge such blasting will shatter and disturb the rock below foundation. He may also put similar restrictions in cases where damage is apprehended to works in the neighbouring areas existing or under construction in such cases rock excavation should be completed by chiselling and wedging etc.

1.5.4 The materials excavated from the trench shall if suitable, be used in the embankment or upstream blanket either immediately or after stock piling as convenient. The suitability or otherwise of the material and the zone of the embankment in which it is to be placed will be determined by the filed laboratory and prescribed by the Engineer-in-Charge. Materials excavated from the cut off trench shall not be placed in the embankment till foundation for the embankment has been cleared, stripped and prepared as specified and adequate arrangements made for watering and rolling the layers of the earth fill in the embankment. This material shall be subject to the same degree of embankment control as materials obtained from borrow pits. The materials excavated from the cut off trench which are not suitable for use or are in excess of dam embankment requirements or other earth work requirement shall be disposed of in a manner as may be directed by the Engineer-in-Charge and in such a way as not to detract from the finished appearance of the project.

1.5.5 Back Filling of Cut Off Trench

Cut off trench shall be back filled with impervious materials 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 impervious earth placed in the continuous approximately horizontal layers not more than 15 c.m. (6 $\frac{1}{4}$ ") 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 layer shall be determined in the field by laboratory test. Watering of earth work and its compaction shall have to be arranged by the contractor.

During placing and compaction of impervious materials in the cut off trench, the water level at every point in the cut off trench shall be maintained below bottom of the earth fill untill 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 at least 1.5 M (5') below the top of compacted fill.

1.5.6 Measurements & Payments

For this purpose grid levels at the ground at 300 cm. (10') or closure intervals will be taken after stripping and before the 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 the finally approved and excavated sections. The classification of various geological strata and classification of soil shall be recorded as the excavation progress and payment made at the rates of each classification in accordance with the description given in the schedule of quantities. Payments for the back filling of the cut off trench shall be made in the same way as for the impervious hearting zone 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 transportation, breaking clods, picking of roots, levelling and laying, watering and compaction. It shall include also all leads and lifts of disposal and shoring wherever necessary. For wet excavation and dewatering no

separate payment shall be made and same will be included in the respective items in schedule of quantities and bids. For running and completed works payments will be made as explained in the foregoing paras.

1.6 FOUNDATION GROUTING

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

1.6.2 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.

1.6.3 Grouting Material: Grout for injection under pressure into rock shall consist of cement, bentonite, water and 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 clay 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.

1.6.4 Casing pipe: Grouting may be started before excavating the trench to the final finished surface by providing a casing pipe of length equal to the depth of zone to be removed. The casing pipe shall be driven tightly against the rock such that there is no leakage of grout along the pipe. No separate payment shall be made for the use of casing. It shall be included in the rate of grouting.

1.6.5 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 verticals 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.

As soon as drilling of holes is completed & holes blown clear of muck, standard 65 mm (2½") black steel pipe, 45 cm (18") long shall be solidly anchored in the drill hole with grout, mortar or lead wool or other suitable material for making connections for grouting. The upper ends of the pipes shall be threaded and a coupling installed for convenience in making grout connections and each coupling shall be fitted with a cast iron plug which will be screwed in loose to prevent the entrance of debris. After grouting operations are finally completed, the contractor will be allowed to take back the steel pipe with fittings. Drilled holes or portion of holes shall not be left ungrouted for long.

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

1.6.6 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 specific pressure, setting the packer and 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 re-drilling. 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 6m, 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 upheaval of the bed rock. Sensitive upheaval indicators shall be installed at suitable locations, and shall be carefully

watched for any indication of uplift during water pressure testing and grouting operations. Higher grout pressure may be used in final sealing.

Bottom of these upheaval 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.

Grouting mixes usually shall range between 10:1 and 0.5:1 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 by 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. Flushing shall be done with the grout intake valve closed, the water supply valve open, and the pump running at full speed.

1.6.7 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.

1.6.8 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.

1.6.9 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 per-forma given in Appendix-I.

1.6.10 Measurements & Payments

(a) Items of Works to be executed in accordance with specifications given in para 1.6.0 to 1.6.9 and to be paid to the contractor are divided suitably as noted in the schedule of quantities and 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 Department unless specified to the contrary.
- (ii) Cement: Cement required for the above item shall be supplied by the Department from stores at _____. 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 documents and signed by both parties at the time of signing of the agreement. The work shall be carried out in a 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 re-drilling shall be paid to the "Re-drilling" rate quoted by the contractor

Drilling shall be measured in metres from the ground collar 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.

1.7 BORROW AREAS

1.7.1 General

All materials required for the construction of impervious, semi-pervious 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 the designated borrow areas as shown in drawing or as designated by the field laboratory. The depths of cut in all borrow areas will be designated by the Engineer-in-Charge and the cuts shall be made to such designated depths only. Shallow cuts will be permitted in the borrow area if unstratified materials with uniform moisture contents are encountered. Each designated borrow area shall be fully exploited before switching over to the next designated borrow area. Haphazard exploitation 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 in the reservoir area shall not be opened within ten times the height of the embankment from the upstream or the down stream toes. Borrow pits shall be operated so as not to impair the usefulness of spoil, the appearance of any part of the work or any other property. The surfaces of wasted materials shall be left in a reasonably level and even condition.

1.7.2 Stripping of Borrow Areas

Borrow areas 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 of in exhausted borrow areas or in the approved adjacent areas.

1.7.3 Borrow Areas Watering

Borrow area watering will be done by the contractor wherever necessary and in the manner considered necessary by the Engineer-in-Charge.

The initial moisture content of the 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. The additional moisture requirements as determined by the laboratory test shall be introduced into the borrow areas by watering well in advance of the excavation to ensure uniformity of moisture content. All care

shall have to be taken to reduce excessive moisture in any of the locations of a borrow area before or during excavation to secure the materials with moisture content close to the optimum. To avoid formation of pools in the borrow areas during excavation, operation, drainage ditches from borrow areas to the suitable out lets shall be excavated wherever necessary.

1.7.4 Payments

No payments will be made for any of the above works as these will be covered in the over-all rate of the earthwork in the dam embankment.

1.8 DAM EMBANKMENT - GENERAL

The embankment shall be constructed to the lines and grades shown on the drawings. Placement of fill within the zones as shown in the drawings, within which fill materials having different characteristics are to be placed, shall be performed in an orderly sequence and in an efficient and workman-like manner, so as to produce with in 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 parts of the foundation for placing embankment materials thereon and of all materials for use in embankment construction will be determined by the field laboratory. Above the dam embankment foundation at any cross section the difference in elevations of the dam embankment shall not exceed 0.6 M unless specifically authorised by the Engineer-in-Charge of the work. The placing of the layers for the embankment portion programmed for construction in the season shall be continuous and approximately horizontal. The dam may be constructed in discontinuous portions for reaches, provided that the slopes of the bonding surface parallel to the dam axis between the previously completed portions of the dam embankment and materials to be placed in each zone shall not be steeper than 4 to 1.

1.9 PREPARATION OF FOUNDATIONS

- (a) Rocky foundation;
- (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 earth fill 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 tests pits or other subsurface investigations and all other existing cavities found within the area which extended 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 earth fill. The foundation immediately adjacent to the masonry structure shall be thoroughly cleaned of loose materials and moistened.

Pools of water shall not be permitted in the foundation for embankment and shall be drained and cleared prior to placing the first layer of embankment materials.

(a) Rocky Foundation:

The treatment of the Work surface under the dam shall be so done as to ensure a tight bond between embankment and the foundation. This shall be obtained by the following procedure.

Before the grout curtain is installed, the area of the rock surface which is to be in contact with the embankment shall be fully exposed by removing all the loose and disintegrated rock leaving the rugged surface of rock rough. Hard rock projections and overhangs shall be removed. If blasting is to be resorted to, care shall be taken to avoid objectionable shocks to foundation rock and abutments. As far as possible the whole contact area shall be exposed at one time to enable examination of rock surface characteristics and planning the method of treatment.

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 decompositions cleaned 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 jet shall be used as a final step in the clean up operation.

Foundation rock which is fairly impervious but has a very rugged surface shall be treated by laying embankment material at a moisture content slightly above the optimum, in thin layers and compacted with mechanical equipment/small tampers to ensure that all irregular depression in the rock surfaces have been filled with soil to create an affective/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 large cracks shall be dug out to a depth as determined by the Executive Engineer and backfilled with concrete.

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 scooped out to the greatest depth practicable (not less than twice their width at the surface) with the aid of crowels, bars and cleaned with air water jets and then filled with slush grout. Slush grout shall consist of cement and sand thoroughly mixed in proportion 1 part of cement to 2 parts of sand by volume with sufficient water to produce a highly plastic and buttery mix.

(b) Soil Foundations:

Soils foundation 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 Engineer-in-Charge. 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 embankment. The purpose of using higher moisture than optimum is to ensure forcing of the soil into any unseen soft zones just below the surfaces. The first few layers of fill for the embankment shall be of depth 10 to 15 cm and shall be carefully placed, ensure uniform compaction and a satisfactory intimate bond between the foundation soil and the fill materials especially under the Central Core. These layers should be composed of the most impervious materials in the central portion. 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 type of rolling equipment will do.

(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%. To minimise the effects of any structural re-adjustment in a loose foundation, earth-fill shall not be allowed to be placed until the foundation has been tested and relative density found to exceed 70%.

1.10 EARTH FILL MATERIALS

The material 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-strata 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 requirement.

Chemical and physical tests of soil in the 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.

1.11 PLACING EARTH FILL

The distribution and gradation of the materials throughout the earthfill shall be as shown on the drawing or as directed. The fill 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 earth fill 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 borrow areas placed accordingly.

The clay blanket shall be laid in a manner similar to clay core and compacted to same degree of compaction of 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 their satisfactory drainage.

No stones, cobbles or rock fragments, having maximum dimensions of more than 10 cms (4") shall be placed in the earth fill. Such stones and cobbles shall be removed either at the borrow pit or after being transported to the earthfill but before the materials in the earthfill are rolled and compacted. The materials shall be placed in the earth fill in continuous horizontal layers, not more than 15 cms. (6") in thickness after being rolled as hereinspecified. Higher thickness of layers may 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 shall be provided to prevent formation of water pools due to rains. If in the opinion of the Engineer-in-Charge, the surface of prepared foundation or the rolled surface of any layers of earthfill 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 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 abutments or walls of masonry or concrete structure, 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 out crop, 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 rock or the structure should be compacted with pneumatic hand tampers in thin layers. The moisture contents 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 so that no damage is caused the hauling machinery by rock out crop 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.

1.12 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 runoff. Prior to resuming work, the top surface shall be scarified and moistened or allowed to dry as necessary.

The contractor shall provide suitable protection works to protect the slope from erosion from rain waters. No payment whatsoever will be made for providing such protection works.

1.13 MOISTURE CONTROL (WATERING)

The water content of the earthfill material prior to and during compaction shall be distributed uniformly throughout each layer of material 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 soils shall be carried out as per designation E-9 and E-22 of U.S.B.R. Earth manual. (1968). Laboratory investigation 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. Here-in-after, the term range of optimum practicable moisture content shall refer to the value as described above.

If additional moisture is required, it shall be added by sprinkling water before rolling of layer. If moisture is greater than required, the material shall be spread and allowed to dry before starting rolling. Moisture control shall be strictly adhered to. As far as practicable, the material shall

be brought to the proper moisture content in the borrow area before excavation. 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.

1.14 COMPACTION OF EACH WORK

1.14.1 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 rollers. The exact number of passes shall be designated by the field laboratory after necessary tests. The layers shall be compacted in strips overlapping not less than 0.6 M. The rollers or loaded vehicles 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" (Table 4 page 275 of Earth Manual of U.S. Bureau of Reclamation) reproduced and attached as Annexure-1.

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

- (i) Portions of the earthfill in dam embankment adjacent to masonry structures and embankment foundation designated on the drawings as specially compacted earth fill,
- (ii) Earth fill in the dam embankment adjacent to steep abutment & locations of instruments and
- (iii) Earthfill at locations specifically designated.

Earthfill shall be spread in layers not greater than 10 cms. in thickness when loose, and shall be moistened to have the required moisture content in accordance with paragraph 1.11. When each layer of material has been conditioned to have the required moisture content, it shall be compacted to specified density by special rollers, pneumatic 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 para 1.11.

1.14.2 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 and downstream of the dam. Tee connections will be provided at regular intervals in the main pipe line to connect the off-take lines having valves to control the flow. The whole system will be such and so laid 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 earth work 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, shall material and clay blanket shall be inclusive of watering and compaction charges.

1.15 EMBANKMENT TEST SECTION

Placement and 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 here in shall be used to establish:

- a) Layer thickness of fill material.
- b) Optimum practicable moisture content.
- c) Number of passes of sheepfoot roller or weight of vibratory roller, vis-a-vis number of passes for effective compaction.

When an appreciable change in material occurs, as may be indicated by an increase in the density, additional test sections should be made during construction.

The procedure for construction of an embankment test section is as follows:

- (a) Select a location 15 M by 30 M (about 50 ft x 100 ft) on the embankment where uninterrupted placing operations are being performed, and 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 the 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 the 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.

(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. meter (1000 sq.ft.) 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 a moisture content slightly higher (1 percent or 2 percent) than the moisture content previously used, maintaining the same roller 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 para (g) above show an increase with increase of moisture, then increase the moisture again by another 1 percent or 2 percent and 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 above (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 contents 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 be reckoned.

(j) All works connected with the embankment test section will be done departmentally and the contractor will allow this to be done without let or hindrance..

1.16 DRESSING SLOPES

The outside slopes of the embankment shall be neatly dressed to lines and grades as the placing of fill progress. To ensure compaction on the edge, the cross section of the fill during construction shall be kept suitably wider as directed by the Engineer-in-Charge and cross section shall be 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 metre rate of completed item of earthwork as dealt with later under measurements and payments.

Compaction shall extend over the full width of the embankment and material in earth slopes shall be compacted as for the rest of the structure. All humps and hollows varying more than 15 Cm. (6") from the neat lines of the embankment shall be regraded. 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.

1.17 SETTLEMENT ALLOWANCE

In the earthfill embankment, settlement allowance of 2% will 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 level remaining same. The edge of embankment at the increased elevations (including settlement) when joined with the point where the slope has changed earlier below shall give 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.

1.18 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.

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.

1.18.1 Before Compaction

Materials delivered to the fill shall be visually examined and their properties estimated by way of inspection.

(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.

1.18.2 During Compaction

It is intended that the checks on operations during compaction shall verify:

- (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.

1.18.3 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. Routine tests on samples taken from constructed embankments shall include; besides density tests, grain size distribution atterberg limits, permeability, shear and consolidation characteristics.

1.18.4 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 than those 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.

1.18.5 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.

1.18.6 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 fortnightly 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.

1.19 MEASUREMENTS AND PAYMENTS OF EARTH-WORK ON DAM & CLAY BLANKETS

(a) The work shall be measured on the basis of cross sections. Initial cross section for this will be the one taken after stripping and in accordance with para 1.7.2.

The cross sections for this will be taken at 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 specifically permitted by the Engineer-in-Charge.

Running measurements for any subsequent bill will be the overall sectional measurements minus the sectional running measurements upto the previous bill and so on.

(b) Running measurements for clay core and shall material will be paid at 90% of the tendered rate upto 50% of the quantity given in the schedule of

quantities and bids. The quantities in excess of 50% and upto 75% will be paid at 95% of the tendered rate. The quantities in excess of 75% will be paid at the 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 at 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 drains, cut off trench, foundation 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 1.13 of the specifications.

Any over section over and above stipulations in para 1 - 5 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 edge 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 the 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 the 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 1.16.

(g) Apart from the items described in the schedule of quantities, rate payable for the item will also cover construction, maintenance and removal of additional haul roads (other than those shown on the map which shall be maintained by the Department) and ramps, lighting of work areas during dumping and compaction and removal of all roots, vegetations 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 the treatment to the foundation as described in para 1.6 if required shall be made to the contractor. The rate of earthwork on dam (hearting & casing) shall include treatment of foundation, laying of layers in uniform thickness, removal

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of roots and vegetations, breaking clods and dressing watering and compaction with all leads and lifts.

Payment of final bill shall be made at the full tendered rate of earth-work for clay core and shell material and clay blanket on the quantities worked out as above.

1.20 ROCK TOE

1.20.1 The material for rock toe shall consist of the most durable rock fragments of approved quality selected for this 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 banks 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 size less than 0.019 cum shall not be used.

The rock fill shall be placed in horizontal layers and properly hand packed. The voids between the bigger stones after hand packing should be filled with rock fragments of smaller size only in quantities enough to fill up the voids. The complete rock and fill shall be stable.

1.20.2 More of Measurement

The payment for rock will be on the basis of sectional measurements of the work done and on the rate quoted per cum of the same in the schedule. The rates shall be inclusive of all leads and lifts of all materials and of all operations including laying hand packing wedging and finishing etc.

1.21 FILTERS

1.21.1 General

Where indicated in the drawings, filter blankets shall be laid on the base under the down stream portion of the earth embankment. The number of layers in the filter blankets 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 the filter with foundation of backfill materials will not occur.

