GOVERNMENT OF INDIA MINISTRY OF IRRIGATION

REPORT OF COMMITTEE ON COST CONTROL OF RIVER VALLEY PROJECTS

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GOVERNMENT OF INDIA MINISTRY OF IRRIGATION

REPORT OF

THE COMMITTEE ON COST CONTROL

OF

RIVER VALLEY PROJECTS

SPECIFICATIONS

FOR

RADIAL GATES AND ROCK FILL DAM

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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 works.

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 specification, centrally drafted, can serve the purpose of every project due to enherent variations from project to project as well as in local practices and availability of local material required to be used to ensure economy in construction. It is felt that in a large number of items connected with River Valley Project a standard pattern of uniform contract specifications can be drawn up. The effort has been made to obtain contractual specifications of few of the Major projects taken up recently for construction. These are given in volume III, IV and V for reference and guidance of project authorities.

SPECIFICATIONS

FOR

RADIAL GATES

NARAYANPUR DAM - UPPER KRISHNA PROJECT

GENERAL SPECIFICATIONS

1. The work will be on the lines of the drawings attached to the tender documents. The drawings show a tentative proposal for installing the various gates and suppurtenant features and dimensions.

The work included in the tender is as follows:

5 Nos. of radial cates for the spillway dam of size 15 M \times 12 M from chainage 2543.884 M to 2632.884 M. with sill level at about R.L. 480.103 M. The top of the crest gate will be at R.L. 492.252 M in the closed position. The size of the crest gate 15 M \times 12 M represents the clear vents size. The height being measured vertically above the crest level of the spillway i.e., 480.252M.

The distance between the adjacent pier is 15 M and the maximum water level is 12 M above the crest of the dam. The pin level of the crest gate is tentatively fixed at R.L. 484.252 M. The radius of curvature of crest gates measured from the pin to the inside of the skin plate is 12 M. The width of the piers is 3.50 M.

All the above levels and dimensions are tentatively fixed. If the tenderer desires to have any change in the dimensions and the position he should specifically indicate the same in his tender as well as his tender drawings.

The work shall be executed as per detailed specifications attached to this tender and as per directions issued by the Executive Engineer or his authorised representative.

2. Units

The rate shall be quoted for each item for units mentioned in schedule 'B' against each item in words and figures.

3. The contractor shall provide at site of work one note book (well bound and pages machine numbered) for being used as a work order book. The contractor shall be responsible for obtaining all the orders entered in the order book and he or his authorised agent shall sign the orders issued by the Engineer-in-Charge in token of acceptance and shall carry them out strictly in accordance with these instructions. The contractor may make his own arrangements to take copies thereof, if necessary.

4. Blasting Operations

Any blasting done by means of explosives in the project area shall be in conformity with the Explosives Act and the rules thereunder, as may be framed from time to time.

5. Errors, Omissions and Discrepancies

- a) In all cases of omissions, doubts or discrepancies in the dimensions or descriptions in the drawings and items of work, a reference shall be made to the Executive Engineer whose elucidation and elaboration shall be responsible for any error that may occur in the work through lack of such reference and precautions.
- b) The contractor shall be responsible for accuracy of all shapes, dimensions and alignments etc., of all the componenets of the work.

6. Supply of Steel

The contractor shall have to make his own arrangements to procure the steel materials required for fabrication works.

Government will recommend to Government of India, for obtaining permits, quota certificates, provided the contractor proposes to fabricate the equipment in India, but the Government do not undertake the guarantee for either timely provision or the price and the contractor shall frame his tender accordingly. If for any reason the Govt. is unable to secure permits, quota certificates the contractor shall make his own arrangements to procure the same. Non securing of the permits, quota certificates shall not be made a plea by the contractor for claiming extra rate but if necessary extension of time for completion of the work will be given for the delay occasioned due to delay in procurement of steel materials and other essential parts provided, the firm approaches the competent authority in writing with convincing reasons and in time for such extension. The Engineer-in-Charge shall at all the times, have access to the stores and sites of the contractor and shall have authority to check and examine the method of storage, records accounting and security provided by the contractor. The contractor shall comply with the instructions that may be given by the Executive Engineer in this behalf.

7. The use of water for work, and domestic consumption from the river will be allowed free of cost to the contractor. The contractor shall have to make his own arrangements for pumping, purification etc., The final disposal of water used for works or removed from work spots as well as the supply used for domestic consumption shall be as directed by the Executive Engineer. The contractor shall make his own arrangements for purification of domestic water supply used by his staff and labour colony and used on the site of work to the satisfaction of the Executive Engineer.

Contractor.

Executive Engineer, ID., UKP.Dam R.B.Divn., Rodal-banda

ADDITIONAL GENERAL CONDITIONS AND SPECIFICATIONS

- 1. START OF WORK: The contractor shall not enter upon or commence any portion of work except with the written authority of the Engineer failing which the contractor shall have no claim to ask for measurement of or payment for work and shall be responsible for any claim or damages that may arise due to such unauthorised commencement or entry.
- SUBMISSION & APPROVAL OF DESIGNS AND DRAWINGS
- i) At least four copies of the complete design calculations and drawings for the crest gates shall be submitted by the contractor within 2 months from the date of work order.
- ii) The contractor shall be bound to make all such modifications in the said design and drawings as suggested by the accepting authority, which consider necessary to comply with the standard codes and specifications mentioned in this contract or in their absence, with the principles of sound engineering practice, at no extra cost to the Department and submit all such modified designs and drawings within a period of one month of the observations. The contractor shall give the Engineer-in-Charge on the 4th day of each month, progress of the work done during the previous month.
- iii) On receipt of the approval to the contractor's design and drawings, the contractor shall supply to the Accepting Authority, within a period of 15 days of the receipt of such communication ten copies of approved drawings for use of the Department. Two sets of drawings shall be signed by both parties to the contract for the purpose of identification.

These drawings when so signed and the design calculations shall become the property of the Govt., and be deposited with the Engineer, and shall not be departed from in any way whatsoever except by the written permission of the Engineer as herein after provided.

In the event of the contractor desiring to possess a signed set of drawings, he shall supply extra set and the Engineer shall sign the extra set and return the same to the contractor,

The contractor, if required by the Engineer, shall supply in addition, copies of any drawings other than shop drawings, which may reasonably be required for the purposes of the contract at his cost. The Engineer or his duly authorised representative, whose name shall have previously been communicated in writing to the contractor, shall have right at all reasonable times, to inspect at the factory or works of the contractor, the shop drawings of any portion of the work.

The contractor shall submit to the Engineer for approval three sets of Amonia prints, or suitable size of all shop drawings containing all required detailed information. One copy of the drawings will be returned to the contractor either approved or with remarks for compliance and repeating the above procedure if and so directed.

The approval of the drawings, however, will not relieve the contractor of any errors or omissions as he is responsible for the dimensions designs and satisfactory working.

The period offered for completion of work will be reckoned from the date of work order.

3. MISTAKES IN DRAWINGS

The contractor shall be responsible for any discrepancies, errors, or omissions in the drawings or other particulars supplied by him and shall pay all the costs of the alteration in the work necessitated thereby notwithstanding the fact that such drawings or particulars have been approved by the Engineer provided that such discrepancies, errors or omissions; be not due to inaccurate information or particulars furnished to the contractor by the Engineer. The purchaser shall be responsible for drawings and information supplied by the Engineer and the purchaser shall pay all the cost of any alterations in the work necessitated by reason of inaccurate information supplied by the Engineer to the contractor.

The stipulation mentioned in para 5 (a) of general specifications of contract shall also hold good.

4. WORKMANSHIP AND MATERIALS

The equipment shall be manufactured, constructed provided, put in position, carried out as mentioned in all respects with the workmanship and materials of the best and most substantial and approved quality to the entire satisfaction of the Engineer who may reject any plant, apparatus, material or workmanship which shall in his opinion, be defective in quality and such rejection to be final and conclusive.

5. INSPECTION AND TESTING

- a) The Engineer, or his duly authorised representative, shall have at all reasonable times access to the contractor's premises or works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the plant during its manufacture and or erection thereof and if part of the plant is being manufactured or erected on their premises works, the contractor shall obtain for the Engineer and for his duly authorised representative permission to inspect as if the plant or materials were manufactured or erected on the contractors own premises for works, at Government cost.
- b) If the fabrication is intended to be done outside India, the fabricator shall comply with such of the conditions as the Engineer may impose for testing the equipment welds, X-rays hydraulic tests etc., The inspection of such tests will normally be carried out through either the India Stores Department or an International Agency or Agencies of repute dealing with such materials, payment for such independent inspection shall be borne by the contractor and the costs of the actual tests, shall be considered included in the various unit rates accepted in the tender.

- c) The contractor shall give the Engineer, notice of any materials being ready for testing, and the Engineer or his said representative shall on giving twenty four hours previous notice in writing to the contractor attend at the contractor's premises or works within fifteen days of the date on which the materials are notified as being ready, failing which visit, the contractor may proceed with the tests, which shall be deemed to have been made in the Engineers presence and he shall forthwith forward to the Engineer duly certified copies of the tests in duplicate.
- d) The contractor shall provide free of charge such labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be deemed necessary to carry out efficiently such tests of the plant in accordance with the contract, and shall give facilities to the Engineer or his authorised representative to accomplish.
- e) When the tests have been satisfactorily completed at the contractor's premises or works the Engineer or his duly authorised representative shall issue a certificate to that effect, and no plant shall be transported before such certificate has been issued. The satisfactory completion of these tests or the issue of this certificate shall not bind the Engineer to accept the plant so passed for shipment should it on further tests after erection be found not to comply with the specifications.
- f) The Engineer or his duly authorised representative shall on giving seven days notice in writing to the contractor setting out any grounds of objections which he may have in respect of the work, be at liberty to reject all or any materials plant or work-manship the subject of any of the said grounds of objection, which in his opinion are not in accordance with the contract, or are in his opinion defective for any reason whatsoever. Unless specifically provided, otherwise all tests shall be made at the contractor's works before shipment.

6. TESTS ON SITE

E

After receipt of the equipment or any integral part thereof the Engineer may ask for any site test to be carried out such as water tightness, prescribed tolerance etc., and the tenderer shall arrange to carry out the same at his cost.

7. TESTS ON COMPLETION

Whenever possible all tests shall be carried out before transportation, should, however, it be necessary for the final tests as to performance and guarantees to be held over until the equipment is erected at site they shall be carried out by the contractor within three months of completion of erection (excluding the monsoon period) or at dates as may be directed by the Engineer. If these tests not come within the mark the tests shall, if required by the Engineer, be repeated within one month from the date the equipment is ready for retest and the contractor shall repay to the purchaser all reasonable expenses to which he may be put by such tests. The responsibility of correct erection and performance of the equipment shall rest with the tenderer and any defects therein shall be made good by him at his cost.

8. TAKING OVER

In the event of the final or any outstanding tests being held over until the plant is erected, the acceptance certificate shall be issued subject to the results of such final or outstanding tests, which shall be carried out in accordance with para 6.

If for any reason other than the default of the contractor such test or tests, as the case may be, are not carried out, the plant shall be deemed to have been taken over and payments due to the contractor on taking over shall be made but nevertheless the contractor shall if called upon to do so by the purchaser make the said tests during the maintenance period and except as aforesaid under the same obligations as specified in para 9.

The Engineer shall not delay the issue of any taking over certificate contemplated by this para on account of minor defects in the plant which do not materially affect the commercial use thereof provided that the contractor shall undertake to make good the same in due course.

9. RIGHT TO OPERATE UNSATISFACTORY EQUIPMENTS

The purchaser shall have the right to operate any and all equipment as soon as and as long as it is in operating condition whether, or not such equipment has been accepted as complete and satisfactory, except that it shall not be construed to permit operation of any equipment which may be materially damaged by such operation before any required alterations or repairs have been made.

All repairs or alterations required of the contractor shall be made by him at such time as directed by the Engineer. The repairs or alterations shall be made in such a manner and at such time that it will cause the least interruption in the use of the equipment.

10. MAINTENANCE

For a period of 12 (Twelve) calendar months commencing immediately upon the satisfactory completion of the final tests after erection at site, the contractor's liability shall be limited to the replacement of the defective parts that may develop in the equipment under proper use and arising solely from faulty design, materials, or workmanship provided always that such defective parts as are not repairable at site, and are not essential in the meantime in commercial use of the plant are promptly allowed to be removed unless otherwise arranged.

If it becomes necessary for the contractor to replace or renew any defective portion of the plant under this para the provisions of this para shall apply to the portions of the plant to be replaced or renewed until the expiration of six months from the date of such replacement or renewal of until the end of the above mentioned period of twelve months, whichever may be later. If any defects be not remedied within a reasonable time, the purchaser may proceed to do the work at the contractor's risk and expense, but without

prejudice to any other rights which the purchaser may have against the contractor in respect of such defects. The fitting of the replaced parts will also be done by the contractor. If any repair, replacement or removal of defective parts is carried out on his behalf at site the contractor shall bear the cost of such repairs, replacement or removal.

11. PATENTS, RIGHTS, ETC.

The contractor shall fully indemnify the Govt. against all actions, suits, claims, demands, costs, charges and expenses arising from or incurred by reasons of any infringement or alleged infringement of any patent rights, trade mark or name, copy right or other protected rights in respect of any machine, plants, work, materials, thing of system or method of using, fixing, working arrangement used or fixed or provided by the contractor, but this indemnity shall not extend or apply to any action suit, claim, demand cost charges or expenses arising from or incurred by reasons of the use of the works or any part thereof otherwise than in the manner or the purpose contemplated by the contract. All royalties and other similar payments which may have to be paid for the use of any such machine, plant, work, material thing, system or method as aforesaid (whether payable in one sum or by instalments or otherwise) shall be covered by the contract (rate) and be payable by the contract (Rate) and be payable by the contract

In the event of any claim or demand being made or action or suit brought against the Government in respect of any such matter or matters aforesaid the contractors shall be duly notified thereof and he shall conduct all negotiations for the settlement of such claim or demand and such action or suit shall also be conducted by him, subject, if and so far as the purchaser shall think proper, to the supervision and control through the officer duly authorised in this behalf.

12. POWERS TO VARY OR OMIT WURKS

No alteration, amendments, omissions, additions, suspensions, or variations of the work (hereinafter referred to as variations) under the contract as shown by the contract drawings or the specifications shall be made by the contractor except as directed in writing by the Engineer but the Engineer shall have full power, subject to the provision hereinafter contained, from time to time during the execution of the contract by notice in writing, to instruct the contractor to make such variation without prejudice to the contract and the contractor shall carryout such variations and be bound by the same conditions, as for as applicable though the said variations, occured in the specifications.

13. DELIVERY OF MATERIALS

No plant or materials, tendered for shall be shipped without the prior approval of the Engineer. The Engineer shall give sufficient notice to the tenderer in case a hold up is likely to occur.

14. INSURANCE

The firm shall be responsible for any loss to the equipment and its ancillary parts till it is finally handed over to the Department in good condition. Towards this end the firm, if desired may insure the plant and its ancillary parts against destruction or damage during transit from the place of manufacture to the site of work and thereafter by fire. Earthquake, flood, storm, undue exposure to the weather or through. 'Riot', civil commotion, War or Rebellion for the full value of the plant and materials until the plant and materials are taken over by the Department.

The cost on account of such insurance and surveys shall be deemed to be included in the price tendered and accepted for the equipment.

15. PROGRESS SCHEDULES

The contractor on acceptance of his tender shall within 30 days, or in such additional time as may be got approved from the Engineer submit a progress schedule in quadruplicate: showing dates by which he proposes to complete the various operations involved in the work, subject to a completion of the whole job as per the prescribed dates.

In case it is found necessary subsequently to alter the schedule he shall submit a revised schedule for fresh approval of the Engineer.

16. OBLIGATORY COMPLETION TIME LIMITS

The obligatory cumulative time limits for submission of design and drawings, supply at site and complete installation of the gate parts after the issue of work order are as under:-

Fabrication, Transporation and Delivery of Parts at Site From the Date of Work Order

- a) Submission of complete designs and drawings. 2 Months
- b) Fabrication of all the embedded parts including transportation to site of work.
 5 Months
- c) Fabrication, testing and transportation of all the parts (except item b). 9 Months
- d) Erection, trial running and handing over to the department. 13 Months

These time limits shall be adhered to subject to such extensions of period as may be granted by the Engineer as per condition No.67 of General conditions of contract. The site for erection will be handed over as and when the civil works are completed. If due to unavoidable circumstances the Department is unable to make available the site for erection by the time all the provision of parts are brought to site, no extra charges for erection will be paid for delay in handing over the site for erection.

16(a) TERMS OF PAYMENTS

Subject to any deduction which the Engineer may be authorised to make under the contract the contractor shall on the certificate of the Engineer, be entitled to payment as follows in the running and final bills in Indian Currency:

i) Advance payment - 85% of cost of steel materials castings, motors, worm reducers, brakes and other lought out items shall be paid subject to production of certificate from the Chief Engineer, or his authorised representative.

For purpose of this clause.

- a) Steel procured shall be at stock yard rates or existing at the times of procurement.
- ii), 90% of the cost of fabrication shall be paid on steel materials after deducting the proportionate advance paid on these materials as per item (i) above subject to the production of a certificate from the Chief Engineer, or his authorised representative. For the purpose of this clause, the rate of fabrication charges shall be taken as 4,000/-(Rupees Four thousand only) per M.T.
- iii) 100% of the cost of transportation at unit rates shall be paid after the materials are actually brought to site. For the purposes of this clause the rate of transportation shall be taken at Rs.100/-M.T.
 - iv) 90% of the cost of erection on percentage of progress made shall be paid at the end of every month. For the purpose of this clause the rate of erection shall be taken as Rs.800/-M.T.
 - v) Balance shall be paid within 30 days from the date of completion of work in all respects. The final bill shall be raised on 'Job-basis' only as specified in schedule deducting the amounts paid as advances under above clauses.

