



**Practical
ACTION**

TECHNICAL SPECIFICATIONS FOR MATERIALS & WORKMANSHIP

For

Construction of Dam Rehabilitation in North Darfur State

Prepared By



DAMS ENGINEERING ENTERPRISES

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TECHNICAL SPECIFICATIONS FOR MATERIALS & WORKMANSHIP

Chapter 1: General

1.1 Location of the Works

The Site is located in North Darfur State.

1.2 Object of the Works

The objective is to construct of Dam for water spreading in order to provide irrigation water for the agriculture.

1.3 The Works

The contractor has to construct all Civil Works needed for the rehabilitation of Azagarfa Dam in North Darfur State

The Site of works is as specified in Contract Documents or as may be defined by the Engineer.

1.4 Climate

The sites lay in a region where arid conditions prevail year. Normally the early rainy season start at the end of May and continues up to October. The climate is hot in summer (up to 48 OC) during summer season.

The Contractor shall ensure that no damage occurs to the Works during rehabilitation/construction by arranging adequate protection against the effects of drought, sun, wind and rain (including flood) ...etc.

1.5 Structural Stability

The method of working for construction must ensure that structures are stable at all time and the Contractor shall guard against damage to the works due to existence of any unstable material.

1.6 Standards

The Contractor shall keep available at his principal site office at least one copy of all standards for materials used in the Works. These Standards where not in the English language shall be accompanied by an English translation and shall be available to the Engineer at all times after the Commencement of Work.

Should the Contractor wish to supply a material to a standard other than that stated in this part of the specification he shall, in making application for approval to the Engineer, include a copy of the Standard to which the proposed material complies.

Save where local Sudanese units are, for convenience, used the System international d'Unites (SI) shall be used throughout the Contract except where otherwise specified.

1.7 Services

The Contractor shall make a record of the position and extent of any services encountered and shall protect them from disturbance. He shall, in good time, arrange with the Engineer for the diversion of any services that encroach upon the Works. The Contractor shall, by notices, guard portals or otherwise, protect any overhead services from damage by the Contractor's Equipment.

1.8 Setting Out

Survey data and bench marks are shown on the Drawings or scheduled as part of this Specification.

All setting out shown on the Drawing is to be treated as provisional and subject to confirmation or correction by the Engineer before use in setting out the Works.

The Contractor shall only use the Contract bench marks shown on the Drawings or scheduled in this Specification for setting out to level. The value of a bench mark shall be confirmed with the Engineer before use.

The Contractor shall be responsible for the maintenance of all control benchmarks shown on the Drawings or scheduled.

1.9 Assistance to the Engineer

The Contractor shall supply such labour as the Engineer may require to assist in checking the setting out of the Works, in measurement and for the security of the office and equipment supplied to or used by the Engineer.

1.10 Contractor's Offices

The Contractor shall obtain the Engineer's approval of the arrangements for his camps, offices and stores and shall include for work associated with them in his programme.

The Contractor shall have an office on or adjacent to the Works (in an area to be designated as part of the Site) and instructions delivered there shall be deemed to have been received by the Contractor as provided for in Sub-Clause 15.1 of the General Conditions of Contract. The office may be at any one of the sites and shall be moved only with the approval of the Engineer.

1.11 Site Clearance

The Contractor shall in preparation for the start of work clear the whole of the area of the Works of debris and rubbish and dispose of it in a manner and at a location approved by the Engineer. The Contractor shall on completion of this preparation

agree the levels on the Drawings or shall make a record of the levels agreed with the Engineer.

On completion of section of the Works or part for which a taking-over certificate is requested, the area shall be cleared as far as is reasonable of all debris and rubbish. On completion of the Work at any site, the area of the Works shall be cleared of all debris and rubbish and all temporary works and of the Contractor's Equipment save as may be approved to remain by the Engineer, and the section shall not be considered complete until this is done.