1.21.2 Filter Material

The filter material shall consist of clean, sound and well graded sand and gravel or 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) D-15 of the Filter - 5 to 40

D-15 of the base material
provided the filter does

not contain, more than
5 percent of material
finer than 0.074 mm
(No. 200 sieve).

- (ii) D-15 of the filter - 5 or less
D-85 of base material

(iii) The grain size curve of the filter should be roughly parallel to that of the base material. In the above D-15 is the size at which 15 percent 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/sizes shall not exceed 75 mm.

The 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 down to their real condition in the embankment.

Following tentative gradation is indicated for the graded gravel/aggregate. It shall, however, have to be precisely determined by laboratory tests so as to satisfy the filter criteria.

<u>Sieve Size</u>	<u>Percentage passing</u>
80 mm	100
40 mm	97-56
25 mm	84-24
10 mm	64-8
4.75 mm	25-1

The materials 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.

1.21.3 Placing of Filter

The foundation shall be cleared stripped as specified in para 1:2 and 1:7 and S.C. largers 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 compactor.

The thickness of filter layer could be increased to 30.48 cm. (12") if compaction is performed by treads of crawler type tractors, surface vibrators, of 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 Bureau of Reclamation relative density tests for cohesionless free draining soils.

The relative density may also be computed using the max. and min. density as follows:

$$D_d = \frac{Y_{d \text{ max}} (Y_d - Y_{d \text{ Min.}})}{Y_d (Y_{d \text{ max}} - Y_{d \text{ Min.}})} \times 100$$

Where $Y_{d \text{ max.}}$ - Greatest dry density of soil as obtained by the laboratory procedure described.

$Y_{d \text{ Min.}}$ - Least dry density of soil as obtained by laboratory procedure and

Y_d - the dry density at which the soil is to be placed, or the in place dry density.

The variation in thickness of each layer shall not exceed 50 mm (2 inches) above or below the thickness specified in the drawings. The other layers shall then be placed on top of first layer subject to the above provisions. Care shall be taken to ensure that materials of different layers do not get mixed at the time of placing or during compaction.

Extreme care shall be taken in placing materials in the filter zone as to obtain a fill free from lenses, layers and streaks of aggregated materials. After completion of the filter blanket, the earth fill 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 Engineer-in-Charge. 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 the earth fill in the initial 60 cms (24") thickness shall be subject to the same quality control regarding to moisture content and dry density as per the rest of the embankment.

1.21.4 Measurement and Payment

Measurement and payment 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 layer. The rate shall be inclusive of all leads and lifts of materials. 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.

1.22 PROTECTION OF UPSTREAM SLOPE

1.22.1 Upstream Slope Cutting

The compacted embankment, the slope of which has been protected with stone pitching shall be trimmed to the lines and slopes as prescribed in the drawings or as directed by the Engineer-in-Charge from time to time. The earth obtained from this trimming shall be laid on top of the embankment as directed by the Engineer-in-Charge.

1.22.2 Thickness of Pitching

Pitching shall be hand placed on up stream slope of the dam embankment. The thickness of pitching shall be as indicated in the drawings. The thickness shall be measured normal to the slope of the embankment.

1.22.3 Material for Pitching

The pitching 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. Stones having thickness less than 50% of their max. dimensions shall not be used as pitching.

1.22.4 Size of Stone

No stone shall be less than 0.021 cum (3/4 cu.ft.) in size. All stones shall have depth equal to the thickness of pitching i.e. 45 cms. No stone shall have any dimensions less than 20 cms.

1.22.5 Placing of Stones Pitching and Finishing

Pitching shall be placed alongwith the fill so that a minimum of break down will occur during placing and spreading. As far as possible, level of pitching shall at no time be lower than 3 M. below the top of earth work. Efforts shall be made to break the joints as much as possible and fill the voids with small stones. The stones shall be placed on edge with the broadest base below and the larger dimension normal to the slope. Projecting corners shall be knocked off with hammer so as to make a rough joint at the base. The stones shall be carefully bounded in all directions and firmly set on the filter bedding. The stones shall be packed with hammer or mallet, closed against each other. After the stones have been placed in position in this manner, the

interstices shall be filled with well fitting stone chips/tightly driven home. The general face slope of the pitching when complete, shall be as shown in the drawings subject to the shrinkages allowed. No more than 10% of large stones shall extend beyond the designed face slope. The maximum projection allowed for such stones shall be 15 cms. A tolerance of 5 cms., below the designed face slope shall be allowed only in case of small isolated patches.

1.22.6 Mode of Measurement Stone Pitching

The measurements for stone pitching on upstream slope will be on the basis of the area of the finished surface of pitching and multiplying the same by thickness of various layers of pitching. The rate shall provide for the cost of quarrying and collection and laying of stones from the approved stones quarries and shall include all leads and lifts. No payment will be made to the contractor for compaction.

1.23 PROTECTION WORKS

1.23.1 The face of the earth dam opposite the river and the side slopes (upstream & downstream) for some length beyond and 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 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 works will have to be completed at site by 31st May every year failing which 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 works/failure (partial or full) and that he shall bear full cost of restoration of earth dam.

The protection works shall have to be dismantled every year after monsoon before resuming the work.

1.23.2 Payments

Intermediate payments of "Providing & dismantling of protection works" shall be made as hereinafter provided subject to the condition that protection work are executed during the various years of construction in accordance with the approved proposal as required in the foregoing paras.

Payment for this item shall be made to the contractor as follows:

After 1st 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 works.

2.1 EXCAVATION AND PREPARATION OF FOUNDATIONS

2.1.1 Clearing Dam Site

The area to be occupied by the dam and appurtenant works, and other structures including coffer dam, retaining walls etc. shall be cleared of all trees, stumps, roots, bushes and other objectionable materials. Any useful material such as wood, bamboos etc., arising from clearing and grubbing operations shall be stacked properly in a suitable place, as directed by the Engineer-in-Charge and shall remain the property of the Government.

All waste materials, debris shall be either disposed of sufficiently beyond the working area or burnt completely to ash. Care shall be taken in burning to ensure that no damage results from burning operations.

Early in construction programme, before any of the work for the excavation of the dam power plant or appurtenant etc. is taken all loose rock and semi-detached rock in or close to the area to be excavated that is liable to fall or otherwise endanger the workmen or the work, shall be stripped. Any material not requiring removal as contemplated here in, but which may later become loosened or unstable shall be promptly and satisfactorily removed. The methods employed shall be such as will not shatter or render unstable and therefore unsafe any rock that was originally sound or safe.

Unless otherwise explicitly provided, the item of clearing as given above, shall be deemed to have been included in the unit rates accepted under the different items under Excavation. No separate payment, as such, shall be made for the above items of work.

2.1.2 Classification.

All the material removed in the required excavation shall be measured by block levels taken before commencement and after excavation and classified under any one of the following groups.

(a) Over-burden excavation.

(b) Rock excavation.

a) Over-Burden Excavation

The over burden excavation shall include all types of earth, gravel, moorum, moorum mixed with small boulders less than one metre in any direction, in size or all such materials which require close application of picks, or scarifiers and shovels to loosen the strata.

b) Rock Excavation

The rock excavation shall include all types of rock viz. soft, weathered, disintegrated rock, sand rock, amygdaloidal basalt, hard rock etc. and all boulders and loose rock which are more than one metre in any direction and any such strata requiring blasting, or to be excavated by chiselling, wedging, barring and any other method.

2.1.3 Excavation for Dam

Excavation 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 rock will be permitted to extend within the prescribed lines not more than 15 cm.

The excavation shall be made to sufficient depth to secure foundation on sound rock, free from weathered material, open seams or other objectionable defects. After carrying out the excavation to the designed levels, boreholes, shafts or test pits shall be put in at the location indicated by the Engineer-in-Charge for inspection of the Geologists and Engineers to ensure that there are no continuous shale or clay layers or weak substance within about 3 M. of the base of the excavation near the toe of the dam. If such layers are found, the foundation shall have to be taken deeper in places indicated by Engineer-in-Charge and upto the levels indicated by him. All necessary precautions shall be taken to preserve the rock below and beyond the lines of excavation in the soundest possible condition. The explosives shall be in such quantity and power and used in such locations as will neither open up seams nor crack or damage the rock outside the prescribed limits of excavation. The firing systems of blasts shall be controlled by the use of delay detonators. As excavation approaches its final lines, the depth of holes for blasting and amount of explosives used for hole shall be progressively reduced. Whenever further blasting is liable to disturb the rock upon or against which concrete or masonry is to be placed, the use of explosives shall be discontinued and the excavation completed by wedging, barring, chiselling, line drilling and broaching or other suitable methods. No large scale blasting operation will be allowed when the foundation excavation reaches last 0.6m and excavation shall be done by other methods indicated above. No blasting shall be done within 15M. of any permanent structure. Where blasting would create a hazard to existing structure or installations, rock excavation shall be performed by methods other than blasting. The general excavation will be to levels and shapes shown in the relevant drawing. The foundation levels are based on indication of preliminary borings and are subject to change as actual site conditions warrant. Before starting concrete or masonry work as large area as possible should be exposed for inspection, lest near by section excavated later should disclose that the former section should have been taken to lower depths.

Rules regarding carrying, preserving, handling and using the explosive material shall be strictly followed in accordance with the provisions of Indian Explosive Act and Explosives Rules 1940. Blasting should be carried out by licence holder blaster so that stability, safety or quality of foundation is not endangered. Blasting should not be carried out outside the blasting limit or at time other than specified by the Engineer-in-charge.

2.1.4 Line Drilling for Rock Excavation

Where vertical or square faces or rock are required in portions of the work, such faces of excavation shall be formed by line drilling and broaching. The 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 diameter and spacing of the holes for line drill-

ing shall be subject to approval. The spacing of the drill holes shall be sufficiently close to ensure that rock will break along the desired lines. No blasting will be permitted in the holes along the sides of the 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 concrete/masonry is to be placed, the use of explosives shall be discontinued and excavation completed by wedging, barring or other suitable methods.

2.1.5 Final Excavation and Grading of Foundation

After completion of rough excavation of foundation, cleaning and trimming operations for the final removal of all slabby weathered, any drummy rock and loosened mass shall be done by the chiselling, picking, wedging and barring. The final foundation surface shall present a rough out line to provide added resistance to sliding and all smooth surfaces shall be roughened. The final surface shall be freed from steep angles and sharp projections. Where slopes are steep the rock shall be benched, the benches shall be given a downward slope towards upstream of about 1 in 10.

The foundation surface after final excavation and grading of foundation should be sounded by striking with hammer and portions which do not return a solid ringing sound shall be chiselled out. Sprinkling the area with water will indicate the joints in rock from the water lines which cling to the cleavages after the area has partially drained up. Such portions shall be tested for soundness and rectified where necessary.

The final preparation of foundation for placement of concrete/masonry shall be as per specifications given at para 2.1.3 & 2.1.7.

2.1.6 Backfill

Backfill is defined as excavation refill or embankment material which is required to be placed under these specifications and which cannot be deposited around the structures until the structures or a part thereof are completed. Backfill consisting of earth or rock bits shall be placed in such location as are shown on the drawings or as directed. All backfill shall be carefully graded to lines and grades as shown in the drawings or as directed.

2.1.7 Over Breakage and Pay Line

All excavation shall be done according to the lines, levels and dimensions shown in the drawing. All overbreakage and excess excavation shall be carefully avoided. The unit rate of excavation includes rate of filling of over breakage and excess excavation which shall be filled by the material specified by the Engineer-in-Charge according to the location of the item and shall also include all connected operations of soil disposal like dressing, spreading in layers etc. at the specified areas.

In special situations, where excavation according to lines, levels and dimensions shown in the drawing is not possible, the Engineer-in-Charge at his discretion may permit excavation with maximum side slopes of 1/4:1 in case of all rocks and 1:1 in case of overburden. In any case, no overbreakage, horizontally at the designed level, or below design level shall be permitted. Wherever, the Engineer-in-Charge permits excavation according to the above pay line, only the excavation shall be paid but the filling with the approved material as directed by the Engineer-in-charge shall be done by the contractor at his own cost and shall be deemed to have been included by the contractor in the unit rate of item of excavation.

No payment shall be made for the work done beyond the specified pay lines. Any or all excess excavation or over excavation carried out by the contractor for any purpose or reason, shall, unless ordered in writing by the Engineer-in-charge be at the expense of the contractor and if the unauthorised excavation has to be filled with concrete or masonry, the extra concrete or masonry so needed shall be carried out by the contractor at his own expenses.

2.1.8 Disposal of the Excavations

Before any excavations is started, the deposition of spoil shall be carefully planned, so as not to obstruct traffice lines required for transport of construction, materials and shall be dumped sufficiently clear of the edges of excavation so as not to endanger stability of the slopes of the excavation and also permit ample space for transways, lorry paths, installation of lift-and pumping devices, staching construction materials etc.

The excavated materials shall be carefully sorted so as to separate the materials useful for various works.

In case of rock excavation, materials suitable for use in the masonry shall be particularly carefully sorted, cleared and then stached.

The waste materials shall be stached in spoil banks, in regular shape with suitable slope and properly trimmed so as to present neat appearance. The spoil banks shall be located in such a way that they will not interfere with the natural flow of the river.

2.1.9 Silting of Foundation Pit Due to Flood

If the excavated foundation pit get silted due to intervening floods, slips or any other cause, the contractor shall excavate and restore the foundation trenches to the required shape and dimensions without any extra cost and the quantity will not be included in the payline.

2.1.10 Measurements and Payments

2.1.11 General

The price entered in the schedule for various items of excavation is inclusive of all compensation for moblising, demoblising, supply of equipments,

labour, supervision, cleaning of site, overbreaking done (without permission of Engineer-in-charge) 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 excavation and preparation of foundation. Before commencement of works, levels shall be taken on cross section situated 3 meters apart at right angles to the axis of dam. Levels on the cross section shall be taken at an interval of 1 metre along the cross section. After the completion of excavation in particular class of excavation, the levels on initial cross-section shall again be taken at the interval of 1 metre along the cross section.

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.

The net volume of over-burdens excavation shall be obtained after deducting the volume of boulders classified as rock excavation and contained in the line of over burden excavation. The rock excavation quantity shall also include volume of boulder classified as rock in accordance with provisions of section.

The volume of the boulders in the overburden excavations/rock excavation shall be determined prior to the removal of the same.

Payment for various items of excavation shall be made on the basis of unit price per cum entered for the particular item in the schedule.

2.2.0 Foundation Treatment

2.2.1 Drilling

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 work. Drilling shall be done by wet percussion methods. The drill holes could be vertical, inclined or horizontal as per requirements of work shown in the drawings or as directed by Executive Engineer. The size of drill hole 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 range, have been got drilled in excess or otherwise.

2.2.2 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 hole has set sufficiently to require redrilling, 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 holes at various depths within the stages until the required depth of the hole is completely drilled and grouted .

2.2.3 Redrilling required, due to contractor's failure to clean out a hole before grout has set, shall be performed at the contractors expense; but where the grout has been allowed to set by directions of the Executive Engineer, the required redrilling will be paid at the rate of 50% of the schedule price for the item in the schedule of work and bid.

2.2.4 Measurement & Payments

2.2.5 The price entered in the schedule for the work 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. No additional payment shall be made for interrupting the drilling of holes to permit testing, washing or grouting or on account of requirements for cleaning out holes before further drilling.

2.2.6 Measurements for drilling holes shall be made from 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.

2.2.7 Grouting

The General Plan for the treatment of foundation rock provides for low pressure blanket grouting immediately following excavation to be followed by high pressure curtain grouting subsequent to the construction of the dam blocks or as directed and providing drainage holes drilled subsequent to the high pressure grouting. On the drawings the shallow holes are designated as 'B' holes for low pressure and the deep grouting holes for high pressure grouting as 'A' holes.

The low pressure grouting aims at improving the foundation conditions by bonding together the jointed or shattered rock into more or less a monolithic mass. It will be limited to the upstream third of the foundation and shall be extended to other areas only if specifically directed. The high pressure grouting aims at effecting a relatively water-tight seal across leaky zones in the foundations, maximum possible drop in hydraulic gradient through the curtain and reduction of uplift. The high pressure curtain grouting shall be done from gallery floor of the dam into the foundation after a specified part of the structure has been constructed.

The work of low pressure and high pressure grouting shall be governed by the conditions encountered at site and shall include, but may not be limited to the following:-

- i) Surface treatment like cleaning etc;

- ii) Grouting test holes within the grouting area;
- iii) Casing of drill holes as required, drilling, washing and testing as required by the conditions encountered at the site of the grout holes and grouting the rock in the area (both at low and high pressures);
- iv) Installation and maintenance of special recording instruments required for the work covered by this section.
- v) Clean up of the grouted area.

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.

All open drill 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.