17. CERTIFICATE OF THE ENGINEER

Every application to the Engineer for a certificate regarding completion of the work or a particular item thereof must be accompanied by a detailed invoice (in-duplicate) setting forth in the order of the schedule 'B' particulars of the work executed and the certificate as to such plant and the work as the reasonable opinion of the Engineer is in accordance with the contract shall be issued within 14 days if possible or within such time of application for the same as is reasonably necessary. If due to unavoidable reasons the certificate cannot be issued by the Engineer or his authorised representative within 14 days as specified the bills claimed by the firm shall be paid subject to vertification during next visit. However the inspection is obligatory before payment of next bill.

No application for a certificate shall be made within 30 days of the previous application. The Department shall assign this work to one Assistant Engineer (Mechanical) to facilitate speedy inspection and prompt issue of certificate (as per G.O. No. PWD 34 GUK 71 dated Bangalore, The 15 October 1973).

No certificate of the Engineer on account of any sum paid on account nor any extension of time for the execution of the works by the contractor under the powers granted by these terms shall effect or prejudice the rights of the purchaser against the contractor or relieve the contractor of his obligations for the due performance of the contract or be interpreted as approval of the work done or of the materials supplied and no certificate shall create liability on the Engineer to pay for alterations, amendments, variations or additional work not ordered in writing by the Engineer or discharge the liability of the contractor for payment of the damages whether due, ascertained or certified nor of any sum against the payment of which he is found to indemnify the Engineer, nor shall any such certificate nor the acceptance by him of any sum paid on account of or otherwise shall effect or prejudice the rights of the contractor against the Engineer.

18. GOVERNMENT AUTHORISED TO WITHHOLD PAYMENT DUE TO THE CONTRACTOR

Government shall have lien on all money, payable to the contractor under this contract and also over his security deposits with held of recoveries made under relevant paras of this contract, in respect of any Government tax or taxes or other money which may become payable to Government by the contractor either alone or jointly with another, under the provisions of the Government Acts or any other statutory enactments in force or in modification or substitution thereof, Government shall at all times be entitled to deduct the said sum or tax due from the contractor from the moneys, securities, or deposits which may become payable or returnable to the contractor under this contract.

19. TITLE OF PARAS

The titles of the paras do not form part of the same and shall not effect their legal construction.

20. JURISDICTION

The contract shall be governed by the laws of Indian Union for the time being in force and be subject to the jurisdiction of Indian Courts.

21. TRAINING OF GOVERNMENT PERSONNEL

The contractor shall, if and so directed by the Engineer provide free of any charge, adequate facilities to the Government for training of Government Officers, Supervisors, foreman, skilled workman etc., not exceeding two in number at any one time at the contractor's works. Their salaries, allowances, etc., will be borne by the Government and training scheme will be arranged by the Engineer in consultation with the contractor.

22. ADDITIONAL CONDITIONS

Any Civil works like concreting in the grooves and civil works connected with the gate installation etc., will be done by the Department.

- 23. Providing ballast, if required for the gate will be done by the Department.
- 24. Permanent wiring for hoists from the source of supply will be done by the Department.
- 25. Hydraulic testing of parts is not included in offer.
- 26. Maintenance of approach roads to various erection sites will be done by the Department.
- 27. Remote control arrangements for the hoists will be done by the Department.
- 28. The Department will pay for any services and supply that are not specifically mentioned in the offer if carried out as per the directions of the department at rates arrived at as per condition No.48 of General condition of contract form.

29. FACILITIES TO BE PROVIDED BY DEPARTMENT

- A) The Department may provide accommodation to the extent available at site as per standard rent for the same.
- B) Department may spare any tools and tackles available with it for the works at mutually agreed rates.

30. ACCIDENTS

Further to clause 39 on page 10 of LCB conditions. If any injury is caused to any of the member of the staff of the Department at the site, due to any negligent act or rash act on the part of the firm, compensation as per provisions of workmens compensation Act shall be paid by the firm. In cases not covered by the Act compensation shall be paid, at rates to be mutually agreed upon.

31. ROAD BRIDGES FOR PURPOSES OF ERECTION

The Department shall make available the Road bridge for taking up erection of spillway gates at places where erection of gates is to be done and the road shall be cleared such that necessary Gantries etc., can be located and materials to be erected can be kept. For erection of embedded parts suitable approaches to the piers also shall be made available by the Department.

32.1 RADIAL GATES FOR SPILLWAY DAM 15 x 12 m

These radial gates are to be installed for 5 additional spillway bays of Narayanpur Dam to create the storing capacity of the Dam to enable regulation of water level in the reservoir, and to dispose off the flood discharge. The various controlling levels are shown in the drawing accompanying these specifications.

- 32.1.1Generally, the gates shall be fabricated of structural steel with mild steel skin plates forming the upstream curved surface. This skin plate shall be adequately supported by a system of cross and vertical girders, so that the water load is transmitted to the trunnion through and connection. Each gate shall be pivoted in two trunnions supported by trunnion girders to which shall be secured the anchorages to be embedded in the gate piers. The gates shall be equipped with rubber seals, securely bolted to the upstream skin plate on sides and along the bottom edge.
- 32.1.2 Guide rollers shall be fitted alongwith the curved edges at either side and along the sides of the gates near the rubber seals. A curved structural steel channel or plate in suitable pieces to form the curve shall be embedded in the face of the pier adjacent to each gate to serve as a Track, for the guide roller. It will also bear a smooth stainless steel plate against which rubber seal will rub during the movement of the gate. Bottom sill formed of an R.S.J. or a suitable structural steel section will be fixed in the ogee shape at the sill level at the appropriate angle in gate opening to support the weight of the gate and form a seat for the bottom seal.
- 32.1.3 The gate shall be operated by a cable or chain type hoist. The hoist shall be electrically operated with a suitable A.C.Electric motor and suitable gearing arrangements. The speed of operation shall be 0.3 M to 0.6 M per minute. Necessary limits switches electromagnetic brake etc, shall be provided as per standard practice. The gate also shall be capable of being operated by manual labour in case of power failure and suitable arrangements to enable this shall be provided.

SPILLWAY RADIAL GATES

These shall be designated to suite a clear vent of 15 metre width and 12 metres height. A drawing showing general arrangement of the gate leaf is enclosed.

The spillway radial gates shall consist of anchor girders for the full thickness of the pier. The tie rods or members with suitable sole plates or hooked ends shall be provided. In addition to the parts mentioned above the following parts shall be included.

- a) Sill beam assembly.
- b) Wall plate assembly.

They are briefly described as follows:

a) Sill Beam Assembly

The sill beam assembly shall consist of rolled steel sections with bearing plates welded on one side to receive anchores or adjustment bolts. The sill beam is proposed to be provided with stainless steel clad flat on one of the flanges.

A flat over which stainless steel sheet 1.6 MM (1/16") thick and width suitable to accommodate the bottom rubber seal shall be welded. The anchor bolt or adjustment bolts shall be housed for adjusting elevation of the sill beam before the sill beam is embedded in the concrete.

b) Wall Plate Assembly

The wall plate assembly shall be out of M.S.Plates forming a guide for the gate in its travel. The wall plate assembly shall be in suitable segments to provide for the gates travel. This shall consist of suitable stainless steel flats of width suitable to accommodate the rubber seal and steel plates shall be connected to side rubber seal of the gate leaf. The mild steel plate of the wall assembly shall be stiffened suitably in the rear and suitable adjusting bolts with bearing plates shall be connected to the wall plate assembly to facilitate the adjustment of the wall plate for verticality. The stainless steel clad flat shall be provided for a height equal to one gate height plus one metre.

INDEPENDENT ANCHORAGES

1. Yoke Girder

In the arrangement of non inter connected anchorages the Hydro static load as delivered to the pedestal shall be resisted by down stream yoke girder and upstream anchor girder which in turn shall be connected by upper and lower M.S., round tie rods or tie flat members. The tie rod or flat shall have no bond in the concrete although they are enclosed in the pier. The tie flats or rods are isolated from the concrete by spraying tar or grease such that there shall be no adhesion between the concrete and tie rod or flat surface. In this arrangement both shall be independent of each other. The tie bars of flats shall be subject to axial stress only. The yoke girders shall be suitably stiffened to resist the load due to hydraulic thrust on the gate. One and of each of the anchor bars or flat shall be welded to the yoke girder. The other end being welded to the anchor girder which shall be embedded in the concrete of the pier.

2. Tie Flats or Tie Rods

The tie rods or flats or the tension members shall be designed to take the hydraulic water thrust at each end and transmit the same to the pier through the anchor girders. The tie rods or flats shall consist of M.S. bars or cut-out flats or obtained as flats. These shall be I.S. 226 quality. The

tie flats or bars are proposed to be 10 metres length from the end of yoke girder to the end of the anchor girder. The full length of the bar or flats shall be obtained by providing suitable butt welds if necessary depending upon the lengths of the rods or flats that are available.

3. Anchor Girders

The anchor girder shall be plate girder which shall be similar in construction to yoke girder and shall be of built up steel plates of welded construction. The web of the anchor girder shall be suitably stiffened. Stress relieving of these girders shall be done wherever it is felt necessary.

4. Rest Beam and Thrust Block

Pedestal of each set of the gate shall rest on rest beam which shall be fabricated out of plates. The rest beam shall have on the top surface suitable bronze sheets such that the frictional forces are minimised during the movement of pedestal when the gate is under hydraulic thrust. The bracket or pedestal shall be bolted to the rest beam. The horizontal component of the thrust shall be perpendicular to the flow, which is proposed to the transmitted to a thrust block. The thrust block shall also be of built up plate girder made out of mild steel plates. Alternatively in the gate leaf the tie member shall be provided connecting the two trunnions such that the end thrust due to the inclination of the arms, shall be taken by this tie member. Bronze of Gun metal flats shall be provided on the bearing surface of the rest beam and thrust block to minimise the frictional force when the bracket moves with the gate under load.

Gate Leaf

The gate leaf shall be designed for the maximum static head of 12 M and the structure of the gate leaf shall be of inclined arm type. The gate leaf shall consist of skin plate rolled to a curved shape. The thickness of the skin plate shall be fixed allowing 1.6 MM(1/16") for corrosion. The skin plate shall be stiffened suitably with horizontal and vertical stiffeners in the rear. The transmit load to three horizontal girders, which shall be supported by inclined end arms. The horizontal girders shall be of built up plate girders suitably welded in shops. The end arms shall be fabricated out of rolled steel section or mild steel plate girders. The bottom of the skin plates shall be given the form of knife edge at the point of bearing on the sill by gas cutting. The gate leaf shall be suitably braced to produce a rigid assembly. The inclined arms shall be braced to withstand buckling at the down stream end. The end arms shall be connected to the trunnion hubs of cast steel, which shall have high tensile bronze bush with provision of lubrication of trunnians at either side. The trunnion on either side shall transmit the load to the trunnion pin which in turn transmit to the trunnionbracket or pedestal resting on the restbeam. These pedestals transmit the horizontal load to the yoke girder and thrust blocks and the vertical load to their rest beams. The pedestals or brackets shall be out of mild steel or cast steel of quality I.S. 1030 or IRS m2 quality grade I, with a UTS of 35 tons per Sq. inch respectively. The trunnion pin shall be out of cast steel

and shall be hollow. The trunnion and trunnion pin shall be of cast steel of the same type. The arms shall be connected to the trunnion by welding by hand, using suitable electrods. The steel casting shall conform to the above quality. Suitable rubber seals shall be provided at either side of the gate and bottom leaf of the gate. These seals shall be of L type of music note type for the sides and flat type for the bottom. These seals shall be fixed by galvanised bolts. The gate leaf shall be fitted with suitable guide rollers.

The part of skin plate forms an upstream flange for the vertical stiffeners. The vertical stiffeners shall be designed as continuous resting over the horizontal girders with a cantilever at the top and bottom. The design of the horizontal girders shall be done taking into account the fact that the central part of the girder is subject to axial and compressive stress due to the arms load.

Hoist

The pier hight will be raised to R.L. 495.752 M so as to locate the hoist. The hoists shall be of electrically operated rope drum type. The lifting pulleys shall be attached on the upstream side of the skin plate. The hoist to be provided shall be upstream suspension type.

The hoist shall be electrically operated rope drum type of suitable for radial gate of 15 M \times 12 M. The hoist unit shall consist of two end gear boxes and a central drive unit. The motor shall be 3 phase 50 cycles 400/440 volts totally enclosed having starting torque not less than 150% of normal running torque. The drive unit shall have a worm reduction unit of ratio 50:1 and of suitable - capacity.

The drive unit shall have an electro-magnetic brake of suitable size which shall grip on which the motor is switched off. Arrangements for manually operating the gates shall be provided in the unit to operate the gates in case of power failure. Transmission shafts or line shafting of suitable size with coupling shall connect the gear reduction units and the central drive unit. The end gear boxes shall have suitably spur gear reduction the gears being made of cast steel. A cast steel drum of suitable size shall be housed in each and gear reduction unit to receive the wire ropes connecting the gate and hoists. The wire rope shall be of adequate size and of constructions 6x37 pr 6x19 having a steel core with a tensile strength of 100 to 100T/Sq.inch. However, if the use of steel core cables result in difficulties in the design of pulleys and rope drums ect. use of equivalent hemp core wire ropes shall be permitted by the Engineer.

A dial gauge to indicate the gate position shall be provided in the central drive unit. The unit shall have limit switches for the gate closed position and gate fully operated position. In these positions the gate operation shall automatically stop due to limit switches cutting of power supply to motor.

Each end box and central drive unit shall have steel covers for protection from rain and dust etc.

The lifting speed of the hoist shall be 0.3 M to 0.6 M per minute.

Each end gear box shall be driven either by one drive unit or two independent drive units. In case one end drive unit is adopted, synchronisation of the gear reduction units shall be done by means of transmission shafting. In case two separate individual gears are used at either end, they shall be synchronised by electrical system.

Load Testing

One set of horizontal girders and one assembly of yoke girder and anchor girder with the rods or flats shall be tested for a load of 125% of the design load. One hoist also shall be tested as per tender specification.

33. SPARE PARTS AND EXTRA TOOLS AND SPARES

The tenderer shall include supply of the following spare parts and tools for the crest gates. All spare parts and tools furnished shall be interchangable with and shall be of the same materials and workmanship as original parts in the equipment supplied. The spare parts and tools should essentially consist of the following.

- 1. One set of rubber seals for one radial crest gate.
- 2. Two bushings for the trunnion pins for crest gates.
- 3. One set of wire rope required for one crest gate.
- 4. One hoist driving motor for radial crest gate hoist.
- One solenoid brake for radial crest gate hoist.
- One limit switch for hoist.

Extras

The tenderer shall, when ordered in writing by the Department perform extra work of furnishing materials, fabrication, providing, erection etc.not covered by the specifications or included in the schedule but forming an inseparable part of the work contracted for. Extra work and materials will ordinarily be paid for at a lumpsum or unit price as may be mutually agreed upon by the tenderer and the Engineer así stated in the order. If the rates of such extra work cannot be mutually agreed upon, the Engineer shall be at liberty to get the work done by the other agency and the contractor will have to provide all reasonable facilities for getting the work done, without any extra claims. Whenever in the judgement of the Engineer it is impracticable because of the nature of the work or for any other reason, to fix the rate, the extra work and materials shall be paid for at actual cost as determined by the Engineer-in-Charge on the basis of the data produced by the tenderer.

34. INSTRUCTIONS FOR OPERATION AND MAINTENANCE

A set of instructions and drawings for the operation and maintenance of the equipment shall be furnished in quadruplicate and one set of these shall be such as can suitably be mounted in the operator's cab or control room as the case may be for ready reference.

35. GUARANTEES

The contractor shall guarantee among other things the following:

- a) The quality and strength of materials used.
- b) Satisfactory operation during the period specified in the general conditions as maintenance period.
- c) Performance figures specified by the tenderer.
- d) Safe stresses as specified for all parts under severest conditions of operation. He shall also sign guarantee clause as per form indicated in para 36 below guaranteeing the workmanship.

36. INSPECTION AND TESTS

Fabrication of the parts shall be carried out under strict supervision of trained Technical personnel. If the Department intends to inspect the work during the course of fabrication the same shall be done during working hours at department's cost.

The work done in the workshop shall be subject to inspection from time to time by the Engineer or the authorised representative on his behalf. The tenderer shall provide all facilities required for such inspection of the material, fabrication of the component parts, at the pace of manufacture and erection.

The tenderer shall at his expense prepare specimen and perform tests and analysis in accordance with standard practice or as mentioned elsewhere in these specifications. All tests and analysis shall be made under the direction and in the presence of the Engineer or his authorised representative. Certified copies of test reports of all tests and analysis, shall be furnished to the Engineer by the tenderer in quadruplicate.

It shall be open for the Engineer to carryout tests on the materials and manufactured products of the gates. The test pieces and samples required to carryout independent tests shall be furnished by the tenderer when so desired by the Engineer at no extra cost.

Erection, Erection Personnel and Erection Equipment

The contractor shall be fully responsible for the correct and accurate erection of equipment offered by him and shall furnish all the erection personnel skilled or unskilled for the installation of the embedded parts, gates and hoists. The contractor shall also furnish his tools and the tackles and other special equipment such as cranes etc.for the erection.

The blockouts necessary for embedding the roller track shall be intimated to the Department after order placing. The department will leave these block outs in the piers. The grip rods shall be provided projecting out of the pier. The anchor bolts shall be kept in position and then the first concreting is to be done. Then the roller track and other embedded parts shall be kept in position and adjusted to vertically by means of bolts. When the embedded parts are sent the concreting will have to be done. Concreting must be done very carefully such that the embedded parts shall not be dislocated. Then the sub-assemblies of gate leaf shall be lowered on to the sill, assembled and then welded.