1.12 Contract Notice Boards

At locations selected by the Engineer, the Contractor shall erect at the start of work at site and shall maintain until the issue of a taking-over certificate for the works at that site a rigid notice board not greater than 3m x 3m or smaller than 1.5m x 1.5m giving the following details of that part of the contract in clear weatherproof form in English and Arabic:

- Name of Employer
- Name of Engineer
- Name of Contractor
- Short description of the Works
- Due date of Completion
- Such other details as the Engineer may request or approve

1.13 Photographs

The Contractor shall take photographs and shall supply to the Engineer photos in electronic format and colour prints not smaller than 148mm x 210mm of such portions of the Works in progress as the Engineer shall direct.

Each print shall have recorded on the reverse, the date of the photograph and an identifying description. Two prints shall be supplied of each photo.

The Contractor may, at his own cost, make and retain an additional print for his own records.

No photographs of the Works may be taken without the approval of the Engineer and without informing the Contractor. No copies of any photographs of the Works may be made by or supplied to any person without the approval of the Engineer.

1.14 Laboratory Testing

All Laboratory testing when specified, shall be undertaken by labs approved by Engineer, save that if the Contractor can demonstrate, to the satisfaction of the Engineer, that he has suitable facilities or access to other suitable facilities, these may be used for such testing.

1.15 Site Testing Equipment for the Engineer

The Contractor shall make available to the Engineer the equipment for the control of Concrete Quality detailed in Clause 3.12 of this specification and any other equipment

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provided on site by the Contractor for use in lieu of using the facilities of the approved labs., as detailed in Clause 1.16 of this specification.

Chapter 2: Earthworks & Embankments

2.01 Notice Prior to Commencing Earthworks

The Contractor shall give to the Engineer at least seven day notice of his intention to commence earthworks on the Site. The written notice will include details of dewatering proposals, borrow areas, use of excavated material, disposal of surplus material and the shoring of excavations. Earthworks on site shall not be started without the written approval of the Engineer.

2.02 Earthworks Levels

Levels shall be agreed with the Engineer as required by this specification. Where dimensions are given from ground level, the Engineer's directive shall be sought when there is any conflict between the Drawings and the ground level as recorded.

2.03 Dewatering

Save insofar as work is undertaken in the water course and where the approval of the Engineer is given for excavation to be undertaken without dewatering, all structures and pipelines shall be constructed in-the –dry.

Should the contractor be unable to undertake work in the water course or without dewatering to the satisfaction of the Engineer the Contractor shall, on the instruction of the Engineer, by cofferdams or by dewatering or otherwise, undertake the work in-the-dry and there shall be no additional payment to the contractor on account of being required to undertake the work in-the-dry.

No payment for dewatering shall be made unless there is special provision for such payment by an item in the Bill of Quantities.

Where the Contractor has to provide sumps for pump suction below the level of the work, these shall be in locations approved by the Engineer and shall be backfilled according to his instructions.

2.04 Materials to be Excavated

The Contractor shall excavate any material for the execution of the works and shall dispose off the excavated materials as specified, detailed in the Bill of Quantities, shown on the Drawings or ordered by the Engineer .

If the contractor encounters any material which in his opinion may be unsound he shall immediately inform the Engineer who will instruct the Contractor in writing as to whether or not the material is to be treated as unsound.

The omission by the Engineer to give any instruction shall not relieve the Contractor of any responsibility for the Works if, prior to construction, the Contractor shall have failed to request the Engineer to inspect the exposed areas to receive foundations or fill.

Unsound material shall be removed and disposed of to the satisfaction of the Engineer. The voids so formed shall be filled as instructed by the Engineer.

The extent of the excavations shall be the minimum practicable for the construction of the Permanent Works.

Excavation for structures shall consist of net excavation on the plan area of the foundation measured horizontally at the foundation level or levels. The Contractor shall be deemed to have allowed in his rates for any additional construction and working space which he considers necessary.