2.2.8 Grouting Programme and Details

i) Low pressure blanket grouting:

The low pressure blanket grouting will be through holes not less than 47 mm in diameter generally arranged on a 6 m x 6 m grid system to a depth generally ranging between 8 m and 10 m. The requirements as to depth and spacing of the holes as shown on the drawings are approximate and are subject to revision during the work of drilling, testing and grouting. As the construction work progresses, the development of leakage or the condition of the surrounding rock may indicate the parts of the foundation already covered with concrete required to be grouted, in such event, holes 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. No allowance above the unit prices bid in the schedule will be made for drilling, grouting of such holes or for the expense of moving equipment to other operations and returning to a previously treated area.

ii) High pressure curtain grouting:

The minimum diameter of the grout holes shall be not less than 47 mm at approximately 3 metre spacing and to depth of 25 metres. The work of curtain grouting shall not be started until all masonry/concrete required within a radius of 60 metre has been placed.

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

grouting operation itself.

It may be necessary to drill and grout certain holes for foundation grouting in successive operations consisting in each case, drilling of the hole to a limited depth, grouting at that depth, cleaning out the grout holes 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 in the seams in the rock surrounding the hole shall be allowed to attain its initial set, before proceeding with the next stage of the drilling. The depth of each successive drilling, the grout mixtures used, the pressure for each stage of grouting and other details of the grouting procedure shall be as directed. The depth of each 'stage' is anticipated to be from 4 to 6 m.

A primary series of holes about 8 to 12 metres apart (according to site conditions) 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 those 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 require to be grouted a fourth series of holes shall be drilled and tested and grouting continued if necessary.

It is essential that a short exploratory 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 shall be stopped and the hole grouted before further drilling is resumed. Upon completion of drilling of a hole it shall be temporarily capped to prevent entry of foreign matter until grouting operations require it to be opened. The holes shall be filled with cement slurry when they are no longer required.

iii) "C" holes for grouting:

For additional safety against uplift, "A" holes will be supplemented by a line of holes called 'C' holes drilled through 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. Drilling and grouting of these holes should be accomplished after drilling and grouting of the 'A' holes of a second line of grout curtain. Stage grouting shall be adopted for these "C" holes as in "A" holes.

It may be found necessary after holes in a region have been drilled and grouted to drill additional holes for treatment. No allowance above the unit prices bid in the schedule will be made for drilling or grouting of such holes or for the expense of moving equipment to other operations and returning to a previously treated area.

2.2.9 Washing of Holes

The washing shall either be Routine washing or special washing as detailed below:-

a) Routine Washing

The washing out of loose material, silt, sand and clay from the seams and fissures is important for proper grout injection and shall be carried out as directed.

On completion of drilling of a hole and before water testing or grouting of any stage of a hole is begun, the hole shall be washed under pressure with water until the return water becomes clear and no drill cutting, rock, cement or any other solid materials are found in the water. If it is found that the hole can not be cleaned with water only under pressure even after a reasonable length of time, it shall be washed with alternating jets of air and water under pressure, injected through a hose or a pipe lowered to the bottom of the hole. Washing of holes shall be a routine part of all the drilling in rock. The part time for routine washing shall be 30 minutes.

b) Special Washing

The result of routine washing may in many cases indicate that special washing procedures are required in order to remove more extensive deposits of loose or clayey materials from fissures, fractures or other zones intercepted by the grout holes. When such a special washing is required at least the nearest two holes in advance of each such hole shall be completely drilled for the same stage and the adjacent holes washed to facilitate flushing out of any intervening clay or silt seams or fractures. All intersected rock seams and creavices containing washable materials shall be washed with pumping of water and into one hole blowing compressed air into adjacent hole. Washing of holes shall follow a pattern which will prevent deportation 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.

2.2.10 Pipe Connections in Holes

i) 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 lengths shall be properly anchored into the drill hole with grout, mortar, lead wool

or other suitable material. 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 entrance of debris or other foreign material. Where the conditions of rock permit grout hole connections may also be made directly to the hole by means of a mechanical or pneumatic expander without the use of embedded pipes.

ii) High-Pressure Grout Holes

Standard 80 mm black iron pipe and fittings shall be installed in the foundation, concrete or masonry as shown on the drawings for drilling as well as grout hole connections. The space between the pipes and the rock into which they are inserted shall be carefully caulked with grout mortar, leadwool or other suitable material to prevent entry of concrete or other materials prior to grouting. The pipes and fittings that are embedded in concrete/masonry 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 couplings fitted with standard cast iron plugs which will be screwed in loosely to prevent the entrance of debris or other foreign material.

2.2.11 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 directed. 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 rods fall suddenly as through an open cavity the drilling shall be discontinued, the debris cleared, the affected portion of the hole filled with thick cement slurry and drilling continued after the slurry sets.

The procedure for water-pressure testing shall be as 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 shall then be pumped into test section under the pressure and for the periods specified below in one continuous operation and leakage in water observed.

<u>Step No.</u>	<u>Pressure</u>	<u>Elapsed time (Minutes)</u>
1	1/3 P	5
2	2/3 P	5
3	P	10
4	2/3 P	5
5	1/3 P	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/Cm^2 at the gauge.

After steps 4 and 5 the valve shall be closed and the pressure drop observed and recorded for a minimum period of 3 minutes in each instance.

The length of test section shall be measured parallel to the direction of hole. Holes shall generally be tested in 2 to 3 metre sections. The pressure testing apparatus shall be subject to 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.

2.2.12 Grout Materials and Procedure

i) Materials

a) General

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

b) Cement

Cement shall, unless otherwise specified, be ordinary portland cement conforming to the relevant clauses of the Indian Standard Specification IS-269-1967 (3rd Revision) as revised from time to time or ordinary portland pozzolan cement conforming to I.S.1489-1976 of ammended from time to time.

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

The 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 assignment. Stacking height of bagged cement shall not exceed 10 feet.

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

c) Sand

Coarse and fine sand sometimes required as filler in the grout shall

conform to Standard Specification IS-383-1970 as revised from time to time.

d) Water

The water used for grout 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,

ii) Grouting Procedure

a) General

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

b) 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/Cm². It shall be kept in a satisfactory working condition at all times and any grout holes 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.

c) 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 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 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 mix. and if an open hole is indicated, it shall be started with a thicker mix. With the grout pump operating as nearly as possible at constant speed, the water cement ratio shall 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 rises 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 ungrouted holes should be left uncapped to facilitate escape of air and water. If grout flows from these holes, an expanding type packer shall be set in these holes immediately above the point of interconnection and the interconnected holes shall be washed out when grouting is completed and before the grout has had time to set.

To relieve premature stoppage during grouting periodic applications of water under pressure shall be made and sudden increases in pressure or pumping rates shall be avoided.

The pressure of grouting operations shall be performed in presence of a responsible Engineer-in-charge of grouting. After the grouting of any stage of a side is finished, the pressure shall be maintained by means of a stop cock and other devices until the grout has set to the extent that it will be retained in the hole.

2.2.13 Grouting Pressures

Grouting pressures must be related to the depth of the stage of treatment, the weight of any 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 increases with the pressure, but the higher the pressure, the greater the benefit from the injection, particularly where fine fissures have to be treated. High pressures are however, no substitute for a proper dilution of the grout. It is expected that in general grout pressures may go upto 5 Kg/CM² in case of blanket grouting and 15 Kg/CM² in case of curtain grouting.

2.2.14 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 pumping shall be reduced or the pumping stopped temporarily and intermittent grouting performed, allowing sufficient time between injections 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 hole is completed, the hole shall be washed free of grout to the depth specified. If regrouting 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 specified depth. Regrouting shall be done not

sooner than 2 days after the initial grouting is completed. After a minimum period of two days, after grouting or regrouting, the portion of the hole washed free of grout, shall be packed with a 'dry' mixture of cement, sand and water.

2.2.15 Foundation Displacement Indicators

The surface bed rock may be particularly sensitive to displacement due to hydraulic pressures developed during pressure testing or grouting. Such displacement shall be controlled with the aid of careful observations of "Foundation displacement Indicators" specially installed for the 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 metre deeper than the proposed grout holes. Above the anchorage the pipe shall be encased in a 50mm as-phalt-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 underside 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 figure, 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.

2.2.16 Technical Field Records

Drilling, pressure washing, pressure testing and grouting records shall be kept neatly, accurately and systematically as the work proceeds. The exact location of all holes with reference to the axis and chainage along the dam shall be recorded and an accurate log of all operations kept. Record maps and sections shall be complete, showing all subsurface conditions as found and corrected by grouting operations. The drill cores shall be suitably boxed and referenced. These field records shall be kept always available for inspection any time during the work period.

During drilling operations full records such as time of drilling per metre or part length colour of wash water, change of sound during drilling with depth sudden fall of drill rod etc., shall be maintained.

All information regarding grouting actual amount of grout taken, effects, observed in the surrounding holes or rock etc. may be kept under the following heads as may be ordered by Engineer-in-charge.

- 1) Hole Number
- 2) Type of hole and methods of drilling indicating equipment used,
- 3) Position given X, Y, & Z coordinate from Dam axis.
- 4) Top level and depth, inclination and direction.
- 5) Date and time of commencement of drilling, and grouting.
- 6) Date of completion of drilling and grouting.

- 7) Quantity of cement consumed.
- 8) Name of person on job during drilling, washing testing and all operations.
- 9) Observation, during grouting concerning behaviour of holes under air and water pressure, appearance of wash water, quantity and proportion and retention of grout used, time and pressure of grouting, application and retention of grout pressure, connection to and effect on adjacent holes, methods of application of grout, stage grouting etc. & other conditions noted while drilling and grouting to enable compilation of complete geophysical record of the foundation.

2.2.17 Measurement & Payment

i) General

The prices entered in the Schedule for the various items of work and materials, as described in this clause, shall constitute full compensation for mobilising demobilising and supplying all equipment, material, labour, supervision, keeping technical records 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. The procurement of water and the connected arrangement for the same shall be the entire responsibility of the contractor and he should not be entitled for any payment for the same. The unit rate quoted for different items should cover the above expenditure.

ii) Sand used in the grout shall be considered of incidental to the work required under the 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) Connections to Holes

Pipes and pipe connections to holes actually used in the work required under this section shall be made at the unit price per kilogramme of the pipes fittings and valves given in bid for the item in the schedule and the unit price shall cover all the brass, steel and cast iron pipes, valves and fittings actually installed and left in place as directed. No additional allowance above the unit price bid will be made on account of varying size, length or number of pipes fittings and valves.

iv) Washing Operations

Measurement for payment for washing operations shall be determined from the time the pump starts to inject water into the hole until the time pumps is stopped. Payment shall be made at the unit price per hour entered in the schedule and this unit price shall include payment for labour, material equipment, such as special nozzles, packers and fittings, including any number of settings in each hole, blowing in compressed air, and all other related incidental work.

v) Pressure Testing

Measurement for payment for pressure testing of holes shall be determined from the time the pump starts to inject water into the hole until the time the pump is topped. Payment shall be made at the unit per hour entered for this item in the Schedule and this unit price shall include payment for labour, equipment, instrument maintenance, materials, tools, use of pipes and fittings and packers, including any number of settings in each hole, and all other related incidental work.

vi) Grouting

Measurement for payment for grouting shall be made on the basis of weight of dry cement in the grout actually injected into all holes regardless of the grout mixture used. No payment will be made for cement lost in grout due to improper anchorage of grout pipes or connections 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.

Payment for grouting shall be made at the unit price entered for this item in the Schedule shall be inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, all material labour supervision, keeping technical records 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.

vii) Foundation Displacement Indicators

Payment for supplying and installing the foundation displacement indicators shall be made on the basis of the applicable unit price entered for the respective item in the schedule and this unit price shall include payment for drilling the holes, supplying pipes and fittings, dial and other gauges and other miscellaneous metal work and materials required to construct the indicators and all labour for installation of the gauges including anchoring, sealing grouting, installing weather protection and maintaining recorders, and other miscellaneous work required including the complete removal of indicators and backfilling of the holes.

2.2.18 Drainage Systems

General

The dam and appurtenant works will be drained by system of drains, the material and construction details of which will depend on the desired functional performance.

2.2.19 Foundation Drain for Dam

Drainage of the dam foundation shall be accomplished by drilling one or more lines of holes from the foundation gallery 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 upstream face or from the top of some lift through previously installed pipes.

After drilling, the pipes shall be plugged at the top and seepage water from the hole taken off at a Tee Connection in the pipe leading to a collection heads or drain, care shall be taken to avoid closing of the drains during the progress of the works and should any drain become closed or obstructed from any cause before final acceptance of the work, it shall be cleared in a manner approved by the Executive Engineer beyond and at the cost of the contractor.

If after, a given area is granted and drilled for drainage, it is found necessary to drill and grant additional grant 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 not less than 150 mm. into the rock foundation and shall be held securely in position while concrete is placed about them. The elevation of the bottom of the drainage holes shall be higher than the bottom of an adjacent grant holes. Drainage holes shall not be drilled until all adjacent grant holes within minimum distance of 45 metres have been drilled and granted.

2.2.20 Drain Pipes in Dam

Internal drainage in Dam, for reducing the fore pressure inside the body of dam, shall be accomplished by 200 mm dia drain holes formed in the concrete of the dam at 3 metres centre to centre as shown in the drawings. Particular care shall be taken to ensure that drain holes do not get closed or obstructed during the progress of work. Top of the each vertical drain hole or drainage pipe shall be sealed with standard C.I. Pipe and fittings. The bottom of each vertical drain hole or pipe shall be connected to the foundation gallery by standard pipe and elbows as shown in the drawings.

2.2.21 Metal Pipe Drains

Cost iron pipe drains shall be constructed as outlets for the spillways drainage system connecting the drainage gallery and spillway drainage system and also for the drains from the roadway gutters at spillway bridge and elsewhere as shown in the drawings.

2.2.22 Open Drain

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

2.2.23 Measurements & Payments

The prices entered in the schedule for the various works required for Drainage System 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, 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 portions of the particular section and payments shall be at the unit price entered in the schedule for particular item of work.

2.3 MATERIALS

2.3.1 Stone

The stone used for masonry shall be clean, hard, durable, tough and free from decay, sandholes, weathered portions, adhering coating, veins flows, cracks, soft seams, sharp corners and other defects. The stone shall be taken only from approved quarries. Approval to quarry does not imply that the material therefrom will be accepted if it fails to satisfy the requirements of quality gradation and strength. The contractor shall not be entitled to any compensation on account of failure of the quarry to supply required material and contractor should do his own prospecting. The stone shall be roughly cubical in shape and no stone weighing*75 kg. and 150 kg shall be less than 25 cm. in any directions, spawls between 10 cm. to 20 cm. shall be used to wedge into thick mortar spaces. No individual stone for use in masonry shall be less than 0.016 cum. in size. The crushing strength in unconfined compression test shall not be less thanKg/Cm² (500 tons/sq.ft.) when tested on in any plane. The percentage of water absorption shall not be more than 1% to 3% of its own dry weight, after 24 hours submersion in water.

2.3.1.1 Face Stone

The stone for face work shall be 28.5 cm in height and not less than 30.5 cm in depth and no stone shall be less than 30.5 cm in length. At least 50% of the stones shall be more than 53 cm in length. Bond stones used in face work shall be at least 61 cm in depth.

Quoin stones shall be of the same height as the face stones and shall be true and rectangular on two faces with their beds and joints one line chisel dressed upto 75 mm depth from the faces. The stones shall be at least 30.5 cm in length on one face and 45.7cm in length on the other face.

The bushing shall not be more than 38 mm and spawls shall not be more than 10% of the stones.

The face stones for masonry dam will be hammer dressed on face and one line chisel dressed on bed, top and sides for a minimum depth of 75 mm from front face. Beyond depth of the 75 mm, the stone may taper, but the tail end of the stone at the minimum length specified as here under shall have at least half the area of the face comprising of:-

- a) Stretcher size 53.5 cm x 28.5 cm x 32.5 cm depth.

- b) Header size 30.5 cm. x 28.5 cm x 61 to 45.7 cm depth.
- c) Bond stone 30.5 cm x 28.5 cm x 71.2 to 61 cm depth. 10% of face stones should be bond stones.

2.3.1.2 Rubble

The rubble shall be clean, hard, durable and tough and shall be free from decay, sand holes, weathered portion adhering coatings, veins, flows, cracks, soft seams, sharp corners, and other defect. The rubble shall be hard, as far as possible of uniform colour, texture and shall be quarried from approved quarry. Minimum size of rubble will be 0.016 cum and maximum size size 0.06 cum.

10% of chips with size 0.001 to 0.01 cum is allowable in the collection of the rubble.

2.3.2 Sand

a) General

The sand for mortar, concrete and grout shall be natural sand or crushed sand or a mixture of natural sand and crushed sand. The maximum size of particle being limited to 5 mm for mortar and concrete.

b) Quality

It shall consist of hard, dense, durable uncoated rock fragments and shall conform to the relevant specifications under I.S.S. 383-1970. It shall be free from injurious amounts of dust, lumps of soft or flaky particles, shale alkali, loam, mica and other deleterious substances. The amount of deleterious substances shall not exceed the percentages given below:-

Deleterious Substance	Percentage by Weight
Shale	1.00
Coal and lignite	1.00
Cinders and clinkers	0.50
Clay lumps and sand stones	1.00
Alkali, mica and coated grain	2.00
Materials passing I.S. Sieve - 8.	3.00

The sum of the percentage of all deleterious substances shall not exceed 5.00%.