All the civil works like concreting the groove will be arranged by the Department. Approaches will be formed by the Department to the road bridge for erection of gates. For speedy erection of radial crest gates the company shall provide all necessary equipment at site, in order to take full advantage of these equipments it will be necessary to make available the road bridge for tackling the erection work.

The tenderer shall hereby declare that the goods stores/articles provided for the work by him to the Engineer under this contract shall be of the best quality/(and workmanship) and shall be strictly in accordance with the specification and particulars contained/mentioned tenderer here by guarantees that the said goods/stores/articles would continue the description and quality aforesaid for the period specified under clause to conform of General conditions as maintenance period and that notwithstanding the fact that the Engineer(Inspector) may have inspected and/or approved said goods/ stores/articles if during the aforesaid period and the said goods/stores/ articles, be discovered not to conform to the description and quality aforesaid or have deteriorated (and the decision of the Engineer in that behalf will be final and conclusive) the purchaser will be entitled to reject the said goods/stores/articles or such portion thereof as may be discovered not to conform to the said description and quality. On such rejection the goods/ stores/articles will be at the contractors risk and all the provisions here in contained relating to rejection of goods etc. shall apply. The contractor shall if so called upon to replace the goods/etc. or such portion thereof as is rejected by the Engineer otherwise the contractor shall pay to the Engineer such damage as may arise by reason of the breach of the condition herein contained. Nothing herein contained shall prejudice any other right of the Engineer in that behalf under this contract or otherwise.

37. MATERIALS

General

The parts shall be fabricated out of structural steel of I.V. quality unless specified otherwise the shafts of hoists shall be of mild steel rounds. The rubber seals for the gate shall be manufactured in shops in suitable moulds. The plummer blocks and bearings shall be of commercially available quality. The electrodes for welding shall be of commercially available quality suitable for welding mild steel parts. The materials used in the

works shall be new and shall be of the kind, composition and physical properties best adopted to the several items of work in accordance with accepted Engineering practice. Where the characteristics of any material are not explicitly specified, approved materials meeting the requirements of the appropriate Indian Standard shall be employed. In the absence of Indian Standard materials as per appropriate British Standard specifications or A.S.T.M. specifications shall be employed.

The materials shall at all times be kept clean and protected from weather and shall be free from excessive scale and rust.

37.1 Material Specification

The materials required for the various components shall Generally conform to the specifications mentioned in table No. 1 below:-

It is open for the tenderer to suggest or specify use of materials other than these specified for the various parts, of the gates and conforming to specifications other than those specified below in which case he shall provide a list of the materials of the parts where he intends to use it and the specifications to which they shall conform. All such deviations shall be subject to the approval of the Engineer.

38. OTHER MATERIAL SPECIFICATIONS

These shall conform to the relevant standard specifications mentioned in Table-I under the para 48.1.

38.1 Brass, Bronze and other metals-Table I under para No. 37.1.

38.2 RUBBER FOR SEALS

Rubber for the seals shall be natural or synthetic containing not less than 1% by weight of copper inhabitors and shall have the shore A Durometer hardness of 60 to 70.

The rubber compound shall not absorb more than 2% by weight of water. The tensile strength of a test specimen, after being subjected to accelerated ageing test of 48 hours in oxygen at 80°C and at 300 P.S.I pressure, shall not be less than 65% of the strength of the test specimen before ageing. The material shall be properly aired in a manner to ensure a degree of homogeneous cross section free from pitting, blisters, porosity and other imperfections and the different elements shall be well bounded together.

39. DESIGN AND DRAWING

Limitations of Layout

The tenderer shall quote for the work on his own design. He shall not have latitude to make any alteration in the clear opening of the gates, the height and location of the gates, alignment of the centre line of the road

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MATERIALS T
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.1 SPECIFICATION O
TABLE NO.1
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						יייי דייייי	ED COLD FOR GAIES (NARYANPUR DAM)		
	SI.	It	Main parts for which to be used	Materials specifica- tion	Sampling accord- ing	Testing accord-	Properties as per Gen material specifi- wor cations.	General workman-ship specifications	Remarks
	-	2	3	4	5	9	7	8	σ
g.	.	Structural steel	Skin plates stiffeners, braces plate, girders and arms anchor rods etc.	IS 226 of 1962 Cla- use-5	IS 226 of 1962 Cla- use - 6	IS 226 of 1962 Cla- use - 7	IS 226 of Ultimate tensile 1962 Cla- stress 27 to 34 tone use - 7 per Sq. inch yield point stress 14.60 to 16.50 tons per Sq.inch IS 226 of 1962 Clause - 7.	IS 800 e of 1962 to nch	
20	2	Cast e steel	Trunnion, Trunnion brackets, lifters brackets and roller bracket guide roller etc.	Grade I IS 1030 of 1962 Cla- use - 6	IS 1030 of 1962 Cla- use - 11	IS. 1030 of 1962 Clause-11	Ultimate istensile stress (max.35 T.S.I 1 minimum % Elonga- tion 15) IS 1030 of 1962 Clause - 4	IS 1030 or 1962	of 7
	ë.	High Tensi- le structu- ral steel	High Tensi- Trunnion pin le structu- (cast steel) ral steel	IS 96% of 1962 Cla- use - 5	IS 961 of 1962 Cla- use - 6	IS 961 of 1962 Cla- use - 7	IS 961 of Min. tensile stress 1962 Cla- 35 T.S.I. Min. Y.P. use - 7 stress 19 T.S. I. Min. Elongation = 20% I.S. 961 clause - 7.	I.S. 800 of 1962 n.	
	4.	Grey iron castings	Hoist drum bracket etc.	IS 210 of 1962 Cla- use - 3	IS 210 of 1962 Cla- use - 12	IS 210 of 1962 Cla- use - 10, 11 & 14	IS 210 of As per appendix A.I.S. 1962 Cla- 210 of 1962 Clause -11 use - 10, 11 & 14	S. IS 210 of 11 1962 Cla- use - 8	
	ري. •	Bronze casting a) Grade C	Seals & Linings	1	1	1	U.T.S. 27 TSi.	A.S.T.	
		b) Grade D	Nut & screws	ī	ì	ī	U.T.S. 31 Tsi	ı	283

	The second		F	0	9	7.	•8
Rolled Sheets and Hard - Bronze strips A. Grade	and Hard	T		1	t	U.T.S. 31 Tsi to 39 Tsi	A.S.T.M. B - 42.
Brass alloy Sheets and No.1 quar- strips ter hard	y Sheets and strips	1		1	ı	U.T.S. 17 Tsi to 21 Tsi	A.S.T.M. B. 36-42 - T
Babit metal Below trunnion Grade 7. Pedestal	al Below trunnion Pedestal	Ī		ī	1	U.T.S. 7 Tsi Y.P. 1.5. Tsi	A.S.T.M. B-23-26
Rivers For general IS 1148 of connections 1964 Clause - 6	×	IS 1148 1964 Cla use - 6	Jo I	IS 1148 of 1964 Cla- use - 11	IS 1148 of 1964 Cla- use - 11	IS 1148 of U.T.S 24.8 to 1964 Cla- 32.4 Tsi Min Elon- use - 11 gation 31 to 35%	IS 800 of 1962 Cla- use - 28.
10. Weldings For general IS 814 of 1 connections 1963 Cla- use - 3 & use - 3		IS 814 or 1963 Cla- use - 3 & 815 of Cl	Н 1 х	IS 814 of 1963 Cla- use - 5	IS 11810f 1957 Cla- use - 4	IS 1181of IS 814 of 1957 Cla- 1963 Cla- use - 4 use - 9	IS 816 of 1956 Cla- use - 6
Wire ropes Gates hoisting BS 302 of Mechanism. 1957	Gates hoisting Mechanism.	BS 302 of	***	ı	BS 302 & 621 of 1957	IS 2266 IS 2365	r E
Turn buc→ For wire ropes BS 716 of kels		BS 716 of 1958			ī	BS 716 of 1958	BS 716 of 1958
Bushing Trunnion bush bronze		T .			1	High tensil Mangenese Bronze UTS 1,10,000 Psi Y.P. stress 65000 Psi (tension) Elongation in 2",12% reduction in area 12% B.H. No.210 to 240- bearing pr.on projected area-2,000 P.S.I.	si in rea od

_	2	3	4	2	9	7	8	é
14.	14. Steel	Gate wheels	IS 1030 ASYMA 51-52 Clause-A	f.	ļ	Wrought steel R.H. No. 260	180 to 220 BHN	
15.	Stainless steel	Wheelpins antifriction	A.S S.I.I.(Type-431)Stain-hard and temp. less st coformi	1)Stain- less steel coforming AISI 304.	steel ming	B.H. No. 375	160 to 200 BHN	
16.	Corrosion ressistant steel	Wheel track	A.S.T.M.A. 276.60	Rail or forged steel	J. J.	B.H. No. 310	200 to 250 BHN	
17.	Corrosion resistant steel	Seal seat	A.S.T.M. 176.49 Grade - I	A.I.S.I 304	₽ H	í	9	

TABLE No. 2 (Ref Clause 42)

		For the Type Conforming to I.S.226	For other types of Steel
1.	Axial stress tensile	18,000 lb/Sq.inch.	0.53 fy or 0.34 x UTs whichever is less.
2.	Axial stress compression	, 	0.53 fy or 0.34 x UTs in compression which ever is less, reduced by a suitable column formula to account for sylenderness.
3.	Bending stress	18,00 lbs/Sq.inch.	0.53 fy or 0.34 x UTs whichever is less.
4.	Shear stress (Average in webs)	12,000 lbs/Sq.Inch.	0.35 fy or 0.20 x UTs whichever is less.
5.	Shear stress on rivet	11,000 lb/Sq.Inch.	0.33 fy or 0.18 x UTs whichever is less.
6.	Bearing stress for rivets	24,000 lbs/Sq.Inch.	0.72 fy or 0,40 x UTs whichever is less.

UTs = Ultimate tensile strength.

Fy = Yield point stress.

bridge, the road bridge, road bridge layout and the various clearance specified on the drawings. It shall be open for him to suggest minor modifications in the layouts of the pier to suit his design. Such modifications shall be clearly brought out by the tenderer in writing and shall always be subject to the approval of the Engineer. The gates are required to regulate discharge at part openings of the gates and shall be designed for trouble free operation at such part openings. The radius of curvature of radial crest gates of the spillway shall be 12 M only as shown in the drawing.

Tender Drawings

The following tender drawings are enclosed herewith:

 An overflow section of Narayanpur Dam showing the general installation of 15 M x 12 M radial crest gates with independent anchorages.

The general arrangement of radial crest gates of size 15~M~x~12~M will be finalised in accordance with the above drawing, if this arrangement is approved by the dept.

40. DESIGN STRESSES

- 40.1 For the structural design the permissible stress in structural steel and other type of steel shall be as specified in Table-2.
- 40.2 When any part of structural steel is submerged in water or likely to remain submerged for prolonged periods an extra thickness of one sixteenth inch, on each face shall be added to the designed thickness for corrosion of each face in case specially non-corrosive steel is not used. For part like R.S.J. channels etc where a direct deduction of one sixteenth inch, thickness for corrosion would complicate the computations, the permissible stresses shall be reduced to 85% of those specified in the table.2.
- 40.3 All steel parts shall not have a thickness including the thickness for corrosion allowance, of less than 3/8" or 10 MM.

41. DENSITY OF WATER

As the water is likely to be silt laden, the density of water may be assumed as 63 lbs. per cubic foot, for design purposes. Therefore, the density should be assumed at 63 or 62.5 lbs. per cubic foot whichever gives the severer conditions of design in each individual case.

42. DESIGN LOAD

Radial crest gates are required to regulate the discharge at part of full opening, either singly or in combination with adjacent gates without exceeding normal permissible stresses in all the gate parts including anchorage, hoists etc when the water is at highest flood level i.e. at R.L. 492.252 M.The gates shall also ensure trouble free operation at all such openings.

supply level from the crest level of spillway shall be 12 M.

MANUFACTURE OF GATES

43. WORKMANSHIP

All the work shall be performed and completed in a thorough workman like manner conforming to accepted modern practice in the manufacture and fabrication of material of the types covered by these specifications. The work shall in all cases be of high grade and carefully performed to the satisfaction of the Engineer. The contractor shall warrant all materials and workmanship furnished by him to be free from injurious defects.

All work shall be performed and completed as per the best shop practice conforming to relevant specifications.

Before being laid off or worked in any manner structural steel plates and sections shall be straightened if necessary to reasonably, remove any twists, bends, kinks, taking care that the materials are not injured. The straightening of plates shall be done in plate straightening machine.

44. FABRICATION OF STRUCTURAL STEEL AND METAL WORK

All structural steel shall be fabricated in the workshop in sections as indicated on the drawings and as will be convenient for handling during transportation and erection. They shall be sent to the site of work, with necessary field rivets, turned bolts, washers, pins rivot and driving nuts and fitting up bolts complete and ready for erection. Members and assemblies shall be snop-checked for fit of parts and shall be clearly match marked. Allowances shall be made for draw-in-tension bracing and for camber in accordance with British Standard Specifications unless otherwise indicated in the drawings.

Method of Fabrication

The fabrication in the shop shall be carried out by welding. The plates shall be cut to shape and size either by gas cutting or by edge planning or machining whichever is convenient. The section shall be cut by gas, saw or by shearing. The plate shall be straightened if necessary and rolled before fabrication to remove any bend. The parts shall be assembled to form required sub assemblies in Jig and welded. Welding shall be as per shop practices. The mild steel electrodes such as 'over cord' and 'Torro speed' shall be used for welding. The parts to be welded shall be fixed by clamps and by adopting proper sequence in welding. The deformation shall be kept minimum. The holes required for fixing the seal bolts will be drilled 1.6 mm dia (1/16") more than the nominal size of the bolts. No reaming of the holes shall be done. The bearing plates, shall be cut by gas or by shearing and holes for fixing anchor bolts shall be punched. The gate and components shall be supplied in suitable sub assemblies in convenient sizes. Necessary site shall be provided by the Department to have field workshop.

45. STRAIGHTENING

Before being laid off or worked in any manner structural steel shall be straight without twists, bends or kinks and if straightening is necessary it shall be done in a way which shall not injure or marks the material.

46. SHEARING AND CUTTING

Shearing and cutting by torch or by electric arc shall be carefully done and all cut edges exposed to view shall be neatly finished.

Sheared or cut edges of plates more than 5/8" thick and shown as carrying computed stresses shall be planned to a depth of 1/4". Re-entrant cuts and copes in beams and channels shall be filletted before cutting. If the cutting or shearing is done by hand the edges shall be carefully examined and all picks removed.

47. BENT PLATES AND SHAPES

Where bending or forming of plates or shapes is required the plate or shape shall be bent by cold forming. heating or hammering to correct bends will not be permitted. Bends in grill plates shall be made across the grain of the plates with the axis of radii of bend, normal to the direction in which the plates were rolled.

48. HOLES

All holes in structural steel work 3/4" and less in thickness shall be sub punched and reamed after assembly holes in materials more than 3/4" shall be drilled after assembly or drilled 1/8" smaller than the nominal diameter of the bolt or rivet before assembly and reamed to full size after assembly.

49. PUNCHING

For sub-punching, the diameter of the punch shall be 3/16" smaller than the nominal diameter of the rivets. The diameter of the die shall be not more than 3/32" larger than the diameter of the punch. All holes shall be cut clean without any form or raised edges.

50. ACCURACY OF PUNCHED HOLES

Holes shall be so accurately punched that after assembling the component parts of a member of cylindrical pin 1/8" smaller than the nominal diameter of the the punched hole may be passed perpendicular to the face of the member without drifting through not less than 75% of the continuous holes in any group in the same plans. All holes shall pass a pin 3/16" smaller than the nominal diameter of the hole.

51. REAMING

Reamed holes shall be cylindrical, perpendicular to the face of the member and not less than 1/16" nor more than 3/32" larger than the nominal

diameter of the rivets. Reaming shall preferably be done only after the pieces forming built up members are assembled and rigidly bolted together so that the surfaces are in close contact. After reaming and before rivetting, the built up members shall be taken apart and all shavings and burs removed.

52. DRILLING

All drilled holes shall be cyclindrical, perpendicular to the face of the member (unless otherwise specified) and 1/16" larger than the nominal diameter of the rivet.

53. ACCURACY OF DRILLED AND REAMED HOLES BEFORE ASSEMBLY

The accuracy of all holes shall be such that after assembly a cyclindrical pin of one eighth of an inch less in diameter than the nominal size of the km holes may be entered perpendicular to the face of the member without drifting is not less than 75% of group of continuous holes in the same plane. All holes shall pass a pin three sixteenth of an inch smaller in diameter than the nominal diameter of the hole.

53.1 During Assembly

Accuracy of reaming and drilling during assembly shall be such that not less than 85% of any group of continuous holes in the same plane shall show off-set greater than one thirty two seconds of an inch between adjacent thickness of the materials.

53.2 Forging & Castings

These shall be as per modern current practice conformating to relevent B.S.S. or I.S.S. mentioned in I.S.S. mentioned in Table - I under clause-37.

54. MACHINING

Structural members dependent on contract for stress transmission should be accurately machined and close butted over the whole section. Care shall be taken when those connecting angles or channels are fixed with such accuracy that they are not reduced unduly in thickness by machining. Where sufficient gussets and rivets are provided to transmit the entire loading the connecting ends need not be machined.

54.1 Machine Finish

Where finished surface are specified or required for parts shown on the drawings the class of finish provided shall be as specified on the drawings or if not specified shall be the clause of finish most suitable for the proper function of the parts involved and the general requirement and designed as follows.

54.2 Very Smooth Finish

The surface smoothness shall be comparable to a lapped, hoaned or finally finally ground finish, or the surface shall be polished, if so specified. This grade of finish is required for surface with very close tolerances for surfaces

in leakage or friction or highly loaded bearing surfaces, or for surfaces which must be polished for appearance.

54.3 Smooth Finish

The surface smoothness shall be comparable to the best finish obtainable using standard machine tools and shall be practically free from tool marks. This grade finish is required for surfaces with close tolerances and for surface in ordinary sliding contact.

54.4 Average Finish

The surface smoothness shall be comparable to a commercial finish such as is normally obtained by ordinary machining methods, and slight tool marks will be allowable. This grade of finish is required for ordinary work.

54.5 Rough Finish

The surface smoothness shall be of a degree necessary to assure a uniform surface, true to diamensions and fairly coarse tool marks will not be objectionable. This grade of finish used primarily for surfaces which are not in contact, but which require finish for dimensional accuracy.

55. RIVETTING

Riverts shall be driven by power riveters of either compression or manually operated type, employing pneumatic hydraulic, or electric power. After driving they shall be tight and their heads shall be in full contact with the surfaces. Rivets shall not be driven and their finished head shall be of approximately hemispherical shape, or uniform size throughout the work for the same size rivet, neatly finished and concentric with the holes.

After driving, the rivets should completely fill the holes. If rivets are countersunk, the counter sinking should be fully filled by the rivet. All rivets shall be heated uniformly, the temperature not exceeding 1950 F and power driven while hot i.e. before the temperature drops below 1000 F.- All shop driven rivets within a distance of 18 inches from a shop weld joint shall be driven after the welding is completed. Reculling and caulking of loose or defective rivets will not be permitted. In removing the defective rivets care will be taken not to injure the adjacent metal and if necessary they shall be drilled out.

56. FIELD RIVETS AND ERECTION BOLTS

15% more field rivets shall be furnished in addition to the number required for each size and length. Adequate number of temporary erection and fitting up bolts of appropriate length and with steel washer shall be furnished for field erection.

57. BOLTED AND PIN CONNECTIONS

The bolts and nuts proposed to be used on the work shall be commercially available quality obtained in the market and suppliers shall be asked to supply as per standard specifications.

Where members are to be permanently connected by bolts, turned bolts shall be used with bodies long enough to extend completely through the several thicknesses of metal. A heavy lock washer shall be used under the nut. The bolts shall be gradually drawn tight equally and uniformly over the entire joint and the threads afterwards burred at the face of the nut with a pointed tool to prevent the nut from loosing.

Washers should be tapered where necessary to give the heads and nuts of bolts and true bearing. The threaded portion of each bolt should project through the nut at least one thread after thightening.

Where the full area of the bolt is to be developed, no threaded portion of the bolt should be within the thickness of the members bolted together. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and threads burred at the face of the nut with a pointed tool. Pin connected members shall be securely restrained against lateral movement of Pins.

58. BOLT HOLES IN RUBBER SEALS

Bolt holes in rubber seals shall be accurately located from the corresponding holes in the gates. The inside surface of all holes in the seals, shall be given three heavy coats of rubber cement to seal the exposed fabric from nature.

59. WELDING

The edges of the plates to be jointed by welding shall be suitably prepared in edge shaping machines or by any acetylene flame cutting. The surface to be welded shall be cleaned of loose scales rust, paint etc. foreign matter by wire brushes and components parts of built up members shall be held in place by suitable clamps arrangements to keep all parts in proper position. The welding shall be done by experienced welders under strict supervision and adopting suitable sequences in welding to minimise the welding distortion. The electrodes shall be commercially available type for welding steel.

It is necessary to radio graph the butt welds connecting the radial arm to the trunion, as these welds are critical and carry the full water thrust-exerted on the gates. The radiographic tests shall be carried out by gammery equipment on these welds at no extra cost.

All welding shall be done by the electric are method by a process which will exclude the atmosphere from the molten metal except where specifically permitted otherwise. The welding electrodes shall be of the heavily coated type designed for all position welding and the size, type and manufacture of the rods shall be as per standard proceedure. The welded metal shall conform to IS 814 of 1957 and IS 815 of 1956 and welding shall be carried out as per IS 816 of 1956. In assembling, and during welding, the component parts of built-up members shall be held in place by sufficient clamps of other adequate means to keep all parts in proper position. Particular care shall be

taken in aligning and separating the edges of plates and shapes to be joined by butt welding, so that complete penetration and fusion at the bottom of the joint will be attained.

Where section of different thickness have to be butt welded and the surfaces are 6 mm or more out of plane the thicker section shall be bevelled off so that the slope of the surface from one part to the other shall not be more than 1 in 5. Alternatively the weld metal shall be built-up at the junction with the thicker part to a thickness at least 25% greater than the thickness of the thinner part.

Butt welds shall not be intermittent. At welded butt joints where the weld material is required to be deposited on both sides of the joints, the weld materials shall be chipped or melted to obtain a clean surface prior to the application of the firsthead of the welding on the opposite side of the joint. Where fillet welds are used, the lapped sections shall fit closely and shall be held together during the welding operations.

Surface to be welded shall be cleaned of loose scale slab, rust, paint and other foreign matter. In all cases where welded joints are likely to be exposed to weather, the joining edges of the contact surface shall be carefully sealed by welding or the part shall be effectively connected by welding so that the contact surface are securely held in contact to prevent the entry of moisture. Where weld metal is deposited in two or more layers, each layer shall be brushed with a wire brush or otherwise cleaned before the subsequent layers are deposited. In welding, precaution shall be taken to minimise stress due to expansion or contraction and distribution due to heat by using the proper sequence in welding, by peaning the weld while hot or by other satisfactory methods.

Correction of distortions by blows after welding is completed and the piece is cold, shall not be permitted. Upon completion, the welds shall be brushed with wire brush and shall show uniform section, smoothness of weld metal feather edges without excessive overlaps, and free from porsity and clinkers. Visual inspection at edges and ends of fillets and butt joint welds shall indicate good fusion and penetration into base metal. No under cut shall be allowed.

Welds shall not be painted until they have been inspected and approved. The material to be welded shall be preferably uncoated, but if protection is considered necessary to prevent corrosion, a coating of pure linseed oil without admixture of paint may be applied, before leaving the works. The coating shall be removed carefully by burnishing of or wire brushing or other suitable means before welding. All welds and particularly those of the anchorage girder shall be tested by 'X' Ray, soric or similar other tests.All defective welds shall be chipped of and redone as directed by the Engineer.

60. STRESS RELIEVING CASTINGS

After all the welding is complete, the anchorage girder shall be stress relieved. This shall be accomplished as specified below.

Earing

The furnace shall be first heated to 550°F and check made that the temperature is uniform throughout. It shall, then be heated from 550°F to 1200°F. in an hour and a half. The rise of temperature from 550°F to 1200°F. shall be uniform. The temperature of 1200°F. shall be maintained for a period of an hour and quarter, during the period of maintaining the temperature at 1200°F. the variation in temperature shall not be more than 120°F throughout the length of the anchorage girder.

Cooling

The anchor girder shall be cooled down from $1200^{\circ}F$ to $550^{\circ}F$ in the closed furnace. Cooling shall be done by closing down as much of the source of heating as required and allowing the girder to cool by radiation. Disturbance of the inside air shall not be permitted. The time of cooling should be restricted to three hours by temperature control. From $550^{\circ}F$ downwards the anchorage girder may be cooled inside or outside the furnace but the air surrounding the girder should be still.

61. CASTINGS

All work shall be laid out to secure good matching between adjoining unfinished surfaces. Unfinished surfaces shall be true to lines and dimensions given on the drawings. Unfinished edges of ribs and similar parts shall be neatly cast with rounded corners and all insite angles shall have suitable fillets. Castings shall be cleaned, and shall be chipped and ground free of all fins, projections, and other irregularities. Depressions of holes not affecting the strength of usefullness of the parts, with the approval of the Engineer, may be filled by welding, in such a manner as approved by the Engineer where there is a large discrepancy. Castings shall be ground or machined to secure proper alignment. After cleaning, all steel casting shall be annealed, or normalised as required to relieve shrinkage of cooling stresses.

62. TOLERANCES

Fits and tolerances for different components shall be according to the best shop practice keeping in view the functional requirements of the parts.

Tolerances and allowances for establishing the limiting sizes of matching parts for any class of metal fit shall be according to the appropriate standard shop practice which shall be specified for apparatus of the type covered by these specifications and which shall be stated on the drawings, due consideration being given to the special nature of functions of the parts and to the corresponding accuracy required to secure proper operations.

63. SHOP ASSEMBLING

General

All the gates shall be completely assembled in the shop to ensure that all parts are fitted properly. Before assembling, the surface of metal to be in contact shall be cleaned. The parts shall be adjusted to line and fit and then will be pinned and bolted or otherwise tightly held together so that the surface are in close contact before and after reaming, drilling or rivetting. The member shall be free from twists, bends or other deformities. Drifting done during assembling shall be only that necessary to bring the parts into position and not sufficient to enlarge the hole or distort the metal. Enlargement of holes, if any, as needed to suit rivets, shall be done by reaming

Checking of all parts and their over all dimensions clearances, accuracy of alignment and tolerances shall be done carefully. After checking, if any errors are discovered, they shall be corrected to the satisfaction of the Engineer. The gate parts shall then, be separated into suitable pieces for transportation.

64. SHOP CLEANING AND PAINTING

All metal work furnished under those specifications shall be cleaned and given one coat of priming paint as hereinafter stated. Paint to be used shall be of best quality suitable for the purpose and should be got approved by the Engineer before use.

PAINTING

The surface of the fabricated parts shall be cleaned in the shops by the wire brushes and one coat of red oxide paint shall be given on the parts before despatch except those which will be embedded in the concrete.

Hoist and hoist machinery parts shall be given two coats of suitable paint in the shop before despatch. The cover and structural parts of hoist shall be given a coat of red oxide primer.

64.1 Preparation of Surfaces

Surface preparation shall be in accordance with the following procedure.

- 64.1.1 Weld spatter or any other surface irregularity be removed by any suitable means before cleaning.
- 64.1.2. All oil, grease and dirt shall be removed from the surfaces by the use of clean mineral spirits, xylol or white gasoline and clean wiping material except that for surfaces which require coaltar coatings, the cleaning solvent shall be xylol. Following the solvent of cleaning, the surface to be painted shall be cleaned of all rust, mill scale and other tightly adhering objectionable substances by sand blasting or grit blasting to uniform bright base metal.

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

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

64.2 The painting of the various portions of the gates shall be according to the following schedule.

64.2.1 Embedded Parts and Steel Lining

All surfaces of the embedded parts and steel lining which are to come in contact with the concrete shall be cleaned as mentioned above and left unpainted. All unfinished surfaces of the embedded parts and the steel lining exposed to atmosphere or water shall be given a coat of cold-applied coaltar paint by brushing at a coverage rate of approximately 120 square feet per gallon.

Gates

64.2.2 All the unfinished surfaces of the gate shall be given a coat of rust inhibitive wash by brush immediately following the cleaning operations and the surfaces shall be thoroughly wetted with the rust inhibitive wash at a coverage rate of approximately 1,500 Sq.ft. per gallon and allowed to dry. Proper reaction will be evidenced by the appearance, after drying or a dull grey phosphate coating. Rinishing after application is not required but unreacted residue shall be removed by wiping the inhabitated surfaces with damp coat of within one hour after the rust inhabitive wash has dried throughly one coat of zinc-chromate aluminium priming paint shall be applied by brushing without thinning, at a coverage rate of approximately 425 Sq. ft. per gallon.

64.2.3 Hoists and Gantry

All unfinished surfaces of the hoist shall be given one coat of alkyed priming paint by brushing at a coverage rate of approximately 500 square feet per gallon. An additional priming coat shall be applied over all irregularities such as rivets, welds, bolts, seams etc. without thinning.

64.2.4 All machined surfaces which are to be in rolling or sliding contact, shall be coated with gasoline soluble rust preventive compound.

64.3 Variation Procedure and Schedule

Depending on the quality and specifications for the paint materials which shall be got approved from the Engineer, it would be permissible to alter the application procedure and painting schedule. All such alterations shall be subject to the prior approval of the Engineer.

65. SHOP ASSEMBLY TESTS

- 65.1 All gates, gate frames hoist and appurtenances shall be assembled at the shops to assure accurate fit and proper alignment of all parts and that the overall dimensions and clearances are as covered by these specifications. All the shop connections of gates which are required to be water tight shall be tested for water tightness prior to shop painting. While the units are so assembled, the holes of radial gate for field connection shall be reamed to full size.
- 65.2 The anchor girder of the crest gates shall be completely fabricated in the shop. Special care shall be taken in all phases of work affecting the strength and rigidity of the anchor girder. One set of the anchor girders for intermediate and end piers shall be individually tested under a load equivalent to 125% of the designed loads repeated 3 to 4 times, for the worst loading conditions by a suitable arrangement which will simulate conditions in the field and which shall be got approved from the Engineer. The tests shall not show any signs of weakness in the anchor girder and the welds shall not show any sign of crack. These tests shall be carried out in the presence of authorised representatives of the Engineer who reserves the right to instal at contractor's expense strain gauges and measure actual stresses at the required points. If during these tests, any defects are noticed in the manufacture of the anchor girder the same shall be remedied by the tenderer as directed by the Engineer at no extra payment.
- One set of horizontal girders of the crest gates selected at random shall be subject to a load test upto 125% of the design load, and the load test shall be repeated thrice. The arrangement of load test shall be got approved from the Engineer. The girders shall not show any signs of weakness failing which the Engineer may direct all the girders to be tested in a likewise manner. The girders which are shown to be defective in these tests shall be liable to be rejected unless, however, the defects are such as can be remedied by local repairs.

All these tests shall be carried out in the presence of the Engineer or his authorised representative.

66. UNIT MARKETING AND MATCH MARKING

Each part of the gates, embedded parts, guides and hoists which is to be transported as a separate piece shall be legible marked to show the unit of which it is a part and match marked to show its relative position in the unit to facilitate assembly in the field. Unit marks and match marks shall be made with heavy steel stamps and with paint, Each piece, sub-assembly or package transported, separately shall be labelled or tagged with consignee's instructions together with the specification number and the mark number of such piece or the number of the parts grouped in such sub-assemblies or contained in the package.

67. WEIGHING

Before transportation, the contractor shall determine by the most accurate means available, the net weight of each, piece or assembly that is to be transported as a unit, and such not finished weights exclusive of boxes crates, or skips shall be furnished to the purchaser and shall be printed on the respective pieces or assemblies and stated on the taggs attached thereto.

68. PREPARATION FOR TRANSPORTATION

All parts shall be prepared for transportation so that slings for handling may be attached readily whenever the parts are to be moved. Where it is unsafe to attach a sling to the box, boxed parts shall be packed with slings attached to the part, and the slings shall project through the box or crate, so that attachment can be made readily. All exposed finished surfaces shall be adequately protected against abrasion during transport, and all long and slender piece shall be adequately supported and blocked. Rubber seals shall be dismantled after shop assembly and shall be transported separately. These shall be wrapped and boxed to protect them from any clements which would adversely affect their size shapes or physical properties before they are field assembled to the gates. The gates and the hoists shall be prepared for transport so as to permit minimum amount of field assembly.

Each case shall be clearly marked 'Upper Krishna Project' Narayanpur Dam' and the items to which the contents pertains and shall contain a packing list which will also include similar details. Copies of the packing list shall also be sent to the Engineer by registered post along with the transportation documents such as shipping documents or railway receipts.

All projecting plates etc, shall be kept in shape in timber or angles bolted to them.

All straight bars and plates, except, small pieces, shall be sent, cut in convenient bundles, temporarily bolted or bound together.

All rivets, bolts, nuts, washers, plates under 0.3 M square and generally such small articles as may be selected shall be packed in strong cases and the hole made secure for transportation to site. All botls, nuts and rivets of different sizes shall be packed in separate bags each having a label indicating the contents of the bags.

69. ERECTION OF STRUCTURAL STEEL

General

The work of erection shall be considered to have started with receiving and unloading of all required materials at the site and shall include, handling, storing, erecting, riveting, welding, bolting, adjusting and holding in position during concreting wherever necessary and the gate including all tools, equipment, labour and expenses incident all therto. Erection in the field

will be by bolting, riveting and arc welding or by any combination of these as may be shown in the drawings or as otherwise directed. This shall not include the cost of centering for concrete and cost concreting that may be required which shall be paid for as separate item.

70. UNLOADING AND STORING

The unloading, hauling to site and storing of all structural materials shall be done so that the metal will be kept clean and not damaged in any way. All metal work shall be stored upon suitable blocking and stored as required to prevent it from touching the ground. Each piece shall be supported in such a manner as not to cause any bending under its own or super imposed weight that will deform the piece.

71. DAMAGE TO MATERIALS

Care shall be taken in handling and erecting all materials and properly supporting them at all times, so that no piece shall be bent, distorted or otherwise damage. In the event of any damage all such damages shall be corrected by the tenderer in a manner approved by the Engineer at no extra cost to the purchaser.

72. ERECTION

All parts shall be accurately assembled and erected as shown on the drawings and in strict accordance with the erection diagrams or as directed and all the match marks of the manufacturers shall be followed carefully. The materials shall be handled carefully so that no part will be bent, broken or ortherwise damaged. Hammering that will injure or distort the members shall not be permitted. The member shall not be overstressed during the process of erection.

Bearing surface and surfaces to be in permanent contact shall be cleaned carefully before the member are assembled or erected.

Temporary bracing shall be provided to take care to all temporary stresses from erection equipment, piles of materials of other construction loads. As the work of erection progresses, the structure shall be bolted and braced or guyed to take care of all dead load, wind and erection stresses and to hold members securely in position and line.