The sand shall also be sound and free from injurious amounts of organic impurities. The methods of testing for sand as specified in I.S.I.2386-1963 (Revised) shall apply.

c) Grading:

The sand as batched, shall be well graded within the limits specified below unless any other alternative grading is approved by the Engineer-in-charge.

I.S. Sieve Designation	Percentage Passing	
	Natural Sand	Manufactured Sand
480	95 to 100	95 to 100
240	80 to 95	75 to 90
120	45 to 80	50 to 70
60	30 to 45	30 to 50
30	5 to 30	15 to 30
15	1 to 5	8 to 13

The grading of the sand shall be so controlled that the fineness modulus of at least 9 out of 10 consecutive test samples of finished sand, when samples are taken hourly, will not vary more than 0.20 from the average fineness modulus of the 10 test samples. For using of wet-sand necessary bulkage allowance will be made.

2.3.3 Cement

Cement shall unless otherwise specified conform to the Indian Standard Specification I.S. 269-1976 (3rd Revision) as amended from time to time. The cement shall be free from lumps. Any cement which is found to contain lumps or foreign material of natures and in amounts detrimental to the results of the work, shall be rejected. Handling facilities shall be so arranged that no cement shall be kept in storage for more than 120 days. Storage bins for bulk cement shall be water tight and shall be so constructed that there will be no dead storage.

2.3.4 Water

The water used in concrete mortar and grout shall be clean, free from injurious amounts of silt, organic matter, alkali salts and other impurities and in conformity with para 4.3 I.S. 456-1978.

2.3.5 Puzzolana

Puzzolana will consist of surkhi or other approved puzzolanic material. Surkhi shall be prepared from clay of approved quality. The temperature of calcination and fineness shall be such as to yield optimum results and shall be based on laboratory investigation. The fineness of surkhi shall be such that after sieving through an I.S. test sieve No. 9, it shall not leave a residue more than 10% by weight. The above fineness shall be adhered to unless the tests for the compressive strength of the red cement mortar (20% cement replaced by

surkhi by weight) indicate that surkhi with lesser fineness could be adopted. The surkhi shall be free from admixture of any foreign matter and shall conform to the specifications under I.S.S. 1344-1968.

2.3.6 Air Entraining Agents

If desired, suitable A.EA which will be supplied by the department, shall be used to improve the quality and work-ability of the mortar. The amount of A.E.A used shall be such as will effect the entrainment of not more than 12% of air by volume of mortar. The exact proportions of air entrainment shall be determined by actual tests.

2.3.7 Coarse Aggregate

i) General

The term coarse aggregate is used to designate aggregate ranging in size from 4.75 mm to 150mm. The coarse aggregate for concrete shall consist of crushed rock or natural gravel or a mixture of crushed rock and natural gravel well graded and blended uniformly.

2) Quality

The coarse aggregate shall consist of uncoated hard, strong, dense and durable rock fragments and free from injurious amounts of disintegrated stones, soft stones, flaky or elongated particles, slat, alkali, vegetable and other deleterious substance.

The percentage of deleterious substance in any size range of coarse aggregate as delivered to the mixer shall not exceed the following values:-

Deleterious Substances	Percentage Limits by Weight	
	Natural Aggregate	Crushed Aggregate
Coal & lignite	1.00	1.00
Clay lumps	0.50	0.50
Material finer than I.S. Sieve-8	2.00	1.00
Soft friable, elongated piece and other deleterious substance	2.00	2.00

The total percentage of deleterious substances shall not exceed 3 percent by weight. The coarse aggregate shall also conform to the requirements for abrasion and soundness specified under ISS 383-1970 and ISS 515-1959. The methods of tests for coarse aggregate as specified in I.S.S. 2386-1963 shall apply.

3) For the purpose of getting good blending of aggregate to produce a dense concrete of specified strength and desired workability, the required percentage will be determined in laboratory after conducting necessary tests.

Following percentages are given as a guide:-

Maximum size aggregate in concrete, in mm.	Percentage of coarse aggregate fractions (Clean separation)					
	Cobbles 80mm to 150 mm.	Coarse gravel 40mm to 80mm.	Medium gravel 20 mm to 40 mm	Fine gravel		
				5 mm (No.4) to 20 mm	10 mm to 20 mm	5 mm to 10 mm.
1	2	3	4	5	6	7
20mm	0...	0...	0...	100...	55 to 73	27 to 45
40mm	0...	0...	40 to 55	45 to 60	30 to 35	15 to 25
80mm	0...	20 to 40	20 to 40	25 to 40	15 to 25	10 to 15
150mm	20 to 35	20 to 32	20 to 30	20 to 35	12 to 20	8 to 15

2.4 MASONRY

2.4.1 General

Stone shall be clean and free from dust to ensure good bond with mortar and shall be wetted before being placed and the masonry shall be kept wet for at least 21 days after being built and at no time or on no account shall be allowed to be dry in this period. Should the mortar deteriorate for want of curing, the masonry shall be pulled down and rebuilt with fresh materials. On completion of work, all masonry shall be washed clean of all stains. The structures shall be built true to line plumb, curved or battered as may be required to meet design requirements and shall be carried out in a workman like manner. Suitable aids like templates, scaffolding etc. shall be used.

Care shall be taken to see that the masonry has proper quantity of mortar as prescribed in the detailed specifications mentioned here-in-after and provided in the tender documents. The joints shall be the minimum possible and chips shall be used to minimise mortar requirements in thick joints. If stones, once placed are to be re-adjusted, they shall be lifted clean and re-set, they shall not be moved one over the other.

2.4.2 Mortar

2.4.2.1 General

The red cement mortar shall consist of cement and sand each complying with its respective specifications and the proportions of the mix for the different locations shall be as detailed later. Red cement shall consist of cement and surkhi in four parts of cement to one part of surkhi or other puzzolana both by weight and each complying with its respective specifications.

2.4.2.2 Mixing

The mortar shall be mixed in a mixer preferably tilting drum type. The following general principles shall be followed:-

- 1) The ingredients should be fed into the mixer simultaneously and in such a manner that the period of flow of each ingredient into the mixer is about the same.
- 2) A portion of water 5% to 10% should precede and remaining quantity should follow the introduction of other ingredients. The remaining of the water should be added uniformly and simultaneously with other ingredients.
- 3) The use of the same mixer for mixing different proportions of mortar consecutively should be avoided. The first batch of mortar at the commencement of the day's work should be made richer by adding 25 kg. of cement extra over and above that required for the particular mix.

2.4.2.3 Test for Uniformity of Mixing

The thoroughness of mixing and adequacy of mixing time so as to give a uniform mortar shall be tested at the start of the job and at such intervals as may be considered necessary. "For any one batch, the difference between unit weights of air-free mortar in samples taken from the front and end of the mixer on mix discharge, when determined in accordance the provisions of mixer performance test, designation-26 in the appendix of VII edition of United States Bureau of Reclamation concrete manual, shall not exceed 1.6 per cent of the mean value.

2.4.2.4 Mixing Time

The minimum time generally specified is as follows:-

The timing to start after all ingredients, except the last portion of the water, are in mixer:-

Capacity of mixer (cubic meters)	Time of Mixing (Minutes)
2 or less	1½
3	2
4	2½
5	2¾
6	3

Overmixing is objectionable because the grinding action increase finds, which require more water to maintain consistency of mortar. Also over-

mixing may drive out entrained air. The mixing time shall be increased beyond the figures given above if mixing operations fail to produce a uniformly consistent quality of mortar. The time, however, should not exceed 3 times the number of minutes given in the tabulation. There shall be no increase in rate on this account. Mixing equipment should be so designed that mixing can be discontinued and resumed with a full load in the mixer.

2.4.2.5 Strengths

The compressive 28 days strength of the red cement mortar used shall be as given below:-

Minimum Compr. strength at the end of 28 days in Kg/Cm².

Rich Red Cement Mortar: 1:3 - 140Kg/cm²

Lean Red Cement Mortar 1:4 105Kg/cm²
1:5 80Kg/cm²

Tests for compressive strength of mortar shall be in accordance with the procedure laid down in the Indian Standard Specifications I.S.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 at least 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 co-efficient of variation for any ten consecutive sample strength shall be less than 0.15.
- iii) Not more than 10% of the specimen strength shall be less than 85% of the specified strength.

Additional tests shall be carried out as and when directed, preliminary tests for mortar should, however, be carried out well in advance in the laboratory prior to commencement of the work. The test should indicate 20% more strength than that of similar on the field as specified in para 2.4.2.5.

2.4.2.6 Mix Proportions

Following proportions of mortar mix are given as a rough guide only. Exact proportions for the red cement and Sand shall be fixed after conducting tests for compressive strength.

Type of Mortar	Proportion of Red Cement : Sand
Rich Red Cement Mortar	1 : 3
Lean Red Cement Mortar	1 : 4, 1 : 5

Mortar

The approximate quantity of cement required per cum. for different types of mortar is given below as a guide for purposes of tendering for the masonry items. The work of preparing mortar for masonry shall however be done by weigh batching and required strength and other specifications as prescribed will have to be achieved by the contractor. The exact mix will be determined by the laboratory tests.

Statement showing cement required per cum. of mortar

Sl. No.	Type	Mix	Approximate Cement content.
1.	Rich C.M. (140 Kg/cm^2)	1 : 3	435 Kg.
2.	Lean C.M. (105 Kg/cm^2)	1 : 4	375 Kg.
3.	Lean C.M. (80 Kg/cm^2)	1 : 5	284 Kg.
1.	Rich Red C.M.	1 : 3	348 Kg.
2.	Lean Red C.M.	1 : 4	300 Kg.
3.	Lean Red C.M.	1 : 5	227 Kg.

Whenever red cement mortar is specified 20% of cement is replaced by Surkhi.

The quantity of mortar in 100 cum. of masonry shall not exceed following limits:-

- i) Face stone masonry & Coursed Rubble Masonry -- Upto 33 cum.
- ii) Uncoursed Rubble Masonry -- Upto 45 cum.

2.4.2.7 Type of Mortar for Different Locations

The type of mortar to be used will be as follows:-

1) Non-Overflow:

- a) Front and if considered necessary rear impervious face of prescribed width, Rich red cement mortar with average compressive strength after 28 days of 140 Kg/cm^2

b) In the hearting portion lean red cement mortar with average compressive strength at 28 days of 105 Kg/cm^2 .

2) Spillway

a) In the upstream face of prescribed width rich red cement mortar with average compressive strength after 28 days of 140 Kg/cm^2 .

b) In the hearting portion lean red cement mortar with average compressive strength at 28 days of 105 Kg/cm^2 .

2.4.3 Final Preparation of Foundation for Placing Masonry

Final preparation of the foundation detailed below shall be so phased that it is covered by concrete and or masonry promptly, without loss of time, so that deterioration is not allowed to occur after the foundations are passed by the competent authority. If, for any reason, the construction is delayed, the area shall be examined thoroughly for cracks and defects, if any, and rectified as directed by the Engineer-in-charge. The contractor shall have no claims whatsoever, for the extra work involved for removal of such defects.

Just prior to starting of masonry work the foundation shall be thoroughly cleaned of all loose particles, dirt, oil or grease by use of stiff brooms, jets of water, air or wet sand under pressure and followed by through washing. The washing and scrubbing process shall be continued until the water collecting in pools is clear and free from dirt.

In the final cleaning process the wash water may be removed by sponges. If any drilled holes are left in the foundation surface which are no longer needed, the holes shall be cleaned with water and air jets and shall be filled up, completely with cement slurry. The foundation shall then be kept moistened for 24 hours. Immediately preceeding the placement operation, the cleaned surface shall be coated with 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 0.4 to 0.6 sq.m. at a time and the layer of concrete (which has to follow) shall be spread immediately thereafter but in no case later than 5 minutes after the slurry coat is given, in order to avoid stiffening-up of the cement slurry which may prevent satisfactory bonding. The layer of concrete shall be spread over the slurry and worked into all the irregularities of the rock surface. The concrete shall conform to class A - 1 of classification given on para 2.5.2. The stones of the first course of masonry shall be carefully pressed into the concrete so as to force the concrete around the corners.

Water from any spring or leakage through the coffer dams shall be kept out off from the foundation area and from any masonry till the later has set. Where pumping is resorted to, care shall be taken to see that it does not lead to disturbance of work already carried out.

2.4.4 Classification of Masonry

a) The rubble shall conform to the specification vide para 2.3.1.2. stones received from the quarry shall be used without any dressing except knocking off weak and sharp corners. They shall be set in the work on their natural flat bed breaking joints. No joints shall be thicker than 35 mm, nor shall it be less than 12 mm thickness.

2.4.4.2 Face Stone Masonry

The front face work in both spillway and non overflow sections will consist of true and rectangular face stones conforming to specification vide para 2.3.1.1. The work shall be in courses of 30.5 cm. thickness and normal to the face better. The joints shall not be thicker than 12.5 mm. The masonry shall be built in header and stretcher fashion, joints shall break in courses above and below generally by atleast half the height of the course. Bond stones of 61 cm or greater length shall be used and every 10th stone shall be a bond stone, except where the header stones themselves tail into by more than 61 cm. The bond stones shall be staggered and marked for identification. The Random Rubble Masonry in hearting shall be carried on simultaneously with the face work. The face work shall be struck neatly and finished as specified in para 2.4.8.

For payment purposes the average thickness of the face stone masonry shall be taken as 0.5m.

2.4.4.3 Coursed Rubble Masonry

Coursed Rubble Masonry shall be of selected stones conforming to specifications vide para 2.3.1.1. except that only hammer dressing shall be done. The work shall be in parallel courses of 30.5 cm thickness. The joints shall not be thicker than 20 mm. The masonry shall be built in header and stretcher fashion and joints shall break in courses above and below generally by atleast half the height of the course. Bond stones of 61 cm or greater length shall be used and every 10th stone shall be a bond stone except where the header stones themselves tail into by more than 61 cm. The bond stones shall be staggered and marked for identification. The Random Rubble Masonry in hearting shall be carried on simultaneously with the face work, shall be struck neatly and finished as specified in para 2.4.8.

For payment purposes the average thickness of the face stone masonry shall be taken as 0.5m.

2.4.5 Location for Use of Different Types of Masonry

The locations for use of different types of masonry in the dam and appurtenant works shall be as below:-

Sl. No.	Location	Type of Masonry	Classification		Nominal Mix.	Remarks
			Type of Mortar	Minimum Compressive strength of mortar		
1	2	3	4	5	6	7
1.	0.50m (Thickness) in front face of overflow and non-over flow sections	Face stone Masonry consisting of face of stone with one line chisel dressed stones in width of 75 mm on all 4 sides.	Rich red cement Mortar	140Kg/cm ²	1:3	
2.	2.0m (Thickness) in front of face of spillway and Non-overflow section at back of face work U/s.	Random Rubble Masonry.	Rich red cement Mortar	140Kg/cm ²	1:3	
3.	1.0m depth at foundation for the full section of dam except area covered by items 1&4 in both Non-over flow and overflow sections.	Random Rubble Masonry.	Rich red cement mortar.	140Kg/cm ²	1:3	
4.	0.5m (Thickness) in rear face of non-overflow dam.	Coursed Rubble Masonry	Rich red cement mortar	140Kg/cm ²	1:3	
5.	1.0m (Thickness) in rear face of non-overflow at the back of face work D/s.	Random Rubble Masonry.	Rich red cement mortar	140Kg/cm ²	1:3	

1	2	3	4	5	6	7
6.	Hearting both spi- llway & Non over- flow (except the depth of founda- tion covered by item 3).	Random Rubble Masonry	Lean red cement mortar	105Kg/cm ²	1:4	
7.	0.5m (Thickness) one side of con- traction joint.	Coursed Rubble Masonry	Rich red cement mortar Lean red cement mortar.	140Kg/cm ² 105Kg/cm ²	1:3 1:4	According to specified zon- es vide item 2,3 & 5.
8.	<u>In Training Walls.</u>					
i)	0.5m (Thickness) at front face of Training wall.	Coursed Rubble Masonry	Rich red cement mortar	140Kg/cm ²	1:3	
ii)	1.0m (Thickness) at the back of face work	Random rubble masonry	Rich red cement mortar.	140Kg/cm ²	1:3	
iii)	In hearting and rear face	Random rubble masonry	Lean red cement mortar	80Kg/cm ²	1:5	

Note: The locations of the different types masonry specified here are typical of a specific project and shall need modification to suit design criteria adopted elsewhere.

2.4.6 Workmanship

The following shall be observed to ensure quality of workmanship:-

- 1) Clean the old masonry surface prior to starting masonry on it, by wet sand blasting and washing. Chipping should be resorted only in extreme cases.
- 2) Do not place mortar which bleeds excessively.
- 3) Thoroughly and efficiently broom into the old surface a layer of mortar and build masonry on it immediately.

- 4) Shake the mortar well by vibrating the stones by hand bar to ensure that the excess mortar, water and the entrapped air comes out and are not trapped at the bottom before driving in chips. The stones shall then be hammered down by a wooden mallet, 4.5 Kg to 5.4 Kg in weight and pressed towards the adjacent stone at the same time without touching it.
- 5) Inadequate supply of spalls in different sizes would lead to excessive use of mortar.
- 6) Avoid under-pinning after a stone is laid as it tends to lift the stone and leave air pockets.
- 7) Avoid putting chips in the intervening space between stones before filling with mortar and shaking it to full depth to a thick quaky mass.
- 8) Avoid putting flat chips at top as these tend to get dislodged easily and in effect levels up the surface also. Drive in all the chips on ends only which will further squeeze and completely fill the mortar at the joints. The thickness of joints should not exceed 38 mm in case of random rubble masonry, 20 mm in case of hammer dressed masonry and 12.5mm for chisel dressed stone masonry.
- 9) Keep the masonry surface as rough as possible to secure good bond between successive layers.
- 10) After the masonry is done once do not permit it to be disturbed until it has attained sufficient strength to with stand traffic and omit the initial clean surface before the final set is attained. Hammering or breaking of stones on fresh masonry shall not be permitted.
- 11) Wire brush the masonry surface after the mortar has set finally, i.e. after 8 to 12 hours, to remove all laitence, excess mortar, etc. Too much delay in cleaning may lead to difficulty and insufficient cleaning, unless carefully and persistently insisted on.
- 12) Work shall be so distributed that fresh layers of masonry are started every alternate day.
- 13) Green work shall be protected from rains by suitably covering the same. Masonry in cement mortar or composite mortar shall be kept constantly moist for all faces for a period of not less than 21 days. In case of fat lime mortar (with or without puzzolana) the curing shall commence two days after laying of masonry and shall continue for 21 days.

- 14) In the case of long stoppage of work in any section construction joints about 2 m wide and 0.6 m deep may be left in the surface of lower section while building so as to provide for a cut out and serve as an additional bond or key between top and bottom sections. While starting the masonry of the top sections, work shall be started first in these pits.
- 15) The mortar shall be used before it has lost the required workability. Use of hardened mortar by retempering with addition of water shall not be permitted.

2.4.7 Permeability Tests of Masonry

To ensure uniform standard of imperviousness, permeability test on the mortar shall be carried out frequently on specimens, 100mm diameter and 50 mm high or similar size prepared from mortar as used on work and the test shall not give a coefficient of permeability greater than:

- 1) Rich red cement mortar : 7.5×10^2 cm/yr.
- 2) Lean red cement mortar : 15×10^2 cm/yr.

All test holes 70 mm dia. 3.66 m to 6.1m. deep shall be core-drilled in the finished masonry and leakage observed. These test holes shall be in two rows, one row within 2.5m from the upstream face of the dam and the second at about a third of the rest of the width of the dam and shall be done in such blocks as directed by Engineer-in-Charge after a minimum of 21 days hardening. The impermeability should be such as to restrict the leakage to 0.49-litres per minute per sqm. and 2.45 litres per minute per sqm. of drill hole in masonry for the upstream and downstream areas respectively at a pressure of $1\frac{1}{2}$ times the head at the bottom level of hole under test. If the leakage exceeds, systematic drilling and grouting shall be carried out to achieve the required degree of permeability. The cost of such remedial drilling and grouting shall be borne by the contractor. The cost of drilling and conducting permeability tests will however be borne by the department, provided that the test holes satisfy the standards of impermeability.

In any portion of masonry is found to be weak or defective in construction it shall be removed and rebuilt by the contractor without extra cost.

2.4.8 Finish

2.4.8.1 Upstream Face Finish

The upstream face shall be flush pointed by dry pack method. The joints shall be raked square for atleast 60 mm depth when mortar is not quite set. Before pointing, the joints shall be cleaned free of all dirt and wetted with water under pressure. The mortar for pointing shall be neither too wet nor dry but shall have the consistency to stick together on being pressed into a ball by pressure of hands without expelling any water.

When the joint is completely filled, the mortar shall be rubbed hard with a trowel and finished convex. The edge shall then be smooth finished with a wet brush. Only as much quantity of mortar should be mixed at a time as can be used within 15 minutes. The sand for pointing may be graded as follows:-

Passing 72 meshes to 25 mm - 25 to 30 percent.

Passing 25 meshes to 25 mm - 50 to 60 percent.

Passing 6 meshes to 25 mm - 100 percent.

The work pointed shall be kept moist for atleast 21 days after pointing is completed.

2.4.8.2 Downstream Face Finish

In the non overflow section, the joints are to be neatly struck and smoothened off.

2.4.8.3 Curing

Specirication of curing as given on page for concrete shall also be - applicable to masonry work.

2.4.9 Measurement & Payment of Masonry

The prices entered in the schedule for the incorporation of various classes of the masonry required by the 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.

Except as otherwise specifically provided in these specifications measurements of masonry for payment will be made only to the neat lines of the structures as shown on the drawings or as established by Engineer-in-Charge and on the basis of the thickness shown in the drawings. Where more than one thickness is shown, the average thickness shown on the drawings will be used as the basis of measurement for payment. No allowance shall be made for the masonry back fill beyond the minimum lines of excavation shown in the drawing except where such payment is specifically authorised. In measuring masonry for payment, the volume of all galleries, recesses, shafts passage ways, chambers, air ducts, water ways, drainage conduits, depressions and all opening of every description having crossectional area more than $0.05M^2$ and for embedded pipes, tiles, wood, work and metal work, except reinforcement bars and fabric and anchor bolts and bars will be deducted.

The rate for masonry unless otherwise specified will include all finish or pointing referred to in these specifications. The quantity of cement as inidcated in column 4 under para 2.4.20 shall be quite sufficient to give the

specified strength as under column 2 for various mixes of mortar. If contractor is required to use any different content of cement per cubic metre of finished masonry for obtaining the stipulated strength, the payment for variations in the cement content in the masonry shall be adjusted upwards or downwards. No other factor like extra quantity of mortar required for the masonry or variation necessitated in labour, material and equipment shall be accounted for.

The cement content for the purpose of calculating variation in cement content shall be arrived at by dividing the total consumption for a particular type of masonry as recorded at the mixing points of mortar (approved for use by the Executive Engineer) by the volume of the finished masonry of prescribed mix placed within the prescribed lines and grades..

The payment for the various classes of masonry shall be made on the basis of the unit price per cum. entered for the respective item in the schedule.

2.4.10 Transverse and Construction Joint

2.4.10.1 Transverse Joints in the Dam

Vertical transverse contraction joints shall be provided in the masonry and or concrete of the dam for convenience in construction and to provide for contraction of the concrete masonry. The location and details of these joints are shown on the drawings. The joint shall extend through the full cross section of the dam profile and unless otherwise directed shall be started from the foundation. The contraction joints in concrete shall be smooth, as obtained with plane surfaces of form work. In the case of masonry the edge of the block at the joint shall be built with selected stones and the surface plastered with red cement mortar appropriate to the zone. The finish of end block of each contraction joint has to be such that an average thickness of 38 mm plaster gives smooth plumb surface.

The joints shall be sealed at the upstream face by installing two lines of annealed copper or monel metal sealing strips of 20 gauge as shown in the drawing. The sealing strips shall be shaped to provide for opening and closing of joints as shown in the drawing and shall be joined carefully together by welding or brazing so as to form a continuous water tight diaphragm. Adequate provision shall be made to support and protect the sealing strips during the progress of work and non working period and care taken in the removal of forms so that the bond between the seal and masonry or concrete is not broken. To provide good mechanical bond, corrugations at intervals shall be provided and in addition, another rods of 10 mm diameter spaced at 9 m centres shall be fixed. 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.

The asphalt seal slot provided between the two lines of metal sealing strips shall be filled with 'H' grade asphalt or blown bitumen maxphalt R85/25.

The asphalt seals shall be poured in lifts corresponding to the concrete lift. In asphalt well, two 12 mm internal dia steam pipes (standard black welded steel) for reliquifying asphalt shall be installed. These pipes will be rigidly clamped in place and will be provided with threads and caps. The steam will be passed through pipe after seal is completed upto top. It shall then be capped as shown in the drawing.

2.4.10.2 Construction Joints

Each layer of masonry will present a construction joint. The surface of the construction joint shall be clean and damp but free of standing pools of water when the next layer of masonry is placed on it. Clean up shall comprise removal of all laitance, loose stones and other foreign material. Cleaning of construction joints shall be accomplished by air water jetting in case of fresh masonry. In the case of joints that have been left exposed for a considerable time, the clean up shall be accomplished either by wet sand blasting or chiselling. The clean up of construction joints in running masonry work can be accomplished with care if freshly placed layer is gone over with air and water jet just after the lapse of three to four hours when the mortar will have set hard enough to withstand any erosion, this period of 3 to 4 hours may be varied slightly to suit conditions arising from the type of cement used and weather.

2.4.10.3 Metal Seals

Metal sealing strips shall be placed across the transverse contraction joints and around the galleries. Monel metal or copper sheets for the sealing strips shall conform to the following specifications:

- 1) Monel metal sheets shall be of 20 gauge and shall conform to B.S.S.-1526-1929 for Nickel Copper Alloy sheets and strips.

In case of monel metal sheets, only the flux coated monel electrodes shall be used for arc welding and monel wire or strip cut from monel sheets, for oxyacetylene welding..

The copper strips shall conform to Indian Standard Specification for copper plate sheet and strip for industrial purpose, I.S. 1972-1961. The material shall have the chemical composition as given for grade 'C' phosphorus deoxidised copper (Non-arsenical)(DHA) in Table-I of the Indian Standard Specifications of copper (revised) I.S. 191-1958 with amendments upto and including No.2 of September, 1965. The material shall have the physical properties as given in Table - I of I.S. 1971-1961 for cold rolled annealed temper (Hot - rolled annealed temper will also be accepted). The thickness of the strip shall be 1.00mm (gauge 20 SWG will also be acceptable). Tolerance in thickness shall be as specified in Table - II of I.S. 1972-1961. Tolerances in width of strips shall be as specified in Table - VI.

2.4.10.4 Measurement and Payments

The prices entered in the Schedule for the work required by this section 2.4.10 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. Except or otherwise expressly provided for specifications, measurement of copper or monel seals and providing rectangular framed holes filled with asphalt, providing steam heating pipes shall be made on the basis of linear length calculated as being contained within the profile of the dam and as shown on the relevant drawings.

Payment for copper or monel seals and rectangular formed holes shall be made on the basis of unit price entered for the respective items in the schedules.

2.5 CONCRETE

2.5.1 Composition

Concrete for dam and appurtenant works shall be composed of cement, sand, coarse aggregate water, surkhi and any other admixture, as specified, all well mixed and brought to the proper consistency. Tests on concrete shall be made at specified intervals during the progress of the work and the mixes modified as necessary in order to consistently to secure the required workability, density, impermeability and strength, together with maximum practical economy. The max. size of coarse aggregate in concrete for any part of the work shall be largest of the specified sizes, the use of which is practicable from the point of satisfactory placing of the concrete. Concrete for the dam shall in general, contain 80 mm to 150 mm maximum size aggregate. It is contemplated that the concrete shall range in character from mass concrete having 150 mm maximum size aggregate and a cement content ranging from 150 Kg to 235 Kg./cum to heavily reinforced concrete having 20 mm maximum size aggregate and cement content approximately 355 kg/cum. The water cement ratio will be regulated by the requirements of strength and durability and required strength shall determine the most suitable water cement ratio for any mix. The proportions of aggregate to cement for any concrete shall be such as to produce a mixture which can work readily into corners and angles of the forms and around reinforcement bars with the method's of placing employed on the work, but without permitting the materials to aggregate or excess water to collect on surface. Uniformity in consistency from batch to batch shall be required. The control of concrete, beside other factors shall be by maintaining a fairly uniform slump at the point of placement and by holding the water cement ratio as closely as practicable to the standards determined for the purpose. Under so conditions shall the slump be greater then that required to provide proper placement and compaction of the fresh concrete within the form. 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 water cement ratio established for each class of concrete. No substitution shall be made in the material used on the work without additional tests to show that the quality of concrete is satisfactory.

2.5.2 Concrete Classification and Location of Placement

Concrete classifications are related to the specified 28 days compressive strength and shall conform with the requirements set out in Table - I here of. The minimum 28 days strength shown in the classification table shall be taken as the average of three tests specimens taken from a single batch of concrete, provided that the strength value of any one specimen is within plus or minus 15% of the mean. In addition not more than 10% of the specimens tested for a given period shall have a compressive strength less than 85% of the required strength and the average of the tests for any given period shall equal or exceed the required strength. Not less than one sample test shall be carried out for every 120 cum of concrete.

Table-I

Class	Classification	Gr. of Concrete	Slump Ranges in M.M.	Specified 28- days 15X30cm. cylinder strength (min)Kg/ cm ²
A1	A20 S280	M 250	50 mm to 100mm	280 Kg/cm ²
A2	A20 S210	M 200	50 mm to 100mm	210 Kg/cm ²
A3	A40 S210	M 200	50 mm to 100mm	210 Kg/cm ²
A4	A80 S210	M 200	40 mm to 75mm	210 Kg/cm ²
A3	A40 S175	M 150	50 mm to 100mm	175 Kg/cm ²
	A20 S 70(Porous concrete)	1:5.5		7 days strength 70 Kg/cm ²

The mix shall be designed to produce the grade of concrete having acquired workability and a characteristic strength not less than appropriate values given in the above table.

The Contractor will be required to give the required strength with the size of aggregate indicated in the above table. The rate shall be quoted accordingly.

The location at which the various classes of concrete are to be placed shall be generally as given in Table II here under unless otherwise specified in the construction stage drawings or as may be directed by the Executive Engineer.

Table-2

Specification for Concrete

Sl.No.	Location	Classification (See item 3 Under notes	Grade of Concrete	Specified 28 days 15 cm X 30 cm cylinder strength (Min) Kg/cm ²
1	2	3	4	5
1.	Mass concrete in foundation for filling up crevices etc. and back filling	A40 S175	M 150	175 Kg/cm ²
2.	All round galleries adits and other openings training walls coping over-non-overflow section and foundation under masonry blocks.	A40 S210	M 200	210 Kg/cm ²
3.	On downstream face of spillway and on spillway crest and bucket except for the exterior 1 m thickness.	A80 S210 (except top 1.0m)	M 200	210 Kg/cm ²
4.	Spillway crest and bucket (exterior 1.0m thickness) and around out lets.	A20 S280 (Top 1.0m only).	M 250	280 Kg/cm ²
5.	Around Metal sealing strips (face of contraction joint)	A40 S210	M 200	210 Kg/cm ²
6.	Road, Bridges, Beams and Slab (Wall and floors less than 0.30m).	A20 S210	M 200	210 Kg/cm ²
7.	Spill way piers and around embeded parts.	A40 S210	M 200	210 Kg/cm ²
8.	Around draft tube, liner and scroll case and divide walls etc.	A40 S280	M 250	280 Kg/cm ²
9.	Switch yard road, heavily reinforced portion of side walls.	A40 S280	M 250	280 Kg/cm ²
10.	Power house walls, floor over 12" (30cm), trash rack structure penstocks pipes and draft tube portions.	A40 S210	M 200	210 Kg/cm ²
11.	Power house sub-structure	A80 S210	M 200	210 Kg/cm ²

1	2	3	4	5
12.	In block outs	A20 S210	M 200	210 Kg/cm ²
13.	Elevator shaft	A40 S210	M 200	210 Kg/cm ²

Note: Location and different mixes specified here above are typical of a specific project and shall need modification to suit design criteria adopted else where.

Notes:- 1/ The designed strength is for 28 days.

2/ Cylinder size will be 15cm X 30 cm.

3/ "A" denotes aggregate and suffix "A" the maximum size in MM.
"S" denotes cylindrical 15cm x 30cm. strength to be tested,
as per I.S.I. specifications and the suffix of "S" the specified Designed, 28 days strength of concrete in Kg/cm²

4/ Wherever red cement concrete is specified 20% of cement is replaced by Surkhi.

2.5.3 Batching

a) General

The prescribed amounts of 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 specified limits of accuracy. The amount of water, cement and aggregate shall be determined by weighing. The proportions shall be changed whenever such change is necessary in order to maintain the standards required by these specifications.

The measuring and weighing equipment shall operate within the limits of accuracy specified and standard test weights and other auxiliary equipment required for checking their satisfactory performance shall be provided.

The equipment shall be capable of controlling the delivery of materials for weighing or volumetric measurement so that the combined inaccuracies in feeding and measuring during normal operation will not exceed 1½ percent for water, cement 10% for admixtures and 2% for sand and 20 mm to 40mm aggregate, and 3% for aggregate of max.size in 80mm. Periodic tests shall be made at least once every two weeks in the case of equipment for measuring water cement and admixtures and at least once every month in the case of equipment measuring sand and coarse aggregate. Repairs, replacement or adjustments shall be made as are necessary to secure satisfactory performance.

2.5.4 Mixing

The concrete ingredients shall be mixed thoroughly in batch mixers so as to positively ensure uniform distribution of all the component materials

throughout, the mass at the end of the mixing period. Mixers should not be loaded in excess of 10% more than the manufactures rated capacity. The following sequence of charging the mixer should be adopted.