The alignment of the structure shall be checked before any connections are riveted. Before driving any rivets, the connection to be riveted shall be tightly drawn up by means of erection bolts, so that all holes are equally matched and the surfaces of contact fit sufficiently sung so that no hot metal can squeeze out or flow between the plates or cause any distoration in the joint.

In bolted connections, the bolts shall be drawn tight and where required the threads shall be burred so that nuts cannot become loosened, where riveting

is required, the field connections shall have no less than one half of the holes fitted with cylindrical erection pins before being rivetted. Fitting up bolts shall be of the same nominal diameter as the rivets and the cylinderical erection pins, before being rivetted. Fitting up bolts shall be of the same nominal diameter as the rivets and the cylinderical erection pins shall be one thirty second of an inch larger in diameter than the rivets. Holes which can be drawn into line by drift pins without distortion of the member need not be reamed. Cutting of excess stock from rivets will be permitted upto 5% of the rivets used. Cutting with a cutting torch will not be permitted.

73. INSTALLING OF EMBEDDED METAL WORK

Embedded metal work shall be placed accurately and firmly held in correct position while the concrete is being placed. The surface of all metal work to be in contract with or embedded in concrete shall be cleaned thoroughly of all rust, dirt, grease loose scale, grout water and other foreign substances immediately before the concrete is placed. All guides, tracks, sill and other fixed metal work shall be installed in exact position and alignment and all machinery shall be in the proper position relative to the equipment that it will operate. Machinery bases and all machinery units not mounted on bases shall be levelled carefully on steel wedges and packing plates and adjusted to correct alignment and grade.

In installing the anchorages of the trunnion girder, of the crest gate the contractor shall if required, provide at his cost steel tamplate which shall be bolted to the anchor bolts before and during placing of concrete around the bolts and will serve as a convenient means of checking the proper alignment of anchorages before final placement of concrete.

74. FIELD RIVETING

All field rivetting shall be done in accordance with the relevant specification as per para 55. Field rivets shall not be painted until inspected and approved by the purchaser.

75. FILED WELDING

All welding shall be performed in accordance with relevant specifications of para 59 and in such a manner as to cause the minimum amount of distortion. When assembled, each gate shall be free from twists, bends and other deformations.

76. RUBBER SEALS

The rubber seals for gates shall be fixed as shown in the drawings or as directed. The tenderer shall carefully spot and accurately drill the holes in the rubber seals. In order to effect a water seal at the junction of the side seal and bottom seal a special corner piece or any other suitable device shall be used.

77. BUSHINGS

Bushings for the end arms hubs of the crest gates shall be of high tensile bronze with provision for lubirdation at either side. The co-efficient of friction in dry state with the material of the pin shall not exceed on tenth (0.10).

78. FIELD PAINTING

PAINTING FINISH

Final painting of the equipment after erection at no extra cost to the department shall be done by the firm and the paints for this will be supplied by the Department free of cost at the site of work.

78.1 Repair or Shop Coats

Metal work which has been shop painted shall be handled with care so as to preserve the shop coat in the best practicable condition, before proceeding with the painting operation, the contractor shall clean the base metal and repaint all areas of shop paint which are defective or damaged. Paint applied to such areas shall be of the same type as used for the original shop coat.

78.2 Application Procedure

A Paint and coating materials shall be applied in accordance with this sub. paragraph and the painting schedule given below. All paint and coating $m_{
m aterials}$ be in a thoroughly mixed condition at the time of application and shall not be thinned, except where here in after specifically provided. warning of the paint shall be performed by means of a hot water bath and the paint shall not be heated to a temperature higher than 100 F. Paint shall not be applied, when the temperature of the metal or the surrounding air is less Surface shall be free from moisture at the time of painting. When paint is applied by spraying suitable means shall be provided to prevent segregation during the painting operations. Effective means shall be provided for removing all free oil and moisture from the air supply lines of all spraying and blasting equipment. Each coat of paint shall be free from runs and sags. Except as otherwise specifically provided, each coat shall be allowed to dry of harden before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after installation except inaccessible surface of metal work of machinery which have been shop coated with priming paint, shall be completely painted as scheduled prior to installation.

The following schedules of painting shall be adopted for the various portions of the gate.

78.3.1 Embedded Parts And Sluice Lining

All surface of embedded parts in contact with concrete shall not be painted. All unfinished surfaces of embedded parts exposed to atmosphere and water, shall be given two more coats of cold applied local tar paint or any other paint, of approved quality and specifications by brush or by spray, at

coverage rates of approximately 120 Sft. per gallon per coat. The spraying shall be permitted only if the contractor uses the special type of spray, equipment designed for spraying heavy bodied materials, thinning will not be permitted.

78.3.2 Gates

All surfaces of the gate except the upstream face of skin plate shall be given two coats of the special aluminium finish paint or any other paint of approved quality and specifications at coverage rates of approximately 400 Sft. per gallon per coat.

On upstream face of the skin plate, a second coat of zinc chromate aluminium paint or any other paint of approved quality and specifications shall be applied without thinning, by brushing or spraying at a coverage rate of While this priming coat is still wet approximately 350 Sft. per gallon. (Within 5 minutes after application) a heavy uniform coat of specified sand shall be applied using a low air pressure, or other effective means to thoroughly embed a uniform coating of the sand in the paint film. After drying for at least 24 hours, the sanded surface shall be brushed or blow down with compressed air to remove loose sand particles. Two coats of aluminium finish paint then shall be applied by spraying without thinning, at coverage rates of approximately 275 and 350 Sft. per gallon respectively. A minimum of 24 hours drying time shall be allowed between application of the various coats. mixing of 2 pounds of aluminium paste per gallon of the zinc chromate primer and 2 pounds of aluminium paste per gallon of phenolic mixing varnish shall be performed in all field paints prior to application. In order to ensure maximum leafing, enough paint for each day shall be prepared at one time.

78.3.3 <u>Hoist</u>

All unfinished surfaces of the hoists shall be given two coats of machinery paint, by brushing or by spraying at a coverage rate of 500 Sft. per gallon per coat without thinning.

78.4 Variation In Procedure And Schedule

Depending on the quality and specifications of the paint materials which shall be got approved from the Engineer, it would be permissible to alter the application procedure and painting schedules. All such alterations shall be subject to the prior approval of the Engineer.

79. GATE HOISTS

General Arrangements

All the specifications hitherto mentioned will be applicable to the hoists wherever they are relevant. In addition the following specifications will be applicable. The general arrangement of the mechanical type of gate hoist shall consist of:

Central Drive Unit

Comprising of an electric motor, brake, worm gear reducer manual operation arrangement.

End Reduction Units_

There are two units one at each end and each required number of sets of spur reduction, gears enclosed in a gear box.

Drums

Two drums, one at each end, each drum is connected to gate. The lay out of the hoist is merely indicative and the tenderer has the choise to alter the layout to suit his design within the limitation of the general layout of the gate installation as specified in para 39 of the specification subject to these limitations.

79. Design

The design of the hoist shall be done according to the accepted practice of design of machine members which shall be clearly indicated. The hoist shall have a rest capacity of not less than 25% over the calculated hoist capacity and it shall enable the gate to the raised at speed of 0.3 M to 0.6 M per minute under the design condition—as per para-42 of the specifications. The hoist shall be provided with arrangements for manual operation in the event of failure of electric supply. It shall also be equipped with all necessary safety devices and limit switch. Since the tenderer is to quote in his own design he shall give comprehensive specifications for the various mechanism of the hoist and shall clearly bring out the deviations any, from the specifications here-in-after specified.

The hoists shall be assembled as shown on the approved drawings. All parts of the gate hoists shall be manufactured in accordance with these specifications and the drawing.

80. WORM GEAR REDUCERS

Where the worm gear reducers are used they shall be of standard high grade, reduction units, suitable for the sections intended, and the proportions of all parts therein shall in accordance with the best engineering practice. The input ratings of worm gear reduction units shall be on the current gear manufacturers practice for rating worm gear reducers, which shall be stated. The worm gear reduction unit shall have input rating suitable for the designed drive motor output with a reduction ratio as per design. Ball or roller bearings shall be provided on warm shaft and the shaft shall be mounted and rated to carry all radial loads and full worm thrust in either direction. The worm gear shaft shall be mounted on ball, roller, or bronze-bushed bearings of suitable capacity and shall extent through the gear housing for a sufficient distance on ball ends to permit the attachment of flexible couplings and shall have key ways out to suit the coupling. Worm and worm-gear shaft openings in

the housing shall be provided with dust proof seals or packing glands. The gearing shall consists of a concave faced high quality gear bronze worm gears, and high carbon of alloy steel worms. The worms and worm shafts shall be forged integrally and finished all over. Each gear reducer shall be suitable for out door service.

81. GEARS

The gears shall be easily accessible, and enclosed gears shall be provided with means of lubrication with oil and grease. Open gears shall be provided with covers for safety to prevent accidents. The mechanical parts shall be of standards types and should ensure trouble free service and availability of spares at short notice. Gear wheels and pinions shall be of cast steel conforming to I.R.S.M -II Grade I quality. The teeth shall cut from solid blank. Provisions shall be made for nipple lubrication.

At the option of the contractor, blanks for spur gear may be stock pattern, provided that face width lengths and diameter of hubs and thickness of the rims are not less than those shown on the drawings. All gear teeth shall be cut accurately from the solid and shall be free from tool marks and other imperfections. When assembled, the teeth shall engage evenly over their full widths and shall run freely without excessive back lash. The end spur gears shall be housed in a gear case, and grease shall be used for lubrication. The gear case shall have a leak proof cover with an opening at the top for inspection. The shaft openings in the gear case cover shall be provided with dust proof seals. Alternatively welded gears can also be used with the prior approval of the Engineer.

82. HOIST DRUM

The hoist drums shall be made of cast iron cast steel, or welded plate steel with heavy section and shall be reinforced to with stand the concentrated load due to the rope pull. The dimensions of the drum shall conform those indicated on drawings. The combined crushing and bending stresses shall not exceed 6,000 pounds per square inch for cast iron drum and 12,000 pounds per square is for a steel drum. The rope attachment to the drum shall simple and secure so that adjustment and replacement of rope may be accomplished without dismantling the parts.

83. COUNTER WEIGHTS

It shall be open for the tenderer to propose a counter weighted type of gate, in which case he shall be indicated with all the details in the designs and drawings subject to the limitations of layout as per para 39 of specifications.

84. SHEAVES

The balancing and the hoisting sheaves, if any shall be made of cast steel or any other material of suitable quality so as to withstand the load due to rope pull.

85. LIFTING AND BALANCING ROPES FOR CREST GATES

The lifting ropes and balancing ropes if provided shall be fastened to the rope sockets at the two ends. Molten zinc shall be used to socket the ropes and this work shall be done carefully and to the satisfaction of the Engineer.

86. FLEXIBLE COUPLINGS

All flexible couplings shall be all metal fully enclosed dust proof, self sealing type and shall be bored for tight fits on the shafts and shall be fitted with straight square keys. All couplings shall be of the rated for shafts which they connect and shall have torque rating suitable for the load transmitted. The flexible couplings between the motors and worm gear reducers shall provide for both angular and offset misalignment of the coupled shafts. Flexible couplings between worm gear red and the drive shafts shall each provide for angular misalignment only and the axes of the coupled shafts of intersect.

87. DRIVE SHAFT

The drive shafts shall be of the appropriate quality mentioned in the designs, which shall be stated and shall be manufactured to the details and lengths etc as on the drawings. If as per layout suggested by the tenderer, the shafts are long in length they shall be supported at intermediate points.

88. ELECTRIC EQUIPMENTS

All the electrical components like brakes, starters, switches, resistance boxes, limit switches, controllers etc shall be purchased from standard manufacturers in India.

88.1 Motor_

The electric motor shall be totally enclosed. Fan cooled, with a high starting torque (normally 150% of running torque), slow starting current, squirrel cage induction motor with direct drive reversing service, horizontal mount and for full voltage across the line starting. The motor shall be designed for operation on 400 volts, 3 phase, 50 cycles, alternating current at appropriate rated H.P. and speed (synchronous speed) for continuous duty, without exceeding a temperature rise of 50°F. The winding insulation for the motor shall be of special impregnation suitable for operation in highly humid atmosphere. The details of the motor shall be clearly indicated by the tender. The motor will confirm to IS 325 of 1965.

88.2 Brakes

Each hoist shall be provided with a spring, set, solenoid released, shoe type brake, or any other suitable type of brake which shall be clearly stated. The brake shall be equally effective in both directions of travel and shall be capable to overcome at least 200 percent of the full load torque

exerted by the hoist motor. When the current is supplied to the motor this will also actuate the brake and release it. Otherwise brake shall be applied automatically whenever the power supply is interrupted. It shall be arranged that the brake can be released mechanically for operating the hoist manually.

88.3 Limit Switch

The limit switches shall be arranged for the full angles of gate lift with adjustment for intermediate positions. The limit switch shall shut off the motor as soon as the gate reaches the extreme positions in either directions. The switch shall be of approved standard type and shall be suitable for service under extreme position in either direction. It shall be so designed that it can be wired or serviced after being mounted.

89. GATE POSITION INDICATOR

For indicating the position of gate at any instant and for limiting the travel of gate, a position indicator and limit switch shall be used. The type of indicator to be adopted shall be clearly indicated on the drawings and shall be subject to approval of the Engineer. It shall be mounted at a convenient position in the control panel of individual hoist. The gate position indicator dial shall preferably be circular in shape and shall read upto 80 MM travel of gate. The foot graduations shall be marked clearly in bold letters. If the indicator reads in the metric units it shall be capable of being read to nearest tenth of a meter.

90. HAND OPERATION ARRANGEMENTS

Provision shall also be made for operating the hoist manually in case of failure of power supply. A suitable arrangement for manual operation shall be provided by the tenderer in the drawings.

91. LUBRICATION

The lubrication of the meter gear reducers and roller and ball bearings shall be as specified by the manufacturer of the respective equipment. The points of lubrication of the bearings and journals shall be readily accessible. Grease grooves shall be provided in the bearings surface for satisfactory distribution of the lubricant. A level type hand compressor for forcing the lubrication to the bearings shall be provided at extra cost. The hand compressor shall be equipped with heavy duty flexible metallic, hose and coupling suitable for the industrial bottom type fittings.

92. ACCEPTANCE TESTS

After each gate has been completely erected in the position, it shall be lowered and raised several times through its full operating range to observe alignment of the side seals and to make sure that it will operate properly and without undue friction and harmful vibrations. It shall also be operated under designed conditions, when so operated, shall operate without undue friction and

SPECIFICATION

FOR

ROCK FILL DAM

ACROSS RIVER CHENAB

SALAL HYDRO-ELECTRIC PROJECT

harmful vibration, remain at the designed speed without unduly straining the various mechanisms. The gates shall be operated manually under design conditions, and shall be easy for operation at the design speed. In closed position the seals shall ensure water tightness.

In case it is not possible to operate the gates for the extreme design conditions, the Engineer may direct this acceptance test to be carried out under near design condition which shall always be in writing and accept the gate after satisfactory operation under the near design condition.

Performance test on the equipment supplied shall be carried out provided the reservoir buildings upto the full height within 12 months from the date of completion of erection. If however the reservoir does not build up within 12 months these tests shall be carried out at extra cost on the basis of actual cost plus overheads plus 10% profits.

1. DESCRIPTION OF WORKS

For the Salal Hydro Electric Project a Rock Fill Dam is proposed to be constructed, as per the drawings No.Sl 2900-C-1 and 2900-C-2 and No. SBD/Dam-3/73-74 enclosed.

The axis of Rock Fill Dam is aligned along a curve of 15000 ft. (4572 meter) radius and is 597.4 meter long at the top EL 493.78 meter. The profile has a rock fill section with a Central core of impervious clay, inclined towards the upstream, well protected with a layer of graded filter. The core is founded 1 m inside rock after removing the over burden fully and a key trench is provided inside the foundation trench 9.14 m. wide and 6.1 m deep with side slope 1:1. The rock fill section has atop width of 15.24 m and has an upstream slope of 2.5:1 and downstream slope of 1.7:1 resting on the river over burden of boulder and gravel after the surface is stripped to a depth of 1.5 m. The upstream portion of the Rock Fill Dam at El 441.9 m is designed as a top bund covered with an impervious blanket to facilitate River diversion. Underneath the downstream slope of the Dam 1.5 m thick filter is also proposed in the rear of the core for effective drainage of the base.

1.01 FOUNDATION TREATMENT

The base of the core in the foundation trench will be grouted with suitable mixes of grout, through a pattern of holes drilled 3 m apart 3 m deep staggered under a pressure of 0.22 Kg/cm² per metre depth (1 lb/psi per feet depth). A grout curtain will be formed in the centre of key trench taken deep upto the one third of the head of water, with side cut offs on either side 6m deep comprising holes drilled, 3 m centre to centre and grouted as directed. Weak faults and sheer zones, any noticed in the foundation trench will be cut open and back filled with cement concrete, or suitably treated otherwise.

The specifications described in the following paras cover the components of the work as under:

- 1) Cleaning of work areas
- 2) Stripping of foundation
- 3) Dewatering of foundations
- 4) Dam embankment:
- 5) i) Rock Fill Body
 - ii) Impervious blanket/Core
 - iii) Filter material
 - iv) Rip Rap on upstream face
 - v) Disposal of undesirable material

1.03 SCHEME OF CONSTRUCTION

It is proposed to construct the entire rock fill dam in a period of 48 months from October, 1974 to September, 1978, as per the programme of construction. The upstream coffer dam will be formed in the period November, 1975 to April, 1976 closing the river course and diverting the flow through the Diversion Tunnel, and through sluices provided in the spillway blocks.

1.04 (I) CLEARING WORK AREAS

This section shall govern the requirements under which areas to be occupied by the dam and appurtenant works and the surface of all borrow pits and aggregate deposits, including a 9 m wide strip measured beyond and contiguous to the limit line of the areas shall be cleared.

Clearing consists of complete removal of obstructions above the ground surface. All trees, stumps, bushes, fences, debris and similar organic matter may be left in place and removed during stripping operations. Trees over 30 cm. in diameter at breast height shall be cut off not more than 60 cm. above the ground surface.

Merchantable timber of useful material shall be removed as required expeditiously so as not to hinder the progress of the work. Debris resulting from clearing shall be burned or disposed of as described herewith. Stumps may be cleared and burned and removed during the foundation stripping operations. No combustible organic material shall be removed from the site or burried under not less than 90 cm, of cover in worked out borrow areas or in waste areas. The depth of cover in the reservoir waste areas shall be such as to preclude floating after inundation of waste areas. Disposal in the stream shall not be permitted and no material shall be piled where it is liable to be floated by floods. Combustible material which is to be disposed of by burning shall be reduced to ashes by controlled burning. Piling and burning shall be done in such manner as to cause the least fire risk and shall be done under constant attendance until fires have burned out or have been extinguished to guard against spreading of fire beyond the limits of cleared areas. Piling for burning will not be permitted in the bottom of ravines, water courses, or under communication and transmission lines.

Trees standing outside the areas to be cleared, which constitute a danger to property or personnel, shall be felled and disposed of in the same manner as specified for other material to be cleared.

1.05 (II) EXCAVATION-GENERAL REQUIREMENT

This section shall govern the general requirements of all excavation work.

Excavation shall be carried out, to the extent of outlines shown on the drawings or specified otherwise in writing in such manner as to cause minimum over break and/or injury to rock beyond the specified lines of excavations.

Blasting where required in hard rock, shall be carefully controlled to minimize overbreak and preserve the rock in the soundest possible condition beyond the lines of excavation. Procedures suited to the structure and fracture of rock types to be excavated which will prevent jarring and loosening of rock beyond specified lines of excavation shall be used. All rock situated at or beyond the specified lines of excavation which has been shattered, loosened or otherwise injured by blasting or other causes shall be removed.

Whenever there is danger of inflicting damage to nearby structures or installation, shots shall be blasted suitably. Where blasting would create too great a hazard to existing structures or installation, rock excavation shall be performed by methods other than blasting.

Unwatering and drainage facilities necessary to maintain the work areas and all excavations free from surface water and ponding shall be provided.

All loose, shattered or potentially unstable rock situated at or beyond the specified lines of excavation, shall be removed by scaling or other suitable methods.

Stability of all excavated faces in rock and over burden formed during excavation of the work shall be ensured by methods such as scaling, rock bolting, application of pneumatically applied mortar or other measures as necessary with a view to maintain overall stability of the areas. Excavation will normally begin from higher elevations towards lower elevations.

1.06 EXCAVATION FOR DAM FOUNDATIONS

The excavation of the foundation areas for the Dam embankment prior to the placement of fill material, shall include:

- 1. Stripping
- 2. Excavation of rock in core foundation and cut-off trench

1.07 STRIPPING

Stripping shall be done over the entire dam foundation areas to the lines and grades on the drawings. Stripping shall be to a sufficient depth to remove all unsuitable material. The unsuitable material to be removed shall include loose rock, vegetation including roots, top, soil, sand, organic silt and rubbish and all other perishable and objectionable materials that may unsuitable for use in permanent embankment construction and might interfere with proper bonding of the embankment with the foundation or the proper compaction of the materials or that may be otherwise objectionable. All hill washm talus and gravel and sand deposits, which are likely to contain compressible silt layers shall be removed. All loose, soft or disintegrated material shall also be removed from pockets and depression; but removal from crevices and seams will not be required. Boulder gravel deposits in the Chenab, shall however, not be removed under the upstream and the downstream shells of the dam unless presence of undesirable material is indicated.

In a direction transverse to the dam axis the base of the outer shells shall not have slopes steeper than 3/4 horizontal to I vertical. In the longitudinal direction grades will not be steeper than 1/4 horizontal to I Vertical.

Accurate trimming of slopes of the stripping will not be required but it shall conform as closely as practicable to the established lines and grades. Sharp points of undisturbed ledge rock shall be permitted to extend within the prescribed lines to not more than 15 cm.

2. EXCAVATION OF ROCK IN CORE FOUNDATION AND CUT-OFF TRENCH

a) General - The central impervious core comprising the clay zone shall be founded on sound rock reasonably free from fissures and cracks and at a level 1.5 m deeper than the rest of the dam to ensure against likely leakage through surface cracks and fissures.

The impervious fill shall be extended in the foundations through a back filled cut-off trench.

b) Extent - Core contact excavation shall extend to a minimum depth of 1.5 m below the stripped rock surface or 1.5 m inside rock underneath river bed material after the latter has been removed. At locations, where cracks and fissures extend to greater depths, the excavation shall be taken down to such depth where the rock is reasonably free from cracks and fissures.

In a direction transverse to the dam axis, the core base shall not slope down at an inclunation steeper than 2 H to I V in the upstream direction and 4 H to I V in the downstream direction. In the longitudinal direction the grades will not be steeper than 1/2 H to 1 Vertical. The cut-off trench (measuring 9 m wide at the bottom and having 1:1 side slopes) shall be located approximately at the upstream edge of the clay zone of the core. It shall be excavated to a minimum depth of 4.5 m below foundation level of the core.

c) Tolerances - Accurate trimming of slopes of foundation excavations will not be required but it shall conform as closely as possible to the established lines grades. Sharp points of undisturbed ledge rock may be permitted within the prescribed lines to not more than 15 cm.

GROUT CAP EXCAVATION

- a) General Because of poor nature of rocks, it may be found necessary to provide for purposes of grouting, a grout cap at the bottom of the cut-off trench. It shall be at location and to sizes as shown on the drawings.
- b) Excavation Excavation of grout cap shall be performed by the use of hand tools or approved mechanical equipment in such a manner as to prevent shattering of the sides and bottom of the excavation. If found necessary in hard rock, lines drilling and light drilling and light blasting may be

employed. If lines drilling and light blasting are employed, the diameter, spacing and depth of line drilling and blasting holes shall be such as would cause minimum disturbance to the rock, and the spacing would be such as to ensure that the material would break along the desired lines. Whenever an excavation for grout cap crosses a fault or seam the excavation shall be carried to a deeper level as may be necessary and shall be keyed into the foundation on the sides of the fault or seam.

4. PROTECTION OF EXCAVATED SHEAR ZONE SURFACE

Where required, the excavated shear zone surface shall be within a 50 mm thick protective coating or pneumatically placed mortar to prevent weathering within 48 hours of its exposure. The initial cost shall include filling of minor depressions. Where depressions are wide, the face of the layer may in general follow the contour of the depression without reduction in thickness. The minimum thickness of each coat shall be 12 mm.

5. DRILLING

All drilling for underground excavation shall be done wet with an adequate supply of water to each drill except for reaming and minor work of rectification for which dry drilling may be done. Percussion drill driven by compressed air shall be used.

The spacing of the holes shall be as shown on the drawings or as directed. Holes shall be sufficiently close to ensure that the rock will break along the desired line.

6. BLASTING

Blasting will be permitted only under personal supervision of competent trained workmen and when proper precautions taken for the protection of persons, the work and private property. All Government laws and regulations relating to design and location of blasting materials, magazines, the transportation and handling of explosives and other measures enacted for prevention of accidents shall be strictly observed by the contractor. Working sites shall be displayed on all powder (explosives) magazines and warning signals given for each blast. The contractor shall have to do the blasting only during the time fixed for blasting by the Engineer Incharge. The blasting pattern shall have to be submitted to the Engineer Incharge who may approve the same pattern or modify or give a new pattern for blasting.

Explosives shall be stored in a safe place at a sufficient distance from the work and dwelling areas under a special care of a watchman so that in case of accidents no damage occurs to the other parts of works.

A make up house shall be provided at each working place in which cartridges will be made up by experienced powderman, required for the immediate work. This make up building shall be separate from other buildings for safety and shall be without any internal source of heat light or electric current.

The use of explosives in a manner which might disturb or endanger the stability, safety or quality of the work shall not be permitted. Explosives of suitable strengths shall be used at locations and in such quantities as to minimize openings and seams outside the prescribed lines.

The best sizes, characterstics, and kind of explosives for the purpose intended shall be determined by actual experiment under working conditions and to the entire satisfaction of Engineer Incharge.

7. SCALING

All loose, potentially unstable, or otherwise dangerous rock situated at any excavated rock face at or beyond the minimum lines of excavation shall be removed.

Continuous inspection of all exposed excavated rock faces shall be ensured so that the occurrence of loose or dangerous rock is kept fully under control.

8. DISPOSAL OF EXCAVATED MATERIAL

So far as practicable, all suitable materials from excavations required under these specifications shall be used in permanent construction. Dolomite rock and alluvium overburden obtained from such excavations will be used in the relevant zones of the dam fill whenever this is possible. In the case the excavated material consists of gravels and cobbles which do not contain undesirable quantity of silts and clays, it can be used in the pervious portion of the dam.

All materials from stripping operations and other excavated material that are unsuitable or are in excess of requirement for the dam and other structures shall be wasted. The waste material shall be similarly disposed of by dumping in pits, etc., or by piling. If piled, the waste pile shall generally be levelled and trimmed reasonably to regular lines to present a neat appearance and sloped to facilitate general drainage. The waste pile shall not interfere with flow through penstocks, outlets and reservoir operations in any way.

Stumps, roots and similar organic material shall be disposed of as directed.

9. EXCAVATION FOR TUNNELS AND SHAFTS

All work for removal of materials by tunnelling method and disposal of all such materials for the completion of drainage tunnels with all connections, and shafts, will be carried out as under:

1. EXCAVATION

a) General - Excavation in tunnels shall be done to the lines, grades and dimensions shown on the drawings. Excavation shall be done by such methods as are consistent with good tunnelling practice. All drilling and blasting shall be performed carefully and in accordance with paragraphs (3) and (8) hereof.

b) Excavations near Portals - Tunnel excavation near the portals, particularly in the reach where rock cover is less than three times the bore diameter of the tunnel shall be performed with great care so as to obviate the chances of any hill slide and formation of chimney.

Use of explosives shall as far as possible be avoided. If explosives have to be used they shall be of such quantity and power and shall be used in such locations as to minimise opening of seams and to cause the least disturbance in the rock mass. The excavation shall be limited to about 60 cm at a time and further excavation shall be done only after the supports have been installed and solidly blocked against the rock.

- c) Method of Excavation The full section of the tunnel will be excavated in one operation. Suitable blasting pattern to give minimum over break shall be evolved.
- d) Trimming of Rock All excavation shall be so done that rock around the periphery of the excavated final section shall not be shattered, loosened or otherwise weak.
- e) Lagging Lagging shall be of timber. Lagging shall be tightly blocked by wooden wedges against the excavated rock surface at intervals as shown on the drawings. Timber shall be well seasoned and will be restricted to the practical minimum quantity. Wooden blocking and cribbing in overbreak shall be so placed that it does not occupy more than 1/3rd of the overbreak space.
- f) Timbering Temporary timber supports may be installed so as to be clear of the clearance lines or dimensions shown on the drawings. They shall be designed to carry safely the loads to which it may be subjected.
- g) Excavation in Ravelling Ground In ravelling ground spilling may be done and solid lagging of steel liner plates provided. The spaces between the liner plates and excavated rock surfaces shall be filled as completely and completely as practicable with gravel blown through a hose. Permanent steel supports shall be braced securely before gravel is placed.
- h) Placement of Steel Sets The steel sets shall be placed in the plane at right angle to the tunnel axis. In order to prevent buckling about the minor axis and displacement of sets during blasting, wooden collar braces shall be provided near the portals and elsewhere as required. Collar braces shall be provided between the webs near the spreader bars. Near the portals almost entire depth of webs shall be supported by collar braces. The steel sets after erection shall not deviate more than 15 mm from the true position.

The spacing of steel supports shall be as shown on the drawings. Blocking and wedging shall be such as to maintain throughout the period of initial excavation to final concreting the supports in correct position and alignment.

- i) Welding Welding of splice plates of joint shall be done soon after installation of the steel rib. All welding shall, however, be completed before placement or reinforce reinforcing steel of concrete lining.
- j) Tolerances After blocking and wedging the rib crown shall be within $50\ \mathrm{mm}$ of the established lines and grades. The spacing of ribs may deviate by $25\ \mathrm{mm}$ of the correct spacing.

10. FILLING EXPLORATION HOLES AND DRIFTS

i) FILLING EXPLORATION HOLES

- a) General Exploratory holes shall normally be back-filled with grout immediately after drilling and tests have been completed.
- b) Clean up Core holes left unfilled shall be reopened and cleaned to the extent possible by jetting and washing with water immediately before filling.
- c) Filling Holes shall be filled with sand-cement mortar mixed in the following proportions by volume:
 - 1. Part water
 - 2. Part cement
 - 3/4. Part sand

These materials shall conform to the requirements of section III thereof. Materials shall be mixed in a suitable mixer for not less than $1\frac{1}{2}$ minutes. Nor mortar shall be used if allowed to stand for more than one hour before use.

d) Placement - The mortar shall be placed by means of an injection pipe extended to the bottom of the hole. The injection pipe shall be raised as the hole is filled, but the discharge end shall be kept burried in the fresh mortar throughout the entire filling operation. Mortar shall be placed up to the ground surface. The top of the hardened mortar should be within 90 cm of the ground surface 24 hours after filling to be acceptable.

ii) Filling Exploration Drifts

- a) General A number of exploration drifts exist within the dam foundation.
- b) Excavation and each clean up The drifts in core area shall be excavated out as far as possible. The areas of drifts left after such

excavation which may have caved in shall be reexcavated and re-timbered for safety. Where support is required and existing supports are deteriorated to the extent of being unsafe or inadequate, retimbering shall be done as necessary. All drifts sections to be filled shall be cleaned of all loose material that has a reasonable probability of falling.

c) Filling - After excavation cleaning and necessary re-timbering the drift within limits of the dam core and upstream shell be filled with concrete or masonry right up to the crown. Immediately prior to filling, as much timber support, blocking and logging shall be removed from the sections as can be removed safely. Concrete shall be placed in sections not to exceed 30 m in length. In the core contact area, contact grouting between concrete and rock shall be done by drilling holes every 6 m from the top.

Drifts in the downstream shell shall be filled with pervious river bed material (all sizes upto $45\ \mathrm{cm.}$)

III. GROUTING OF FOUNDATION AND TREATMENT

The requirements for grouting of foundation bed rock and the left abutment hill in order to reduce the seepage from the reservoir and to reduce the detrimental effect of this seepage through the rocks, will be governed as under:

1. General Programme

The grouting work envisaged is:

- a) Blanket grouting of the core base of main dam from the surface after removal of cover on rock.
 - b) Curtain grouting the foundation rock under the dam embankment.
 - c) Curtain grouting the left hill abutment of the dam.
 - d) Grouting the alluvium overburden under the upstream coffer dam.

2. Grout Materials

- a) General Grout shall normally be composed of portland cement and water. It is possible that the additional of sand and calcium chloride may also be required. The grout mixtures shall be varied as required to meet the characteristics of each hole, or of each stage of the hole, as determined by rock conditions encountered.
- b) Basic Grout Materials Water, portland cement and sand used for the performance of work shall be known as basic grout materials and shall conform to the following requirements:
- (1) Water used for all drilling, testing and grout mixing shall be river water.

- (2) Cement Cement used in grout mixtures shall conform to the requirements of relevant I.S. Code.
- (3) Sand Sand used in grout mixture shall conform to the requirements of ISS for concrete sand, with the limitation that sizes above No. 120 Indian Standard Sieve size shall be excluded.
- c) Admixtures It is anticipated that admixtures will not be required. Accelerators such as calcium chloride if required, shall conform to the requirement for grouting of river determined gravel.

It may be necessary to use bentonite and chemicals, determined by the site conditions.

d) Grout Mixtures - Grout to be used shall normally be a water-cement mixture. The ratio of water to cement will be varied to meet the characteristics of each hole as revealed by the grouting operations. The mix shall be such that the grout may reach the bottom of the hole and that no obstructions are created in the hole which may cause bridges or seepages below which the grout will not penetrate. As a general rule initially the grout shall be fairly thin in relation to thicker mixes expected to be used so that the characteristics of the foundation rocks could be estimated without chances of losing the hole.

Grout mix used shall be tested at frequent intervals to ensure that the materials 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 day's work shall be rejected.

Bedrock Surface Treatment

Some bedrock surface treatment may be required in the grouting area in order to seal cracks and cavities, voids, etc. if encountered in the bedrock after final excavation. The required treatment will include the cleaning of cracks and cavities and their sealing or plugging with concrete having a 28-day cylinder design strength of 127 kg/cm² (1800 psi) pneumatically placed mortar, grout, wedges, oakum lead or other suitable caulking or sealing materials. The cracks and cavities shall be cleaned to the maximum practicable depth with air jet prior to sealing.

4. Grout Cap

Excavation for grout cap shall be carried out as per requirement of site.

All grouting is proposed and grout curation may be grouting from the surface when grout cap will be needed.

Grout cap shall however be needed for blanket grouting, the depth being as required by site conditions.

Concrete laid in grout cap shall have 75 mm maximum size of aggregate and a 28-day cylinder design strength of 127 kg/cm 2 (1800 psi). Pipes for drilling of holes underneath shall be embedded in the grout cap at 3 m spacing or as directed.

While grouting, care shall be exercised in grouting the upper zone to keep the pressures low enough to prevent raising of the cap.

5. Casing Pipe

An alternative to provision of grout cap is to commence grouting from the impervious core foundation level by providing a casing pipe of length less than the depth of the backfilled cut-off trench excavation till the completion of grouting.