- a) A portion of the water (between 5 & 10%) should precede and remaining quantity should follow the introduction of the other materials. The remainder of the water should be added uniformly with the other materials.
- b) The ingredients (cement, puzzolana, if any and fine and coarse aggregate) should be fed into the mixer simultaneously and in such a manner that the period of flow of each is about the same.
- c) The minimum mixing time generally specified is as follows. The timing to start after all ingredients, except the last portion of water, are in the mixer.

Capacity of Mixer (cum)		Time of mixing minute
2 or less	-	1½
3	-	2
4	-	2½
5	-	2¾
6	-	3

It is recommended therefore that mixing time shall not exceed 3 times the number of minutes given in the table. Mixing equipment should be designed so that mixing can be discontinued and resumed with a full load in the mixer.

- d) The adequacy of mixing shall be determined by the pycnometer method (U.S.B.R. Designation 2.6). For any one mix. the variation of the air free unit weights (range between max. and minimum air free weights) of 3 samples taken from the front, centre and back of the batch of concrete in the mixer shall not exceed the following.
- | | | |
|--------------------|---|--------------------|
| For one batch | - | 37. 2 Kg. per cum. |
| AV. for 3 batches | - | 25.90 Kg. per cum. |
| AV. for 20 batches | - | 19. 4 Kg. per cum. |
| AV. for 90 batches | - | 14.60 Kg. per cum. |

2.5.5. Tests

Test for consistency of concrete (slump test) and compressive strength of concrete shall be made in accordance with the recommended procedure laid down in Indian Standard I.S. 456-1978.

For compressive strength test a minimum of three test specimens shall be made for each 150 cum. of reinforced concrete and for each 380 cum. of mass concrete placed there shall be at least three test specimens for each day of concreting even if only a few cubic meters 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 strength 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 strength shall be less than 85% of the specified strength.

Additional tests shall be carried out as and when directed.

If the test results show that the concrete blocks give results below the specified standard such bad quality of concrete shall be removed and redone by the contractor at his cost. In case of doubtful work cores shall be extracted from the hardened concrete and shall be tested by the department in the presence of the Contractor or his representative. The result shall be binding on him.

All tests as specified under this para shall be carried out at the cost of the contractor.

2.5.6 Transporting

The methods and equipment for transporting concrete shall be such that concrete having the required composition and consistency will be delivered to the work without objectionable segregation or loss of slump. Placing of mass concrete shall, in general, be done by means of bottom dump buckets of such design and capacity that the concrete deposited in one spot may be compacted effectively into an approximately horizontal layer of the specified thickness with the minimum amount of lateral movement and accompanying tendency for segregation. The design of the amount buckets shall be such as to permit close regulation of the quantum of concrete to be deposited at each dumping operation. Method of conveying concrete by chutes, belt conveyors and similar equipment in a thick continuous and exposed flow to the forms will be permitted with the written permission of Engineer-in-Charge only for limited and isolated sections of the work.

Where concrete is being conveyed in chutes or on belts, the free fall of drop shall be limited to 1.5 m unless otherwise permitted wherever there is a free fall within the conveying system suitable baffle plates, splash boards, or down spouts shall be provided to prevent segregation, splashing or loss of ingredients.

2.5.7 Preparation for Placing Concrete

General Requirements

No concrete shall be placed until all form work and installation of parts to be embedded and preparation of surface involved in the placing have been approved by the Engineer-in-Charge.

b) Time Interval Between Mixing and Placing

Concrete shall be placed within 30 minutes, after it has been mixed unless otherwise authorised by the Engineer-in-Charge.

c) Foundation Surfaces

Immediately before placing concrete, all surfaces of foundation upon or against which concrete is to be placed shall be cleaned of standing water, mud and debris. All surface of rock upon or against which concrete is to be placed besides satisfying the foregoing requirements shall be clear solid and free from oil, objectionable coatings and loose, semi detached, or unsound fragments and shall be sufficiently rough to ensure satisfactory bond with the concrete. Seams in rock, if any, shall be cleaned to a suitable depth and to firm rock on the sides. The cleaning and roughening of the surfaces of rock shall be performed with the use of the high velocity air water jets, wet sand blasting, stiff brooms, picks or other effective means. Where the rock is dry enough to absorb water from the mortar layer, it shall be kept continuously wet for at least twenty four hours immediately prior to placing concrete thereon.

On many rough or broken surfaces, the first few batches of concrete shall, if so desired by the Engineer-in-Charge contain only about one half of the regular proportion of coarse aggregate.

d) Surfaces of Construction and Contraction Joints

Concrete surfaces upon or against which concrete is to be placed and to which new concrete is to adhere, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed, are defined as construction joints..

The surfaces of construction joints shall be clean and damp when covered with fresh concrete or mortar. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coating and foreign materials. Cleaning of the surfaces of construction joints shall be accomplished by wet sand blasting followed by thorough washing. The joints in mass concrete and where practicable in other concrete, shall be cleaned and washed immediately before concrete in the next lift is placed. Where it is not practicable to clean the joints after forms are set, the joints shall be wet sand blasted and washed at the last opportunity prior to setting the forms and the joints shall be washed thoroughly with air water jets immediately prior to placement of the adjoining concrete. The methods to dispose off waste water used in curing and washing of concrete surfaces shall be such that the waste water does not

stain, discolour, or affect the exposed surfaces of the structures. All pools of water shall be removed from the surfaces of construction joints before new concrete is placed.

The surfaces of all construction joints shall be cleared thoroughly of inaccuracies of concrete, mortar or other foreign material by scraping, chipping or other satisfactory means.

e) Chipping and Roughening of Concrete Surface

Concrete surfaces upon or against which additional concrete to be placed shall be chipped and roughened to a depth of not more than 25mm. of the surfaces. The roughening shall be performed by chipping or other satisfactory methods and in such a manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface. After being roughened, surface of the concrete shall be cleaned thoroughly of all loose fragments, dirt, lime and other objectionable materials and shall be sound and hard and in such conditions as to assure good mechanical bond between old and new concrete. All concrete which is not hard dense and durable shall be removed to the depth required to secure a satisfactory surface. Cost of work of chipping, roughening and cleaning shall be deemed to have been included in the rate tendered for item of concrete.

2.5.8 Placing of Concrete

a) Concrete shall be placed only in the presence of a representative of the Engineer-in-charge. The prepared surface shall be covered with layer of mortar approximately 12.5mm thick. The mortar shall have the same water cement ratio as the concrete. The mortar shall be spread uniformly and worked thoroughly into all irregularities of the surface. Concrete shall then be placed on mortar layer immediately. Concrete shall be deposited in all cases as nearly as practicable directly in its final position and shall not be caused to flow in a manner that will permit or cause segregation. Excessive separation of the coarse aggregate from the concrete caused by allowing the concrete to strike the forms or re-inforcement steel, will not be permitted. Where such separation would otherwise occur, suitable drop chutes shall be provided to confine the flowing concrete. Any concrete which becomes so stiff that proper placing without retempering cannot be assured, shall be wasted.

b) Cleaning Equipment

At the end of each run and before again placing concrete, all hardened concrete or mortar shall be removed from the inner surfaces of the mixing and conveying equipment. All mixing and conveying equipment shall be maintained in good order and kept reasonably free from deposits of stiff concrete and leakage of mortar.

c) Transporting and (d) Spreading mortar layer on foundations before concrete or masonry is laid shall be as specified under para 2.5.7 and 2.5.9.

d) Mass Concrete

All formed concrete shall be placed in continuous and approximately horizontal layers, the thickness of which generally shall not exceed 45.7 mm for mass and 30.5 cm for re-inforced concrete. In placing mass concrete in a lift, the exposed area of fresh concrete may be maintained at the practical minimum. The slope formed by the unconfined edges of successive layers of concrete shall be regulated to minimise segregation and to secure adequate compaction without unnecessarily enlarging the area of exposure of fresh concrete. The concrete shall be deposited as nearly as possible in final position and shall not be piled up in large masses at any point and then pushed or vibrated into space for long distances. The full capacity of the bucket may be deposited in one operation where this has no objectionable effect on the placing of concrete but near forms, in and around embedded metal work, and elsewhere as directed, the contents of the buckets shall be discharged in such quantities that satisfactory placing will be secured.

f) Rate of Placing

Concreting shall be continued without avoidable interruption until the structure of section is completed or until satisfactory construction joints can be made. Concrete should not be placed faster than the placing crew can compact it properly. In placing thin members and columns precaution should be taken against too rapid a placement which may result in movement or failure of the form due to excessive internal pressure. An interval of at least 12 and preferably 24 hours should elapse between the completion of columns and walls and the placing of slabs, beams or girders supported by them in order to avoid cracking due to settlement. All concrete shall be placed in approximately horizontal lifts not exceeding 1.5m in thickness except to expedite the placing of embedded materials. The difference in elevation between adjacent blocks shall not exceed 6 m.

g) Consolidation

Each layer of concrete shall be worked with suitable appliance until the concrete has been consolidated to the maximum practicable density, free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded material. The concrete may be consolidated with electric or pneumatic, power driven, immersion type vibrators operating at speeds of at least 7000 revolutions per minute when immersed in the concrete. Layers of concrete shall not be placed until the layers previously placed have been thoroughly worked as specified. Care shall be exercised to avoid contact of the vibrating head with surfaces of the forms or displacing reinforcement or embedded metal parts. Large voids or air pockets which may be left in the permanently exposed face of the structure by vibration shall be eliminated by systematically spading the face with an approximate flat tool.

Excessive vibration causing segregation and laitance or tending to bring an excessive amount of water to the surface shall be avoided. Coarse aggregate/gravel protruding from the surfaces of the lift shall be embedded into the mass during the initial compacting and vibrating operations. Surface vibrators or pudders shall not be used.

Disturbance of the surface concrete at a construction joint during the early stages of hardening shall be avoided. Necessary traffic on new concrete shall be on timber walkways constructed so as not to cause injury to the concrete.

For formed concrete surfaces which are to be exposed to high velocities of water special precautions shall be taken to prevent or minimise surface pitting without resorting to over manipulation of the concrete next to the form.

Temperature of Concrete

When placed in the forms, concrete shall have a temperature of not more than 90°F. Where necessary, measures like cooling of aggregate by spraying with water and air blasting and cooling of mixing water by refrigeration may be adopted. In the alternative the concrete placing schedules shall be so arranged that concrete will not be placed during certain hour of the day when the placement temperature of concrete will exceed 90°F.

2.5.9 Tolerance for Concrete Construction

1) General

Permissible surface irregularities for the various classes of concrete surface finishes are specified under next heading and are defined as "Finishes" and are to be distinguished from tolerances as described herein.

2) Where tolerances are not stated in the specifications or drawing for any individual structure or feature thereof permissible deviations will be interpreted in conformity provisions of the clause.

The contractor shall construct all concrete structures to the exact lines, grades and dimensions established. However, inadvertent variation from established lines, grades and dimensions will be permitted to the extent set forth herein, provided that the Engineer reserves the right to diminish the tolerances set forth herein if such tolerances impairs the structural action or operational function of the structure. The notation on the drawings of specific maximum or minimum tolerances in connection with any dimension shall be considered as supplemental to the tolerances specified herein. Rejected work shall be remedied or removed and replaced at the expenses of, and by the contractor.

3) Tolerances in Dam and Appurtenant works

(i) All Structures

a) Variation of constructed linear outline.

from established position of plan.

In 6 m 12 mm

In 12 m 19 mm

- b) Variations of dimensions to individual structural features from established positions:

In 24 m or more 30 mm

In buried construction - Twice the above amount.

- c) Variation from the plumb, from specified batter, or from curved surfaces of Structures, including the lines and surfaces of columns, walls, piers, buttersses, arch sections, vertical joints grooves.

In 3 m 12 mm

In 6 m 19 mm

In 12 m 30 mm

In buried construction - Twice of the above amounts.

- d) Variations from the level or from the grades indicted in the drawings in slabs, beams, soffits, horizontal joint grooves and visible arises.

In 3 m 6 mm

In 10 m 12 mm

In buried constructions - Twice the above amounts.

- e) variations in cross sectional dimensions of columns, beams, buttersses, piers and similar members.

Minus 6 mm

Plus 12 mm

Footings for columns, piers, walls, buttresses, and similar members

- i) Variations of dimensions in plan

Minus 12 mm

Plus 50 mm

- ii) Misplacement or eccentricity - 2% of footing within the direction or misplacement but not more than 50 mm.

- iii) Reduction in thickness.

5% of specified thickness.

- 4) Sills and side walls for Radial gates and similar water tight joints. Variation from plumb and level - Not greater than a rate of 3 mm in 3 m.

5) Tolerances of placing reinforcement steel.

i) Variations of protective covering.

With 50 mm cover 9.5 mm

with 80 mm cover or more 12 mm

ii) Variation from indicated spacing -

2.5 cm for spacing of 15 cm and above, 12 mm for spacing below between 8 cm and 15 cm, and 6 mm for spacing 8 cm or below.

2.5.10 Finishes and Finishing

2.5.10.1 General

Concrete surfaces shall be tested where necessary to determine whether surface irregularities are within the limits specified. Surface irregularities are classified as 'abrupt' or 'gradual'. Offset and fine caused by displaced form sheathing or lining or a form section or by loose knots in forms or otherwise defective timber forms shall be considered as abrupt irregularities, and shall be tested by direct measurement. All other irregularities shall be considered as gradual irregularities and tested by use of a template consisting of straight edge for plain surfaces or the equivalent thereof for curved surfaces. The template shall be 1.5 m for testing of formed surface and 3m for unformed surfaces.

2.5.10.2 Formed Surfaces

The classes of finish for formed concrete

Surfaces shall be designated by the symbols F-1, F-2, F-3, F-4 unless otherwise specified or indicated on the drawings the classes of finish shall apply as follows:

Finish F - 1

Shall apply to formed surfaces upon which or against which back-fill or concrete is to be placed. The surfaces required no treatment after removal of forms., except removal and repairs of defective concrete and the specified curing. Correction of surfaces irregularities, shall be done only for depressions which when measured as described under 2.5.11.1 exceed 25 mm.

Finish F - 2

Shall apply to all permanently exposed formed surfaces for which finish F-3 and F-4 is not specified. Surface for which finish F-2 is specified will need no filling of pits or sack rubbing and no grinding other than that needed for repairs of surface imperfections. Surface irregularities, measured as

described in para 2.5.10.1 shall not exceed 6 mm for abrupt irregularities and 12.5mm for gradual irregularities.

Finish F - 3

Finish 3 apply to frames surface where:

1) Accurate alignment and evenness of surface are essential from prevention of destructive effect of running water. i.e. it applies to hydraulic surfaces. Such surfaces include spillway crest, spillway face, spray walls, part of the divide wall exposed to running water, intake for canals, penstock outlets for canals, energy dissipation for outlets works, intake structures, spillway face, except where special finish is required.

Immediately after removal of forms from surfaces designated for F-3 finish, all required patching, clean up and correction of major imperfection shall be completed and the surfaces shall be given a sack rubbed mortar finish in the following manners:-

The surfaces shall be thoroughly wetted and permitted to approach surface dryness before starting the sack rubbing. The surfaces shall be finished in area sufficiently small to prevent complete drying of any part before the sack rubbing is completed for that area. The mortar used for the sack rubbing shall consist of one part of cement to two parts, by volume of sand passing a I.S. Sieve 100 and enough water so that the consistency to the mortar is that of thick cream. The mortar shall be rubbed thoroughly over the area with clean burlap or a sponage rubber float, completely filling all pits and irregularities. While the mix in the holes is still plastic, a mixture of the dry ingredients of the mortar in the same proportions shall be rubbed over the area. After the mortar has stiffened adequately to prevent smearing but before it has hardened, the excess mortar shall be removed by rubbing with clean burlap. After the final sack rubbing a light fog spraying shall be applied to the coated surface, the moisture thus applied being just sufficient to damp the surface, without allowing water to run down the face of the walls. All sack rubbed areas shall be kept continuously damp for atleast 72 hours after the final sack rubbing or until completion of the curing period for the concrete. When measured as described in para 2.5.10.1 abrupt irregularities shall not exceed 6 mm for irregularities parallel to the direction of flow and 3 mm for irregularities in other direction Gradual irregularities shall not exceed 6 mm. Irregularities exceeding these limits shall be reduced by grinding on a level of 1 in 20 rate of height to length.

Finish F - 4

Shall apply to forward surfaces where absorptive form lining is used. The surface provided by absorptive form lining shall not be rubbed or treated in any way except for cleaning by wire brushing and grinding off with fins or small projections.

2.5.10.3 Unformed Surfaces

The classes of finish for unformed concrete surfaces are designated by the symbols U-1, U-2, U-3.

Interior surfaces shall be sloped for drainage where shown on the drawings. Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless the use of other slopes of level surface is specified, narrow surfaces, such as top of walls and curbs shall be sloped approximately, 3 cm of per m width. Broader surfaces such as walls, roadways plateforms, and decks shall be sloped approximately 2 cm per m. The classes of finish to be applied shall be as detailed below:-

Finish - U - 1

(Screeded Finish) shall apply to unformed surfaces that are to be covered by back fill or by concrete and concealed surfaces such as floors which will be covered by concrete floor topping. Finish U-1 is also used as the first stage for finishes U-2 and U-3. Finishing operations shall consist of sufficient levelling and screeding to produce even uniform surfaces, surface irregularities, measured as described in para 2.5.10 shall not exceed 1 cm.