The casing pipe shall be driven tight against the rock such that there is no leakage of grout along the pipe. It shall be capped and furnished with fittings for water testing and grouting. It shall have an inside diameter sufficient to accommodate the size of the bit required for drilling the hole.

6. Drilling

Hole shall be set out and drilled at locations and to depths as shown in the drawings or as required by site conditions Vertically upward drilling shall be required for grout curtain, the maximum depth so drilled being about $25\ m$.

Drilling shall be done in a manner so as not to disturb the faces. Accordingly rotary type drills will be used and use of percussion type of drill shall not be permitted, except for consolidated grouting, when percussion drilling could be allowed.

The minimum diameter of each grout shall 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 vertical 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 hole. An accurate log of all drill holes shall be maintained.

On completion of drilling the holes shall be immediately capped or plugged with wooden plug or steel caps and shall be protected from entry of dirt, muck, grout water or any kind of waste. Drilled holes or portions of holes shall not be left ungrouted for long as they may collapse in shear zone.

It may be necessary to install casing in the upper portions of the hole drilled for grouting, unless otherwise directed. Any casing that is installed for the purpose of keeping the grout holes open for grouting shall be removed simultaneously with the grouting process. In portions of the cased hole where grouting is required, the casing left in places shall be performed.

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

7. 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.

When during drilling abnormal gain or loss of drill water is observed, or caving of the hole, binding of the bit or falling of the drilling rods as through an open crack or cavity occurs, it may be required that drilling be discontinued and the hole 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 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, pressures and quantities of water used for testing section of a hole shall be maintained.

The pressure testing apparatus shall be calibrated before use, and shall be periodically testing 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 pressures and times:

Step No.		Pressures (P)	Elapsed time, 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 =	= 1/3 P ₃	5

The pressure for step number 3 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.

8. Pressure Grouting

The general requirements for grouting described herein shall be followed throughout 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.

Stage and packer grouting shall be used and drilling and grouting shall be performed in successive operations. In such case the hole will be drilled to a limited depth, has refused grouting (to the extent specified hereinafter). It shall be flushed out before the grout in the hole has set sufficiently to require redrilling. After the grout surrounding the grouting hole has set the hole shall be water pressure tested and may be regrouted if considered necessary. Thereafter, successively deeper stages shall be drilled, grouted and tested at increasing pressures, 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.

The packers used shall be so designed that they can be expanded to seal the drill hole at the specified elevation 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 10 to 15 m but may vary as required by site conditions.

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

The maximum grouting pressure will be based on $0.2~\mathrm{kg/cm}^2$ per metre (1 psi per feet) depth of packer, or grouted zone, measured on the back pressure gauge located at the header. In no case the pressure be such as will cause upheaval of the bedrock. 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 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 place 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 pumps, 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 or seams.

Grout mixes usually shall range between 10:1 and 05:1 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 water — cement ratio is used after the initial 5 minute 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 bedrock 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 a 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 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 excessive grout intake, sand grout mixtures 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 cleared, the grout allowed to set, and additional drilling and grouting shall be done in this hole or in the adjacent area, 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 grout flow was observed and grouting completed at the pressures specified in this section.

The grouting of any hole shall be continued until the hole or grout connection takes grout at the rate of less than one cubic foot of grout mixture in twenty minutes if pressure of 3.5 kg/cm² (50 psi) or less are being used in fifteen minutes if pressure between 3.5 kg/cm² (50 psi) and 7 kg/cm² (100 psi) are being used in ten minutes if pressure between 7 kg/cm² (100 psi) and 14 kg/cm² (200 psi) are being used and in five minutes if pressures in excess of 14 kg/cm² (200 psi) are being used.

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 conditions, 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 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 the 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 close, the water supply valve open, and the pump running at full speed.

9. 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 nearer if required. Pressure tests in these holes, and core recovery, may indicate that parts of the foundation already grouted required additional grouting. In such event additional hole shall be drilled and grouted as and when required.

10. Protection of Work and Cleanup

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

The appearance of grout from any of the cracks, opening cavaties, 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 progress of the work all open drill holes, cleaned out faults, cavities, cracks in the bed 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.

11. Technical Field Records

As accurate and up-to-date technical field records of all survey, drilling, testing, grouting and control operations and observations required to be performed in connection with this work, shall be maintained for each hole in a chronological order in the proforma that may be prescribed. Suitable forms shall be used for recording other relevant information not covered by the proforma.

12. Foundation Surface Treatment

Three main shear zones with strike along the valley are like to be met with. In addition, finer shear zones will be encountered. The shear zones will be given a dental treatment in the zone of the core base as below:

The shear zones will be excavated to the underlying dolomite upto a depth equal to the width of the shear zone, the excavated slope of the upper dolomite rock being left at half of one. The final 300 mm of the shear zone material shall be removed just before the commencement of backfill operations. The trench so formed shall be backfilled by 125 kg/cm 2 concrete to the depth indicated on the drawing. The treatment could be augmented by other measures if the site condition so.

IV. DAM EMBANKMENT

As shown in the drawing, the dam embankment comprises the following fill zones:

Zone : 1 - Clay blanket/Core, (Central Clay Zone).

Zone: 2 - Filter material behind the clay, blanket, and upstream and downstream of the core.

Zone: 3 - (A) - Mixture of boulder gravel and rockfill for the coffer dam and upstream toe of the Dam.

Zone: 3 - (B) - Rock fill for upstream and downstream shall in the body of the Dam.

Zone : 4 - Rip Rap on the upstream slope (Selected coarse Rockfill).

Zone: 5 - Muck disposal area for fine material which cannot be used in coffer dam or main Dam.

Each of these zones will perform a particular function in the performance of the whole embankment. In order to properly fulfil its function, each zone must contain fill having definite and known characteristics, such characteristics, will be determined by the nature and condition of the fill materials placed within each zone, and the procedure used in fill placement.

Fill materials which shall be placed within such zone or part of the dam embankment are defined herein. Except as otherwise provided in these specifications or elsewhere, or otherwise defined, any fill material not satisfying completely the requirements given herein for that zone or part shall not be placed within any zone or part of the dam embankment.

Definition of Zone Materials

a) General

The physical characteristics and composition of fill material as well as their sources, shall govern their final position in the dam embankment. All fill materials as defined herein for the zones or part of the dam embankment shall be obtained from compulsory excavation or from within the boundaries of the borrow areas.

b) Zone 1 - Clay Blanket/Clay-Core

This portion of the dam embankment shall consist of a selected impervious mixture of clay, silt, sand and gravel available from borrow pits, in the designated borrow areas or from any other source approved by the site Engineer, Zone 1 material roughly shall have the following gradation:

Indian Standard Sieve Size	Percentage Passing
100 mm	100
No.480	40 - 100
No. 8	20% of actual No.
	480 Material.

c) Zone 2, Filter

Layer of filter material which is adjacent to the clay zone shall consist of a non plasting free draining mixture of sand and gravel in which individual particles are hard and durable. Filter material shall be obtained from natural river bed material by processing the best practicable manner, so as to obtain reasonably cleaned and well graded material meeting the following gradation requirements.

First layer (adjacent to the clay zone)

Second Layer
(Adjacent to shell Zone)

i) Tolerable clay fraction shall not exceed 1 %

ii) Not more than 5% shall pass through 200 sieve.

Material shall not exceed 3" (75 mm)

- iii) D 50 of filter material -12 to 58 9 to 30 D 50 of base material
- iv) $\frac{D 50 \text{ of filter material}}{D 15 \text{ of base material}} = 12 \text{ to } 40$ 6 to 18

It may be possible to place the whole filter material in a single layer of the granular material available in the river bod after suitable sieving.

d) Zone (3 and 3 - B) - Mixture of Boulder, Gravel and Rockfill

This portion of the dam embankment shall consist of gravel and over size boulder locally available from river bed and blasted material from rock quarry site. The rockfill shall comprise of suitable free drain mixture of hard durable rock fragments. The maximum particle size shall not be less than 30 cms. nor greater than that which can be encompassed in each layer without interfering with the satisfactory compaction of the layer.

Not more than 15% shall pass a one inch B.S. Sieve.

e) Zone 4 - Rip Rap on the Upstream Slopes (Selected Course Rock Fill)

Rock fill to be used in the zone shall be hard, dense and durable and shall be handled from the Rock Quarry site. Material when placed shall consist of a well graded mixture of rock fragments within the following limits.

- i) The maximum size rock particle shall weigh not less than 2000 Kg.
- ii) Not less than 25 percent material shall consist of particles weighing not less than 1000 Kg.
- iii) The portion of the mixture consisting of particles weighing not less than 1000 Kg. and more than 50 Kg. shall comprise between 45 percent and 75 percent of the material.
- iv) Less than 25 percent of material shall consist of particles smaller than 50 Kg.
 - f) Zone 5 Muck Section

Material K in this zone shall consist of rejected material from other zones, spoils wastes and river bed shingle and boulder.

V. PRODUCTION OF FILL MATERIALS

a) General

The material for dam embankment shall be obtained primarily from borrow areas designated for the purpose. Materials may be obtained from the excavation of core trench of the main dam, and stripping for foundations.

The requirements herein apply to the production of material from borrow areas as well as from compulsory excavation.

b) Clearing and Stripping

The surface of all borrow pits, stockpile sites where clearing of these is necessary, and all waste sites shall be cleared prior to excavating or dumping fill or waste materials.

All borrow pit sites shall be carefully stripped of top soil, sod, loam and other materials which are unsuited for the purpose for which the borrow pit is to be excavated.

The stripped surfaces of borrow pit shall be maintained free of vegetation until excavating operations in that borrow pit are completed. Materials from stripping and/or excavation which are not suited for use in fill material shall be deposited in the spill bank.

If material unsuitable, or not required for permanent construction purposes, are found in any borrow pit, such materials may be left in place or excavated and wasted.

c) Excavation

In the excavation to fill materials for the dam embankment, such equipment and procedures shall be applied which will produce the maximum quantities of uniformly blended materials fulfilling the requirement for each zone material. Variation in gradation of each zone material shall be kept to the minimum possible. In gravel terraces and river bed borrow areas excavation shall be across the soil strain ever the maximum attainable height of the faces, after removing the silt deposits from the top, if any.

For operation of quarry, height of faces and location of benches shall be suitably choosen. One or more horizontal berms shall be formed at regular intervals and quarry site shall be left in tidy and safe condition.

Excavating operations shall be conducted in accordance with provisions contained herein such a manner as to provide the maximum yield of matter also meeting the requirements given herein. Blasting operations shall be done in accordance with the provisions already described.

d) Drainage

The moisture content of all fill materials immediately prior to their compaction in dam embankment, shall be in accordance with the applicable requirements given hereinafter. In order to prevent wetting of fill materials in the borrow pits to moisture contents in excess of those specified, all borrow pits shall be effectively drained. If at any location in the borrow pits for the dam embankment fill materials before or during excavating operations, there is excessive moisture measures shall be taken to reduce the moisture content by selective excavation by excavating drainage ditches, by allowing adequate time for drying or by other suitable means, to secure materials of requisite moisture content.

e) Haulage

The design, provision and operation of all facilities and equipment necessary for transporting of fill materials, from borrow pits, excavations and stock piles to the final point of placement within the dam embankment shall be such that fill materials when placed in the embankment completely fulfil the requirements of these materials, and do not produce unacceptable segregations, wetting, drying or other undesirable effects in the fill materials.

VI. PROCESSING OF FILL MATERIALS

a) General

Materials excavated for placement in Dam embankments shall where necessary be processed prior to delivery to the Dam embankment.

The processing equipment shall be of such design and shall be operated in such a way, as to provide uniformly blended fill materials on the Dam Embankment.

b) Zone 1 Material

It is anticipated that no processing of impervious material shall be required before taking it to the fill except removal of particles larger than 100 mm size at the fill.

c) Zone 2 Material

Filter Material to be laid in the above zone shall be obtained by processing river bed materials through the processing plant. The operation would evolve passing of natural material through screens and water scalping and classifying tanks, and re-mixing in requisite proportions.

d) Zone - 3 A & B Material

No processing of material shall be necessary except removal of fines.

e) Zone 4 Material

No processing of material shall be required before placing on the embankment except removal of fines.

f) Zone 5 Material

No processing will be required.

VII. PREPARATION OF FOUNDATION SURFACES

The suitability of each part of the foundation of dam embankment for placing fill materials shall be examined and approved before fill placement. No fill materials shall be placed on any part of the foundation, until the foundation is inspected and surveyed and deemed as ready for fill placement.

No fill materials shall be placed on any part of the foundation of the dam embankment until that part of the foundation has been unwatered.

All portions of excavation made for test pits or other subsurface investigations, and all other cavities, existing within the area to be covered by the dam embankment which extend below the dam embankment foundation shall be filled with material fulfilling the requirements specified for the zone located above the part of the foundation in which the excavation cavity occurs. The foundation surface when so composed of bed rock shall be prepared by levelling and compacting in the same manner but with double the number of coverages as is specified for the subsequent layer of hill to be placed thereon.

No dam embankment fill shall be placed until all surface grouting required to be done within 45 metres of the location where material is to be placed, has been completed.

Before any embankment is placed, all loose material shall be removed from the foundation surfaces and from trench side slopes, and fresh rock exposed. Final excavation and clearing in alluvium overburden soil shall be done just prior to placement of fill.

VIII. FILL PLACEMENT (GENERAL REQUIREMENT)

a) <u>General</u>

Except as otherwise provided herein only the fill material defined already shall be placed within the dam embankment and those only within the relevant zones, and portions shown in the drawing. Any materials placed within a zone which do not satisfy fully the requirements for that zone shall be removed to another zone for which that material is suitable or to a waste pile within the disposal areas. Within any zone, fill material shall be placed at locations in accordance with specified requirements of that zone. No brush, roots, top soil, peat or other perishable or unsuitable material shall be dumped within the dam embankment.

The distribution and gradation of the materials placed within different zones of the dam embankment shall be such that these fills are free from lenses, streaks and layers of materials differing substantially in texture, of gradation from the surrounding material. The combined dumping, spreading and compacting operations shall be such as to prevent segregation and the material when compacted in the fills will be blended sufficiently to secure the most homogeneous fill in each of the zones. Successive loads of materials shall be dumped in their respective zones or portions so as to produce the best practicable distribution of material.

Gravel and rock places larger in size than the maximum allowable specified for a zone shall, if found in otherwise acceptable fill materials, be removed before the materials are compacted in that zone; provided that such oversize gravel and rock pieces may be placed in other zones if such placement is not considered objectionable.

Dumping and spreading of materials on the embankment shall be performed with the haulage and spreading units travelling approximately parallel to the axis of dam.

The differential height between adjacent zones, measured at the division line between the zones shall be maintained between the following limits during construction.

- i) Elevation of Zone 1 plus 60 Cms. above zone 2
- ii) Elevation of zone 2 plus 45 Cms.
- iii) Elevation of zone 3 No limit above zone 4

Zone 3 could be raised higher than zone 2, but beyond 3 m. of it.

It shall be ensured that fill materials placed within zones of the dam embankment are placed accurately to the lines shown on drawing defining the boundaries between the zones. Interfingering and overlapping of the materials placed in any zone with those placed in adjacent zone shall be permitted only to the extent specified. Materials placed outside these limits shall be removed and wasted or replaced within the boundaries of the applicable zones.

During the placement of fill in the dam embankment the water level at every point within the limits of the dam embankment shall be maintained, as required.

b) Bonding Surfaces

Except as otherwise provided herein and as may be shown on drawing, each zone of the dam embankment shall be constructed in continuous and approximately horizontal layers for the full width and length of the prescribed section. However in case of delay in filter or clay supply at any time, the rock fill, boulders and shingle could be raised higher, the bonding surface so produced being not steeper than 1.5 to 1. Provision of temporary haul roads

in the fill would be permitted in which case the sloping surfaces for road gradients shall be allowed. The bonding surfaces in the embankment fills shall be excavated to sufficient depth to remove all loose materials and horizontal scarified in Zone 1 only and prepared for the placement of fill, in accordance with the requirement given hereinafter.

c) Restrictions Due to Weather

Fill materials in Zone 1 of the embankments shall not be placed during periods of rains, snow or sleet of an intensity which interfere with the specified moisture conditioning. However, rain shall not be considered determental to the continuance of placement and compaction in other zones. When work is stopped on any section of zones 1, because of rain or impending rains, the surface of this section shall be treated as per requirements to facilitate drainage. Before work is resumed in this section, the surfaces shall be scarified and moisture conditioned as specified hereinafter.

Water shall not be used as an aid to compaction of any fill materials placed in the dam embankment during the period when air temperatures are at or below 0° C, provided that water may be used during such periods if quantities of calcium chloride sufficient to prevent freezing of the water, at that temperature are first added.

d) Moisture Conditions

All dam embankment fill material shall be conditioned so that the moisture content on the dam embankment immediately prior to compaction is within limits specified for each zone of designated moisture content. Such moisture contents for each zone material shall be determined at daily intervals or at significant changes in the compaction characteristics of the materials being placed.

It is expected that for zone 1 material, the designated moisture content will normally not exceed the optimum moisture content, defined as that moisture content which will result in the maximum dry unit weight of the material as determined by standard proctor Compaction test.

In general, the moisture content of impervious fill materials be placed in the embankment shall be conditioned prior to delivery of these materials on the embankment. Impervious material for which, if scrappers are to be used for borrowing and hauling, shall be moisture conditioned at the borrow area, or during processing, if such processing is to be done.

Supplemental moisture conditioning performed on the dam embankment shall consist of such measures as are necessary for final correction of the moisture content of the fill materials prior to their compaction, such measures shall include controlled sprinking followed by such mixing as is necessary to obtain uniform moisture content increase throughout the material, working with discs, horrow, or other suitable equipment and allowing to dry, receiving spreading and blending wet material with a selected dry material complete removal of wet or dry material from the dam embankment and such other suitable methods which may be necessary.

e) Spreading And Compacting

Fill materials conditioned to the proper moisture content as specified and dumped within their respective zones in the dam embankment shall be spread in continuous horizontal layers and compacted by the applicable number of coverages of suitable compacting equipment to achieve the desired density.

One coverage is defined as the action achieved when all portions of the surface of a layer have been transversed at least once by the compacting surfaces of the compactor. One pass is defined as the continuous motion of the compactor only.

Compaction of each layer of fill material shall proceed in a systematic, orderly and continuous manner so as to ensure the specified coverages by the compactors. Rolling shall, in general be performed parallel to the direction of fill placement. Special means of placing and compacting fill materials shall be employed at locations where it is impracticable to use the equipment and procedures specified for placement of the bulk of the fill in the embankment. Such locations shall include:

- i) Portions of the dam embankment adjacent to structures if any, and embankment foundations where required.
- ii) Portions of the dam embankment at steep and irregular abutment. Fill materials which cannot be compacted by the specified; rollers because of the location of such materials shall be compacted by special compactors to densities at least equal to those achieved by the specified rollers.

Each layer of fill material in roller turning areas shall be rolled perpendicular to the normal rolling pattern to obtain compaction equal to the reminder of the fill in the zone.

IX SPECIFIC ZONE REQUIREMENTS

a) General

In addition to satisfying the general requirements covering fill placement in the dam embankment, fill in a zone or portion of the dam embankment shall be placed in accordance with the specific requirements given in this paragraph that zone or portion. All layer thickness specified in this paragraph shall be measured after compaction.

b) Zone 1

Clay blanket zone fill material placed in zone 1 shall not overlap the boundaries of the adjacent zone 2 by distances greater that 30 cms. Zone 1 fill material shall have moisture content within the limits of 2 percent below to 1 percent above the designated moisture content immediately prior to compaction, except that the moisture content of zone 1 shall be increased

when placed adjacent to foundation, abutment, and concrete surfaces. It shall be increased to 3 percent above the specified moisture contents. Such foundation, abutment and concrete surfaces shall also be sprinkled with water before laying the fill material. Supplemental watering on the embankment may be used to achieve the desired moisture content. In general, however, supplemental moisture conditions of zone 1 materials shall be performed only as necessary minor final correction of the moisture content of the material on the embankment prior to compaction.

Fill shall be placed in zone 1 layers not to exceed 16 cms in thickness after compaction. Each layer surface of compacted fill shall be scarified immediately prior to placing the succeeding layer of material thereon. The depth of scarification shall as directed but will not exceed a maximum of 7.5 cms. should the surface of the embankment become so dry or so wet that proper bonding or compaction of the material to be placed thereon is impracticable, supplemental moisture conditioning shall be performed as specified to bring the moisture content within the specified limits prior to placement of the next succeeding layer of materials thereon. Particular care shall be taken at abutment contacts, where fill material may have a tendency to thin out and dry.

After each layer of zone 1 material has been spread and finally conditioned to the correct moisture content, it shall immediately be compacted by the required number of coverages of suitable compacting equipment to achieve a density not less than the standard proctor maximum density.

At abutment contacts, the compacted materials during their placement in Zone 1 shall be kept suitably higher than the elevation of the adjacent embankment layers. Such contact materials as are outside the limits which specified roller can effectively operate shall be compacted by special compactors in a manner best suited for the job in order to achieve the prescribed density.

c) Zone 2

Filter fill materials shall be placed in Zone 2 without segregation, in layers not more than 30 cm in thickness after compaction.

Extreme care shall be taken during placing materials in this zone, to obtain fill free from lenses, layers and streak of segregated materials.

Overlapping of fill material placed in filter zone and in the adjoining zones 1 and 3 shall not be permitted to an extent, such that the horizontal thickness of zone 2 reduced below those shown on the drawings. Local reduction in horizontal width of zone 2 to the content of 30 cms shall be permitted, provided that the average thickness remains undiminished.

No addition to the moisture to the materials placed in these zones shall be required. After each layer has been spread, it shall immediately be compacted by number of coverages which shall not be less than

four) of 4 ton vibratory smooth steel drum roller or other suitable equipment such that not less than 70% relative density is achieved. At the abutment contact, filter materials shall be compacted by special compactors in a manner best suited to the job in order to achieve the prescribed density.

d) Zone 3 and 4

Rock fill material in zones 3 and 4 shall be placed in approximately horizontal layers not exceeding 1.82 m in thickness when compacted, provided that within 3 m of the zone of 2 material finer zone 3 material shall be placed in 45 cm thick layers. Each layer of material in zone 3 and 4 shall be evenly spread to a level surface with no large voids and compacted by four passes of a vibratory rollers shall meet the following requirements:

- i) The static weight of the roller including the frame, the vibrating part of the roller and all accessories shall not be less than 8000 Kgs. weight.
- ii) The roller shall be capable of vibrating at frequencies down to 1100 vibrations per minute.
- iii) The centrifugal force generated by the vibrating parts of the roller shall be not less than 13500 Kgs. weight at a frequency of 1250 vibrations per minute.
 - iv) The motor supplying the power for the vibrating part of the roller shall develop not less than 55 BHP.

Before compaction, each layer shall be sluiced with hydraulic monitor or other suitable equipment for washing out fines and helping interlocking of rock.

If no completion of each layer of zone 3 and 4 material, the surface of the layer is such that it will obstruct free drainage of water through the zone, or such that it will not be possible to obtain satisfactory bond with the succeeding layer, the surface shall be ripped, sluiced or otherwise prepared to provide a satisfactory surface.

Embankment materials in Zone 3 and 4 shall not encroach upon adjacent zone further than allowed by the following tolerances measured perpendicular to the dam axis and in horizontal plan from Division lines shown on the drawing or as adjusted.

i) About the Division line between zone 2 and 3 of Plus 0 minus the embankment. 60 Cms.

- ii) About the Division between zones 3 and 4 of the dam embankment
- a) Away from Dam axis 5 metre.
 - b) Towards the Dam axis 0 metre.
- iii) For the outside face of the Dam embankment
- a) Towards the Dam axis 0 metre.
- b) Away from the Dam axis 2 metre

Zone 3-A comprises mixture of boulder and gravel and rock fill in the body of upstream coffer dam which is a part of the main rock fill dam.

Selected Rock Fill Material from the quarry and excavation spoil bank shall be dumped in running water from both the banks for the initial closure of the river. Simultaneously, the material containing fines will be dumped in order to reduce the voids in the fill. If need be, angle iron crates filled with rock or boulders shall be launched in deepest river portion for the initial closure.

After attaining a level of 1370 feet (417.58 m) the natural river bed material shall be placed in layers not exceeding 60 cms. after compaction. Before compaction just sufficient water shall be sprinkled on the layer to bring it near saturation condition. After each layer has been spread and moisture conditioned, it shall immediately be compacted by the required No.of coverages (which shall not be less than four for 4 ton roller and 2 for 8-10 ton toller) of vibratory smooth steel drum roller or other suitable equipment, such that not less than 70% relative density is achieved.

At the abutment contacts, the materials shall be compacted by special compactors so as to achieve at least 70% relative density.

e) Zone 5 - Upstream Disposal Area

All waste material from excavation of the ridge, tunnels or from other sources shall be simply dumped in this zone. No proper compaction of the material in this zone is needed. However for the purpose of the movement of the machinery the top surface may be trimmed to reasonably easier slopes. The exposed surface, if practicable, may be protected by laying big size boulder, against erosion,

X. SPREADING AND COMPACTING EQUIPMENT

Tests fills shall be constructed for all the fill materials and extensive tests shall be performed under varying conditions to evaluate the performance of different type of equipment in order to determine the most suitable type for the job in hand. Best operating conditions and technique and number of roller passes etc., required for the different fill materials shall also be determined for the equipment, so as to get the maximum density with minimum effort.

XI. QUALITY CONTROL

a) General

All sampling and testing work necessary for the delivery on the dam embankment, ready for compacting of fill materials of satisfactory gradation and moisture content and all such work necessary for determination and control of the quality of the fills produced in dam embankment after compacting of the fill materials shall be performed during the progress of work.

b) Fill Materials_

I shall be ensured that the fill materials placed in the dam embankment comply fully with the applicable requirement for each zone materials contained herein and that these materials are placed and compacted in the embankment at moisture contents within the applicable limits specified for each zone.

For this purpose all sampling, testing and other work necessary for the determination of the gradation and moisture content characteristics of the fill materials to be placed in the embankment shall be performed, with sufficient frequency to ensure the placement of the fill materials full compliance of the specifications. On the basis of the results obtained from such work, all personnel who are engaged on fill production or placement shall be directed so as to ensure that the requirements of these specifications are satisfied in every respect.

The gradation of fill materials, where required, shall be determined in accordance with the United States Department of Interior Bureau of Reclamation Test Method, Designation E-6 as described in their Earth Manual, first Edition and the moisture content of fill materials in accordance with the United States Department of Interior Bureau of Reclamation, Test Method, Designation E-9.

A systematic method of identifying tests and test samples shall be used in recording the results of all fill materials controlled tests. For each such tests there shall be recorded the date, shift, number of that shift, location of sampling and the purpose of the test.

c) Fills_

Such soil and other tests as are necessary to ensure the satisfactory quality of the fill as placed in the dam embankment shall be continuously performed during the work.

For determination of the quality of the fills placed in the dam embankment samples of fill from the dam embankment will be taken and tests conducted as may be deemed necessary either on the embankment or in soils testing laboratory. Such tests will include those for the determination of fill density-in-place, optimum moisture content fill in place moisture content and fill permeability. Such tests shall be performed as frequently as shall be considered necessary for the proper evaluation of the quality of the fills placed in the dam embankment.

d) Tests

All tests shall be made in accordance with the recommended procedure given in the relevant I.S. specifications.

The contractor shall provide all necessary facilities, materials and labour for these tests as the Engineer-in-charge may consider necessary for which no extra payment shall be made. The contractor shall at all times have access to an association with sampling design and test of trial mixes and similar other operations. It shall be the responsibility of the contractor to associate himself, or through technically qualified representative with the work of tests in the Government laboratory and in the field. The contractors representative shall sign the record of such tests kept by the laboratory staff in token of acceptance. Failure on the part of the contractor to associate with the operations aforesaid shall not absolve him of the responsibility of producing, on the work, fills of specified quality and strength with design fill determined from laboratory tests and results.

e) Instrumentation of Rock Fill Dam

This work includes erecting, laying and installing following materials and instruments including test apparatus in the dam embankment and grouting tunnel:

- Installing hydraulic twin tube piezometers in the dam foundations and within the dam embankments and continuing the tubing to various terminal points.
- 2) Installing cross arm settlement measuring units within the dam embankment.
- 3) Installing horizontal movement measuring units within the dam embankments and excavation slopes.
- 4) Erecting instrument wells.
- 5) Installing and completing instrument terminal assemblies.
- 6) Installing water supply system for instrument terminal.
- 7) Constructing seepage measurement facilities.
- 8) Installing surface settlement points on the surface of the dam embankment.
- Installing aluminium slope indicator casings for slope indicator measurements.
- 10) Installing instruments for seismological observation.

General

All instrumentation required by this section shall be installed to the lines and elevations shown in the drawings, in the presence and under the supervision of an Engineer. No portion of any instrumentation shall be covered until tested and approved. Tubes will be tested with water under pressure and leaks disclosed by this test shall be immediately repaired. Terminal assemblies will be similarly tested and if required shall be repaired. Care shall be taken to protect the apparatus from damage or displacement during the execution of the work. All tubes and devices shall be marked at a maximum spacing of 15 m to ensure that such items are kept in proper order and sequence as they are extended through the dam embankment to the terminals.

Embankment instrumentation and associated tubes shall be installed during the day light hours only. Such installation shall be completed as expeditiously as possible so that terminals can be placed into operation as the embankment elevation increases. No traffic or equipment shall be allowed to pass over any part of an internal instrument. Installation until that part is covered by a minimum of 45 cm (18") of completed embankment. Soil tests shall be made at as many of the instrument locations as deemed necessary to ensure that the work is being performed in accordance with the specification and to make a permanent record of soil properties at these location. Open ends of all incomplete lines of tubing shall be sealed temporarily during obstruction to exclude foreign matter.

Backfill compaction for instrumentation shall be accompanied by special compactors and selected fill shall be used. The term "selected fine material" as used in this section shall mean material passing the No.480 IS sieve and otherwise conforming to the requirements of the same embankment material in which the trench is excavated or in which the instrument is installed.

The scheme of instrumentation layout and details shall be as shown in the drawings. The instruments shall be supplied by the Department at site of work.

XII, PROTECTION MAINTENANCE AND CLEAN UP

a) General

The dam embankment shall during the progress of the work be maintained in a satisfactory manner until final compaction. Any material that is lost by weathering or other cause shall be suitably and properly replaced.

b) Protection of Fill

i) During and/or after placement of materials in zones the materials shall be protected against confirmation by clay, top soil, other objectionable material from the passage of construction machinery or by any other means.

- ii) Extreme care shall at all times be taken to preserve the homogeneity and permeability of zone 2. The prime consideration in this regard shall be to prevent entry of the fine material placed in the adjacent zone and soil fractions eroded from the surfaces of the abutments by water draining towards the fill. Proper arrangements shall be made for effective system of drainage of the fill as well as abutments.
- iii) Embankment Instrumentation: Extreme care shall be taken for the protection of the instruments that will be embedded in the body of the dam. No traffic or equipment shall be allowed to pass over any part of an internal instrument installation until that part is covered by a minimum of 45 cm of completed embankment. Any damages ensured by the contractor's operation shall be recoverable from him.

c) Clean Up

During placement of ill in the dam embankment the surfaces and slopes of the dam embankment fills shall at all times be kept free from accumulation of rubbish, rejected or unsuitable fill or waste materials. On completion of the work, all constructional plant, surplus material, waste materials and rubbish, shall be removed from within the limits of dam embankments and the dam bankments and all the borrow pits and other areas used a sources of fill materials shall be left in a neat, clean and presentable condition.

After completing, excavations in any of the borrow pits for gravel or soil materials, the excavated faces of the pits shall, if necessary and for safety purposes, be flattened to slopes not steeper than 1 vertical or 1.5 horizontal.

d) Selected Surfacing

Selected surfacing shall be placed as shown on the drawings on crest of dam embankment.

Selected surfacing material shall consist of rockfill, river bed material with fines (semi-pervious) free from vegetable matter, and other deleterious substances reasonably well-graded upto 38 mm maximum screen size. The surfacing material shall be placed, thoroughly wetted, and suitably compacted, Segregation of coarse and fine particle shall be avoided and any segregated materials shall be remixed by harrowing and blading. When compacted the surfacing shall conform to the established lines, grades and dimensions.

XIII. DEWATERING OF FOUNDATIONS

This shall govern the requirements for dewatering of foundations for carrying out all excavations and placement of fill materials below the water level, (including spring water).

Unwatering and drainage facilities necessary to maintain work areas and all excavation free from surface water and ponding shall be provided and suitably maintained.

Unwatering shall be accomplished in a manner that will prevent loss of fines from the foundation, maintain stability of the excavated slopes and bottom of excavation and will result in all construction operations being performed in the dry.

For proper seepage control, installation of drains leading to sumps from which water shall be pumped, may be required. Such pipe drains and/or sump if embedded in the damembankment fill or in the foundation below such embankment fill shall be confined to areas outside the boundaries of zone of dam embankment. In addition, pipe drain, where used, shall be of uniform diameter for each run, shall be provided with grout connections and returns at intervals of not more than 15 metres and shall be embedded in reasonably well graded gravel or like materials. Any unwatering system such as pipe drains including surrounding gravel and sumps, which of necessary must remain in the dam embankment or in the foundation shall have to be filled with cement mortar grout when no longer needed.

The rates quoted for all the item of work will be considered inclusive of all dewatering operation that may be required.

During the placement of dam embankment fill in the excavated area the water level at every point in the area shall be maintained below the bottom of embankment until the compacted embankment at that point has reached a depth of 3 metres after which the water level shall be maintained at least 1.5 metres below the top of the compacted embankment.

XIV. SAFETY MEASURES

Safety measures shall be taken during execution of all items of work. The relevant I.S. Standards of safety as amended from time to time shall apply.

XV. ACCURACY OF ALIGNMENTS, GRADES, LEVELS ETC.

The contractor shall fix his permanent points and bench marks in relation to bench marks and fixed references points given by the Engineer-in-Charge in work area.

The contractor shall execute the work to proper alignment grade and levels, and check these at sufficiently frequent intervals as the work progresses. The Contractor shall provide free of cost all facilities like labour, instruments etc., to the Engineer-in-Charge to check the alignments, grades levels etc., whenever they are asked for, such checking by the Engineer-in-Charge shall not absolve the contractor of his responsibility of maintaining the accuracy of the work, any discrepency or error detected during the course of execution and or at the end of work shall be set right by the contractor at his own cost and to the entire satisfaction of the Engineer-in-Charge.

XVI, MEASUREMENTS AND PAYMENTS

Cross section will be taken normal to the axis of the Dam at as close intervals as necessary and practicable but not more than 16 metres and 8 metres apart in over burden in rock respectively prior to the staring of excavation for foundation in each class of material, unless otherwise directed by the Engineer-in-Charge, in any particular location of work. The volume of excavation in each class of material shall be worked out from the area of cross section. The computation shall be done by mean area method.i.e....,

Quantity = H (A₁ + A₂ +
$$\sqrt{A_1 \times A_2}$$
) 1/3

For the final measurements. The sections in all materials shall be measured only upto the clear dimensions marked on the drawing unless otherwise modified or ordered by the Engineer-in-Charge.

The term "Excavation" has herein used shall include excavation, drain-age, removal and transportation of excavated material to the dump areas shown on the drawings.