Finish U-2 (Floated Finish)

Shall apply to unformed surfaces not permanently concealed by backfill or concrete or unformed surfaces for which finish U-1 and U-3 are not specified, and shall include floors of sumps, tops of walls, parking areas, parapet walls, surface of gutters, side walls and outside entrance slabs. Finish U-2 is also used as the second stage for Finish-U-3. 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 and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. If finish U-3 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 para 2.5.10.1 shall not exceed 0.5 cm. Joints and edges of gutters, side walls entrances slabs and other joints and edges shall be tooled where necessary.

Finish U-3 (Trowelled Finish)

Shall apply to unformed surface, such as slabs to be covered with built up roofing or membrane water proofing and stair treads. 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 so as to flatten and smoothen the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Light steel trowelling will be permissible on surfaces of slabs to be covered with built up roofing of membrane water proofing, in which light trowel marks are not considered objectionable. Surface irregularities measured as described in para 2.5.10.1 shall not exceed 6 mm.

2.5.10.4 Special Finishes of Concrete Surfaces

It is contemplated that a special finish, as herein after specified, may be required on the inside and to surfaces of the parapets on the dam, on some of the surfaces of the power plant, on the towers of the dam, and on positions of other surfaces. Where such special finishing is required, the forms shall be removed while the concrete is still green, but no sooner than 12 hours and no later than 24 hours after the placing of the concrete.

Immediately after the forms have been removed. Any required patching or pointing shall be done and major imperfections of finish shall be removed or corrected, according to provisions given in the item of work called finishes and finishing, except the addition of water specified therein for facilitating the finishes of patches shall be omitted. The entire surface shall then be thoroughly wetted with brush and rubbed with a hard wood float dipped in water containing about 1 Kg of portland cement per 10 litres. The rubbing shall be continued until all form marks and projections have been removed. The grinding from the rubbing operations shall then be uniformly spread with a brush in such a manner as to fill all pits and small voids. The brushed surface shall be allowed to harden and shall then be kept moist for about three days, after which the final finish shall be obtained by rubbing with Carborandum stone of approximately No. 36 grit until the entire surface has a smooth texture and is uniform in colour. The time at which wood float rubbing is performed is critical, wood float rubbing shall not be started so soon that the aggregate grains are easily dislodged nor so late that the surface is too hard. It is to be just sufficient to reduce the surface condition required without unnecessary cutting of the aggregate grains. After the final rubbing is completed, curing of the surface shall be continued by sprinkling water until the expiry of the curing period.

2.5.10.5 Special Requirements

General

All concrete in the dam, and appurtenant structures shall conform to the requirements of sections and to detailed requirements of the following paragraphs. All structures shall be constructed in accurate workman like manner to the lines, grades and dimensions shown on the drawings and to the tolerances and finish specified. For explanation of the classes of the finishers, mentioned below, the dimensions of each structure shown on the drawings will be subject to such changes as may be necessary in the structure to suit the conditions disclosed by the excavation.

Concrete in Dam

This item of schedule includes all concrete in the main dam except concrete in spillway crest, spillway bucket, spillway piers, training walls, round openings for galleries, sluice penstock etc. and around metal sealing strips in the masonry portion, emergency gate assembly storage structure, block outs for embedded materials, roadway slab, side walls curbs and parapets.

Care shall be taken to spade or vibrate properly the concrete adjacent to the forms, particular care being observed to produce smooth surface, free from projections and deviations from the prescribed lines. The forms for surface between adjacent panels may be removed as soon as the concrete has hardened sufficiently to prevent surface damage.

All surfaces of the concrete including interior surfaces shall have a finish F-2 and F-3 with the following exceptions. The surface of spillway shall have a finish F-3 or U-2 and surface against which back fill is placed shall have finish F-1 or U-1.

The concrete in the outer 1.0 m on the D/s face of the spillway shall conform to class A-1.

2) Concrete in Spillway Crest

The item of the schedule for concrete in the spillway crest include all concrete in the spillway crest and downstream face above elevation. All embedded metal works and pipes shall be carefully placed and maintained in position until concrete is placed above them. In laying this concrete particular care shall be taken to get smooth and durable surface on the crest and D/S face using absorptive form and shall be free from projections or deviations from prescribed lines shown in the drawings. This concrete shall have a finish F-3 or U-2 and shall conform to class A-1.

Masonry underneath the concrete on the spillway crest shall be stepped so as to provide proper keying for the concrete.

The following general rules shall be adopted for ensuring efficient construction joints between masonry and concrete.

- 1) Do not permit placing of concrete or mortar which bleeds and forms laitance excessively.
- 2) Avoid excessive working of fresh concrete or mortar on the construction planes.
- 3) After the masonry is placed, do not permit it to be disturbed until it has attained sufficient strength to withstand traffic.
- 4) Keep the surface continuously moist until the concrete is placed. Where practicable wet sand as curing medium is preferable to any other.
- 5) Clean the old surface thoroughly prior to placing concrete, the most satisfactory method being by sand blasting and washing. After the surface is essentially free of laitance and coating, thorough wire brushing and washing will give good results. Where time interval for next lift is not more than 3 days high velocity water jets may be sufficient. Chipping should be used

only in extreme cases where damage or defective areas are encountered.

- 6) Thoroughly and effectively broom into the old surface a layer of mortar and place concrete immediately.

- 3) Concrete in Spillway and Roller Bucket

The surface of this concrete shall have finish F-3 or U-2. Concrete in the roller bucket will conform to class A 1 for top 1-0 m and class A 4 for the rest.

- 4) Concrete in Spillway Piers

This item includes all concrete in spillway piers outside the limits of concrete in the spillway dam but does not include any concrete in the spillway bridges. Concrete shall be placed in 1.5 m lifts, in horizontal layers not greater than 30 cm. in thickness. All embedded structural members and those directed be held firmly in place during placing of concrete. Concrete under this item shall conform to class A3 and shall have finish F-3 or U-2.

- 5) Concrete in Spillway Bridge, Road, Slab and Beams etc.

This item includes all concrete in the deck structure and the protective covering on the outside faces of the exterior girders of the spillway bridge between the expansion joints and the end of the bridge and the road and the road slab but does not include concrete in the supporting piers.

The concrete shall be placed to the lines grades, and dimensions shown on drawings or as directed and exceptional cares shall be used to secure high quality of workman-ship and finish. The location of all construction joints and the sequence of placing concrete shall be subject to the approval of the Engineer-in-Charge. Expansion joints shall be constructed as shown on the drawings or as directed.

All exposed surface of the bridge shall be given a F-2 or U-2 finish and upper surface or roadway slab U-1 finish. The concrete will conform to class A2. The structural steel for expansion joints and for railing posts, and the drain inlets and pipes shall be accurately placed and shall be securely held in place, while the concrete is being placed. However the construction of road bridges does not come under the scope of this contract.

- 6) Concrete Inside Walls, Roadway Curbs Parapits etc.

This item includes all concrete in the side walls and parapets on each side of the top of the abutment sections of the concrete portion of the dam, all concrete in the side walls curbs and parapets on each side of embankment portion of dam. Special care shall be taken in construction of side walls, curve parapets to ensure high quality of workmanship, accurate dimension and strict adherence to alignment and grade No. irregularities in alignment due to inaccurate finish of top surface, bulging forms or other defects will be

permitted. The surface, of the side walks shall be given uniform slope from the parapet to the curbs and surface shall be given a float finish with a float to give the surface F-2 or U-3 finish. The concrete shall conform to class A2. However the construction of roadways does not come under the scope of this contract.

7) Concrete in Trash Rack Structures

This shall include all concrete U/s of the normal outline of the dam which is placed in the trash rack structures at the penstock intakes. Trash rack structure will include the associated stoplog located U/s of the face. All slabs shall be accurately constructed of uniform made straight and smooth so that trash rack and stoplog will run freely and seat properly and true. The streamlined sections shall have finish F-3 or U-3 and all other surface F-2 or U-2. The concrete of the structural base shall conform to class A3.

8) Concrete in Elevator Towers Shafts Hoists, Gate Assembly Transfer and Storage Structures

This item includes all concrete in the above structures which lies outside the limits of mass concrete. Exceptional care shall be taken to ensure high quality of workmanship and finish. Exterior surface of walls shall be given special finish so that the appearance from outside is that of masonry. This shall be achieved by manufacturing suitable forms or otherwise suitable coats of appropriate shade be given to match the colour of the concrete with that of masonry. The surface of the gate assembly, transfer and storage structures shall have finish F2 and U.2. The concrete under this item shall conform to class A3.

9) Concrete in Blockouts

This item of the schedule for concrete in blockouts' includes all concrete required to be placed in blockouts constructed to permit the installation and adjustment of gate seats frames, guides, tracks, bases and thrust-blocks and of track rails before the metal work is embeded in concrete, but does not include any part of any foundation or part of any structure beyond the lines of adjacent concrete surfaces. The block out shall be chipped and roughened as provided under chipping and roughening concrete surface before the concrete is placed. Exceptional care shall be taken in placing the concrete in block-outs to ensure satisfactory bond with concrete previously placed and to secure perfect and complete concrete with all metal work in the blockouts. The concrete of this item will conform to Class A2.

10) Concrete Around Sluice and Drainage Gallaries

The concrete provided for these portions shall be class A-3 with surfaces finished with U-2 finish.

2.5.11 Protection, Curing and Repairs to Concrete

2.5.11.1 Protection of Concrete

All concrete shall be adequately protected from mechanical injury. Unhardened concrete shall be protected from heavy rain and flowing water. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. All galleries, conduit and other dam openings shall be bulk headed during construction period to prevent free circulation of air and resulting drying of concrete. Exposed finished surfaces of concrete shall be protected from the direct rays of the sun for at least the first three days after placement. Such protection shall be made effective as soon as practicable after placing of unformed concrete or after the removal of forms from formed concrete.

2.5.11.2 Curing of Concrete

All concrete shall be cured by water for a period of not less than fourteen (14) consecutive days. This period shall be increased to 21 days if a pozzolanic admixture is used. Curing shall start immediately following placement of the concrete, and shall be accomplished by covering the surface with water, saturated material or by a system of perforated pipes, mechanical sprinklers or porous hose, or by any other method which shall keep all surfaces of concrete, being cured continuously wet. Appropriate measures shall be adopted to protect exposed surfaces of fresh concrete from water spray. All equipments such as pumps, pipe lines needed for round the clock curing including arrangements for overhead tank of suitable capacity shall be installed before actual placement begins. The arrangement must also be at hand for all exigencies such as power failure, dislocation of pipe line, faults in pumps etc. Detailed plans provision and procedure whereby the various protection and curing phases will be firmly established shall be settled prior to the initial stages of concrete operations.

Water for curing shall be clean and free from any elements which will cause staining or discolouration of concrete besides meeting the specifications for water used for mixing concrete.

Where forms of wood logging are used and left in place during the curing logging shall be kept wet at all times to prevent the logging from opening at the joints. Construction joints shall be cured in the same manner as other concrete surfaces and shall be kept moist up to a least 72 hours prior to placing additional concrete upon the joints.

2.5.11.3 Repairs to Concrete

Repairs to concrete shall be performed by skilled workmen. All imperfections of the concrete surfaces shall be corrected as necessary to produce surfaces that conform to the requirements specified under "Finishes". Repairs of imperfections in formed concrete shall be completed as soon as practicable within 24 hours after the removal of forms. Fins shall be neatly removed from the surfaces for which finishes F-2, F-3 and F-4 are required. Concrete that is damaged from any cause, concrete that is honey-combed, fractured or otherwise defective and concrete which has excessive surface depressions must

be removed and built up to bring the surface to the prescribed lines or shall be removed and replaced by dry pack mortar or concrete as herein after specified.

Where bulges and abrupt irregularities protrude outside the limits specified under "Finishes" on formed surfaces for which finishes F-2 and F-3 are required, the protrusions shall be reduced by bush hammering and grinding so that the surfaces are within the specified limits. Dry pack filling shall be used for holes that have surface dimensions smaller than the depth of the hole, for holes left by the removal of fasteners from the ends of form tie rods, for grout insert holes and for narrow slots left out for repairs of cracks. Filling of holes left by removal of fasteners from the ends of tie rods in the surfaces, for which finishes F-1 is specified will not be required. Dry pack shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.

Mortar filling, placed under impact by use of mortar gun shall be used for holes too wide for dry pack filling and too shallow for concrete filling and not deeper than the far side of the reinforcement that is nearest to the concrete surface.

Concrete filling shall be used for holes extending entirely through concrete sections, for holes which are greater in area than 1000 sq.cm and deeper than 100 mm and for holes in reinforced concrete which are greater in area than 500 sq. cm which extend beyond reinforcement. All materials, procedures and operations in the repair of concrete shall be subject to directions by officer in charge. All filling shall be bonded tightly to the surfaces of the holes and shall be sound and free from shrinkage, cracks and drummy areas after the filling has been cured and dried. All fillings in surfaces for which finish F-3 as specified shall contain sufficient white portland cement to produce the same colour as that of the adjoining concrete.

All patching shall be done with extreme care so that patches will not be noticeable from a distance of 25m. Coloured cement as an ingredient of patching mortar may be used if necessary to produce patch of same colour as the adjoining concrete.

2.5.11.4 Dry Pack-Mortar

Repair operation shall be proceeded by a careful inspection to see that the hole is thoroughly clean and slightly wet but with a small amount of free water on the interior surfaces. The surfaces shall then be dusted lightly and slowly with cement by means of a small dry brush until all surfaces have been covered and hardened by the absorption of water by the cement. There shall be no dry cement in the hole when packing begins and such cement, if present shall be removed. The holes shall not be pointed with wet cement grout.

Dry pack mortar shall consist of mixture of 1 part of cement to 2½ parts of sand that will pass a No.16 screen cement shall be used in sufficiently quantity to produce uniform colour matching with that of surrounding concrete at points, wherever desired by the Engineer-in-charge.

For packing cone bolt holes, a leaner mixture of 1 to 3 or 1 to 1 $\frac{1}{2}$ will be used. Only enough water shall be used to produce a mortar which when used will stick together on being moulded into a ball by slight pressure of hands, and will not exude water but will leave hands damp. (The proper amount of mixing water and proper consistency are those which will produce a filling which is at a point of becoming rubbery when the material is solidly packed).

Dry pack mortar shall be placed and packed in layers having a compacted thickness of about 10 mm. The surface of each layer shall be scratched to facilitate bonding with the next layers. One layer may follow another immediately unless appreciable rubberiness develops, in which case work on the repair shall be delayed 30 to 40 mts. Under no circumstances shall alternate layers of wet and dry materials be used.

Each layer must be solidly compacted over its entire surface by use of a hard wood stick usually 20 to 30 cm. long & 25 mm in dia. and hammer. Much of tamping shall be directed at a slight angle and towards the sides of the hole to assure max. compaction in these areas. The holes shall not be over filled and finishing shall be completed at once by laying the flat side of hard wood piece against the fill and striking at several good blows. Steel finishing tools shall not be used and water must not be used to facilitate finishing.

2.5.12(i) Forms for Concrete

Forms shall be used wherever necessary to confine the concrete and shape it to the required lines, or to insure against contamination of concrete by materials caving or sloughing from adjacent excavation or other features of the work. All exposed concrete surface having slopes of 1 to 1 or greater shall be formed. Where the side slopes or walls of an excavation for a concrete structure can be trimmed to the prescribed lines without sloughing, the use of forms will not be required. Forms shall have sufficient strength to hold concrete and to withstand the pressure of ramming and vibration of the concrete and shall be maintained rigidly in correct position. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Moulding strips shall be placed in the corners of forms so as to produce bevelled edges on permanently exposed concrete surfaces. Interior angles of such surfaces and edges at formed joints will not require bevelling unless so indicated on the drawings. Forms for concrete surfaces for which finishes F-3 and F-4 are specified shall be reset and tightened at construction joints, so that they fit snugly and firmly against the hardened concrete when concrete placement is resumed. Additional form ties shall be used as necessary to insure against spreading of the reset forms under pressure of the subsequently placed concrete and consequent offset from the previously formed face.

ii) Form Sheathing and Lining

Wood sheathing or lining shall be of such kind and quality or shall be so treated or coated that there will be no chemical deterioration or discolouration of the formed concrete surface. The type and condition of forms sheathing and lining the ability of the forms to withstand distortion caused by

placement and vibration of the concrete, and the workmanship used in form construction shall be such that the formed surfaces after being finished will conform with the applicable requirements of these specifications pertaining to finish of formed surfaces. Where finish F-3 is specified, the sheathing or lining shall be so placed that the joint marks on the concrete surfaces will be in general alignment both horizontally and vertically. Except where otherwise specifically provided, materials used for form sheathing or lining shall conform to the following requirements:-

Requirement finish of formed surface	Wood Sheathing	Steel Sheathing or Lining
F - 1	Any grade.	Steel sheathing permitted
F - 2	No. 1 common slip lap or plywood sheathing or lining	Steel sheathing permitted if necessary
F - 3	No. 1 common tongue and grooved except where plywood lining or sheathing is specifically required.	Steel sheathing not permitted. Steel lining not permitted.
F - 4	No. 1 common tongue and grooved for plain or cylindrical surface thin plywood lining or warped surfaces.	Steel sheathing permitted. Steel lining not permitted.
F - 5	Absorptions form lining backed with No. 1 common slip lap.	Steel sheathing not permitted. Steel lining not permitted.

Steel "sheathing" denotes steel sheets not supported by a backing of wood boards. Steel lining denotes thin steel sheets supported by a backing of wood boards.

iii) Plywood Form Lining

Plywood shall be used for lining forms for surfaces that will be exposed permanently to view. The plywood shall be water proof, non warping, non-wrinkling concrete form plywood manufactured with special water resistang glue. So far as practicable the plywood sheets shall be of uniform width length and shall have a uniform thickness of not less than 16mm or not less than 10mm if backed with sliplap or other approved backing. Tempered, water proof, pressed board or similarly approved material not less than 3mm thickness may be used instead of plywood if backed with sliplap or other approved backing. The joints between the plywood or pressed board sheets shall be smooth and as nearly perfect as practicable and no patching of the plywood or pressed board lining will be permitted. Minor imperfections in the plywood or pressed board lining shall be corrected by the use of plastic wood secured firmly in

place and prepared smooth after it has hardened thoroughly. The use of sheet metal to correct imperfections in such lining of forms will not be permitted.

iv) Forms for Warped Surfaces Designated F-4 Finish

Forms for the draft tubes and transition of penstock and such other warped surfaces shall be constructed so as to conform accurately to the required curvatures of the sections. Dimension from the centre lines of the draft tubes to the concrete surface shall be given at general sections throughout the length of the draft tubes. Intermediate sections will be interpolated as necessary for the type of form construction being used and the forms shall be constructed so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form sheathing shall be built of laminated splints, cut to make tight and smooth form surfaces.

The forms shall be so constructed that the joints marks on the concrete surfaces inside the principal water conduit shall, as far as possible, follow the line of water flow. After the forms have been constructed, all nails shall be hidden and any roughness and all angles on the surface of the forms caused by matching the form materials shall be dressed to the required curvatures.

v) Form Ties

Embedded metal rods used for holding forms shall remain embedded and shall terminate not less than 30mm clear of the formed faces of the concrete where the max. size of aggregate in the concrete is 40mm or less and not less than 50mm clear of the formed faces of the concrete where the max. size of aggregate is 50mm. Embedded fasteners on the ends of rods shall be such that their removal will leave holes of regular shape. Embedded wire ties for holding forms will be permitted in concrete walls for which finish F-1 is specified, except walls to be subjected to water pressure. Embedded wire ties will not be permitted in concrete wall for which other finishes are specified. Wire ties shall be cut off flush with the surface of the concrete after the forms are removed.

vi) Cleaning and Oiling of Forms

At the time concrete is placed in the forms, the surfaces of the forms shall be free from incrustations of mortar, grout, or other foreign materials that would contaminate the concrete or interfere with the fulfilment of the specification requirement relating with the finish of formed surfaces. Before concrete is placed, the surfaces of the forms except those of timber meant for concrete surfaces which are to be plastered, shall be oiled with a commercial forms oil to effectively prevent sticking and staining of the concrete surfaces. After oiling, surplus oil on the form surface and oil on the reinforced steel or other surfaces requiring bond with the concrete shall be removed. For wooden forms, form oil shall consist of straight, refined, pale paraffin mineral oil. For steel forms, form oil shall consist of refined mineral oil suitably compounded with one or more ingredients which are appropriate for the purpose. Special care shall be taken to oil thoroughly the form strips for narrow grooves at windows, doors and elsewhere so as to prevent swelling

of the forms and consequent damage to the concrete prior to or during the removal of forms.

vii) Erection of Forms

Before concrete is placed, precaution shall be taken to see that all forms are in proper alignment and that forms, anchors and ties are thoroughly secured and tight. Where forms for continuous surfaces are placed in successive units, the form shall fit tightly over the completed surfaces so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface.

Care shall be taken in forming the construction joints of the dam so as to form a smooth joint free from sharp deviations, projections or edges, and particular attention shall be taken in setting and tightening the form, so that the contraction joint surfaces are plumb and in accurate alignment.

viii) Removal of Forms

Forms shall be kept rigidly in place until, they can be removed by careful and experienced workmen without chipping, spalling or defacing the concrete surface. Forms shall be removed as soon as practicable in order to avoid delay in water curing and also to enable earliest practicable repair of surface imperfections. In order to avoid excessive stresses in concrete that might result from swelling of forms, wood forms for wall openings shall be loosened as soon as this can be accomplished without damage to concrete. Forms for opening shall be constructed so as to facilitate such loosening.

2.5.13 Porous Concrete

This item of schedule for porous concrete is generally composed of one part of cement to five and a half parts of aggregate by weight. The fines in the aggregate on i.e. sand may be permitted upto 10% of the total aggregate. Only so much water shall be used in the concrete as is required to produce a paste which will coat the particles without filling the voids. In placing porous concrete, care shall be taken to ensure that it is not over tamped or compacted so as to reduce its porosity. The porous concrete after curing shall be pervious and of free drainage type. As soon as the concrete hardens, so that the paste cannot be washed away it should be sprinkled and kept moist for at least 14 days. The compressive strength of porous concrete at 7 days as determined by tests on 15 cm. by 30 cm. cylinders should not be less than 70Kg/cm² and the porosity at 7 days be such that water shall pass through a slab of the concrete 30 cm. thick at a minimum rate of 0.07 litre per minute/cm² of the slab with a constant 100 mm depth of water on the slab.

The porous concrete so prepared shall be poured into rectangular moulds of convenient size in order to be able to incorporate central holes of 20cm. diameter. After curing, these blocks of porous concrete shall be used for making the formed drains near the upstream face of the masonry dam.

2.5.14 Measurements and Payments

2.5.14.1 General

The prices entered in the schedule for the incorporation of the various classes of concrete, plain, reinforced and porous required by the section shall be all inclusive constituting full compensation for mobilising, demobilising and supplying all equipment, forms, materials, curing, 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 included in the schedule.

2.5.14.2 Except as otherwise expressly provided for in the specifications, measurement of the 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.

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

No measurement shall be made for the concrete backfill beyond the minimum lines of excavation shown on the drawings except where such payments is specifically authorized. Measurement of concrete shall be made after deducting the volume of all recesses, shafts, passageways, chambers, opening cavities and depression, embedded pipes and metal works but without deduction for round or bevelled edges or spaces occupied by electrical conduit and reinforcement.

2.5.14.3 The item of concrete in foundation faults, seams and crevices including all concrete in the shaft below the bottom of the trench shall be measured on the basis of the volume of pocket.

2.5.14.4 The item of concrete upto crest level of the dam include all concrete in the main structure of the dam contained between normal upstream and downstream faces of the dam including concrete in block outs, trash rack, river sluices, irrigation sluice, 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.

2.5.14.5 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 over flow portion of the dam, power dam and block outs 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.

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

2.5.14.7 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.

2.5.14.8 Wherever red cement concrete is specified 20% of cement is replaced by Surkhi

The department will replace a part of the cement upto (about 20%) by Surkhi or other puzzolana material. The rate for modified mix obtained by replacement of cement by puzzolana shall be worked out by the difference in cost of cement and puzzolana. No other charge will be added to or reduced from the rate tendered by the contractor.

2.5.14.9 Payment for the various classes of the concrete shall be made on the basis of unit prices per cubic metre entered in respect of items in the schedule.

2.5.15.1 Placing Anchors in Concrete

Anchor bolts, structural shapes, plates and bearings required in connection with the installation of gates, gate hoists, operating machinery and other apparatus shall be placed in concrete as shown on the drawings or as found necessary. Wherever practicable, anchors shall be installed before the concrete is placed, and except as otherwise provided drilling for installation of anchors in concrete will not be permitted.

Where installation of anchors prior to placing of concrete is not practicable, satisfactory formed openings shall be provided and the anchors shall be grouted with the openings at some later time. Anchor holes for machinery may be placed in approved pipe sleeves to facilitate installation of machinery and the sleeves shall be completely filled with grout after the locations of the holes are finally determined.

2.5.15.2 Drilling Holes and Grouting Anchor Bars in Rock

In the spillway apron, the spillway retaining walls and elsewhere as shown on the drawings, or as directed, holes shall be drilled into the rock to receive bars for anchoring concrete structures or parts thereof with the rock. The types and dimensions of the anchor bars, the locations, diameters and depths of the anchor bar shall be as shown in drawings or as directed. The diameter of each anchor bar hole shall not be less than $1\frac{1}{2}$ times the diameter of the largest transverse dimension of the bar specified for that hole subject to minimum of 12 mm over the bar dimensions. Anchor bar shall be cleaned thoroughly and shall then be completely and compactly filled with grout or proper proportions. Each anchor bar shall be forced into place to full depth immediately after the grout has been placed and shall then be rammed or vibrated until the entire embedded surface of the bar is in intimate contact with the grout. Special care shall be taken to prevent any movement of bars after they have been placed, till the grout has adequately hardened. Alternatively, the insertion of the anchor bar into the fresh grout filled hole may

be carried but immediately prior to replacement of concrete in the locations, the hardened concrete will then prevent undesirable vibration being imparted to the anchor bar and lead to avoidance of separation.

2.5.15.3 Measurements and Payments

The work of drilling holes for receiving anchor bars shall be measured in accordance with provision of the relevant portion of the section of "Drilling" and shall be payable at the unit price entered for the item "2" Wet percussion drilling 47 mm to 75 mm dia. holes". The work of providing anchor bars, shall be measured in accordance with provisions of the relevant portion of reinforcement and shall be payable at the unit price for respective item of "Reinforcement".

The grout actually utilised in filling holes of anchor bars shall be measured in accordance with the provisions of the relevant portion of the section "Grouting" and shall be payable at the unit price for the item "Grouting including cost of Cement".

2.5.16 Reinforcement Bars Fabric and Anchors

2.5.16.1 General

Steel reinforcement bars shall be placed in the concrete wherever shown on the drawings. Steel reinforcing bars shall be mild steel or cold twisted deformed bars or tor steel as indicated in the drawings.

2.5.16.2 Quality of Reinforcement shall be of any of the following:

- i) Mild steel and high tensile steel bars and hard drawn steel wire conforming to I.S. 432-1960 as revised from time to time.
- ii) Structural steel sections conforming to I.S. 226-1955 as revised from time to time.
- iii) Cold twisted steel bars complying with requirements of I.S. 1786-1966 of amended from time to time.
- iv) Such other reinforcement as may be proved suitable having regard to yield point stress, ductility ultimate resistance to the tension and other essential properties of completed reinforcement as produced in readiness for reinforced concrete.

2.5.16.3 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.

2.5.16.4 Cutting and Bending.

Reinforcement bars shall be of the size prescribed and shall be accurately cut to the length and bent to the shape and fixed in position of shown on the drawings or as directed by Executive Engineer and shall conform to I.S. 2502-1963 as revised from time to time.

2.5.16.5 Deformed bars shall not be reset after being bent and straightened unless initial bending and subsequent straightening and bending are carried out under proper approved supervision.

2.5.16.6 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.

2.5.16.7 Jointing and Splicing

Joints or splices in the 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 position of joints and splices in adjacent bars are staggered and are placed as approved

2.5.16.8 Reinforcement bars 38 mm in diameter 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.

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

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

2.5.16.11 Butt welding of reinforcement bars shall be performed under cover from weather and may be performed 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 accumulated 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 to be joined by arc welding and the ends of

the bars shall be matched accurately and shall be retained firmly in position during 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 to be joined by electric arc welding, the weld metal shall be deposited in successive layers and each layer shall be thoroughly cleaned before 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 rewelded.

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 rewelded.

- 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 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, and preparation, pressure, heating and upsetting as will be used for 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 workmanship of welding operators will be subject to inspection and approval at all times during the progress of the work.

2.5.16.12 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 various sizes and grades shown. Hooks will not normally be prescribed for splices in structural grade deformed bars.

Lapped Splices			
Diameter of bars in m.m.	Grade of bar	Minimum Length of Straight splices.	overlap in
		For S.210 Concrete	S 175 Concrete
8	M.S. Rounds	21 cm	28 cm
10	M.S. Rounds	35 cm	47 cm
12	Deformed ribbed bars	49 cm	66 cm
16	-do-	65 cm	88 cm
20	-do-	82 cm	110 cm
22	-do-	83 cm	110 cm
25	-do-	94 cm	125 cm
32	-do-	120 cm	160 cm
36	--do-	135 cm	180 cm
40	-do-	150 cm	200 cm.

2.5.16.13 Binding wire used shall be of soft annealed steel of 16 S.W.G. 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.

2.5.16.14 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, 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.

2.5.16.15 Measurement of steel reinforcement shall be made for the weight of the steel reinforcement, exclusive of weight of weld 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 cost of supplying binding wire, labour in making lap joints, tack welding, welded joints, ties, 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 will be made on account of wastage. The rate shall be inclusive for wastage of steel bars. Steel used for supports, ties, pins etc. will not be measured for payment. Wherever welding is done as per direction of the Executive Engineer it shall be payable. Welded joints shall be paid

on the basis of equivalent lap length of the bar of respective diameter and shall include cost of all material and labour.

The weight as specified by the manufacturer's sectional tables shall be taken as standard for purpose of computing total weight of steel used as reinforcement.

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

2.5.17 Furnishing and Installing Instruments in Dam

It is desirable to make instrumental observations on internal temperatures, the joint openings, stress distribution, uplift pressure and deflection of the dam in order to check the design assumptions and to watch the behaviour of the structure during and after construction.

For this purpose electrical instruments like thermometer, joint meters, stress and strain meters, pressure cells and other appliances like uplift pressure pipes with the gauges and plumb line well shall be installed as directed at locations indicated in the drawings. This work does not come under the scope of this contract.

Instruments

The thermometer, joint meter, stress meter, strain meters, pore pressure cells and conduits if required will be furnished with necessary lengths of electrical leads attached for connecting the instruments to terminal boards located in the galleries. The electrical instruments mentioned consists of small electrical resistance coils sealed in suitable protective coating of metal and rubber tubing and will not weight more than a few pounds each. The terminal boxes shall be installed in the side walls of the galleries and mounted flush with walls.

The leads will be specially fabricated rubber insulated and rubber sheeted cable, designed to minimize the possibility of mechanical injury and to ensure long life when embedded in concrete or masonry. In general it is desirable to avoid splicing and splices will be made only when absolutely necessary. Suitable recess or grooves shall be provided in the concrete or masonry before it has obtained final set and the electrical instrument shall be placed as directed in these recesses and properly embedded in fresh concrete or masonry as directed. The cables from all instruments shall be embedded directly in concrete, or in grooves formed in masonry covered with concrete or placed in conduits as directed. The work does not come under the scope of this contract.

Appendix-I

PRESSURE GROUTING RECORD

Hole No. :	Grout Cap :	Uplift Gauges
Co-ordinates :	Width :	Bottom Elevation
Diameter :	Depth :	Top Elevation:
Elevations :	Casing Pipe :	(Space for sketch)
Natural Ground:	Depth :	
Top of Hole :	Diameter :	

Parti- culars	Hole Log	Type of grouting	Stages of grouting	Date	Time	Water Pres- sure	Pressure Test Intake Grout litres/ mix minu- tes.	Pressure Grouting Pres- sure litres con- sum- ed	Intake Cem- ent litres No.	Obs.Obs. poi- nt. No.	Leakage from nearby holes surface Hole	Extent of joints & fis- sures.			
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 holes being grout together with location and condition of nearby holes. Holes that have been drilled will be indicated by 'D' supported with the number showing the depth of the hole, such as 'D-25'. The hole has been grouted will be demarketed by the letter 'G' in similar manner. Position of upheaval 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. Cement 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 caulked", hole No. _____ capped "grout pump down", grouting suspended due to _____ hole completed and so forth.

CRITERIA FOR CONTROL OF COMPACTED DAM EMBANKMENT

Type of Material	Percentage of No. 4 fraction by dry weight of total material.	Percentage based on minus No. 4 fraction.					
		50 Feet or less in height		Greater than 50ft. high		Moisture limits	
		Minimum acceptable density	Desirable average density	Minimum acceptable density	Desirable average density	Wo-Wf	Moisture limits
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	Dd = 90	Soils should be very wet.
	Medium sands with 0-25	Dd = 70	Dd = 85		Dd = 70	Dd = 85	
	coarse sands and gravels with 0-100	Dd = 65	Dd = 80		Dd = 65	Dd = 80	
Wo - Wf	Is the difference between optimum water content and fill water content in percent of dry weight of soil.						
D	Is fill dry density divided by Proctor maximum dry density in percent.						
Dd	Is relative density as defined in Section 14, Chapter 1.						
I	Cohesive soils containing more than 50 percent gravel sizes should be tested for permeability of the total material if used as a water barrier.						
2.	For high earth dams special instructions on placement moisture limits will ordinarily be prepared.						

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 ten days	3	
2.	Filters	5000 m ³	-	10000 m ³	-	-	-	-	