2.05 Support of Excavations

The Contractor shall provide, as Temporary Works, all supports necessary for the excavation and shall remove them only when, in the opinion of the Engineer, they can be removed without risk to the Permanent Works or to adjoining property and the arrangements for backfill are satisfactory.

2.06 Slips & Falls

The Contractor shall take every care to avoid having slips and falls of material from the sides of excavation and embankments.

In the event of slips and falls occurring the Contractor shall at his own expense make good all earthworks and associated works and make any modification of the Works necessitated as a result of such slips and falls to the satisfaction of the Engineer.

2.07 Excavation for Pipelines

Whether trenches for pipelines are constructed with vertical, sloping or stepped sides, that portion of the trench which extends from the formation to a level no less than 300 mm above the crown of the pipe when laid in position shall, unless otherwise ordered by the Engineer, be formed with vertical sides the minimum practicable distance apart so that, except for an allowance for trench supports approved by the Engineer, work shall conform to the following:

Nominal Internal Diameter of Pipes (mm)		Max. Distance between Barrel & Trench Side (mm)
Not Exceeding	300	200
Over 300, but not Exceeding	825	300
Over	825	395

2.08 Excavation for Foundation

The Contractor shall excavate ponds to the best practicable finish which, in the opinion of the Engineer, can be obtained by the skilled use of the Contractor's Equipment approved for use.

At all changes of cross section or slope the Contractor shall form transitions to give a smooth change.

2.09 Disposal of Dewatering Water

The destination and method of disposal of water from the excavations shall be subject to the approval of the Engineer.

2.10 Trimming of Formations for Structures

Where the formation of any excavation, being other than rock, is to support the foundations or floor of a structure, the bottom 150mm thereof shall be carefully excavated and trimmed immediately before the placing of the Permanent Work on it. The approval of the Engineer shall be obtained before placing of the Permanent Work and any additional excavation necessary to provide a firm base and any additional Permanent Works that result shall be at the expense of the Contractor.

2.11 Backfill & Fill

Backfill shall mean the material required to refill, with due allowance for settlement, excavation outside the Permanent Work up to the ground levels prevailing at the commencement of the works .

Fill shall mean the material required above the ground levels prevailing at the commencement of the works to make the embankments comprised in the Works, with due allowance for settlement.

Unless otherwise specified, the material used for fill and backfill shall be selected excavated material to the approval of the Engineer.

Backfill against the Permanent Works shall be selected free from boulders, cobbles, rock fragments and the like greater than 50mm, nominal size. Other backfill and fill shall contain no such particles as aforesaid greater than 150mm nominal size.

After approval has been given by the Engineer for backfilling or filling of any part of the works to begin, the operation shall start with the minimum of delay and shall continue without interruption until the work is completed.

2.12 Compaction of Fill & Backfill

Unless otherwise specified, the Contractor shall deposit backfill or fill in layers of uniform depth no exceeding 200mm thick when loosely spread and shall compact it by evenly distributing over it the passage of earthmoving equipment to a minimum

compaction of 95% of the maximum dry density at optimum moisture content. The layers shall have a slight cross fall away from the Permanent Work.

Where the space available is insufficient to permit the evenly distributed passage of earthmoving equipment, the Contractor shall use mechanical compactors or other methods of compaction in a manner and for a duration approved by the Engineer to achieve the compaction which would otherwise have been achieved had the space available not been insufficient as aforesaid.

2.13 Special Compaction

For special compaction, that is where the degree of compaction is specified, the Contractor shall adopt such methods and use such construction equipment as is necessary to achieve the degree of compaction specified. Where the degree of compaction is expressed as a percentage, it is the per cent ratio of the dry density of the compacted material to the maximum dry density as determined by the compaction test (Test Number 11) in BS 1377, or other test approved by the Engineer.

At least one month before commencing such compaction of backfill or fill the Contractor shall submit to the Engineer details of the method and construction equipment proposed for use and shall , if so instructed, make trials on site. The Contractor shall make such tests of materials before and after compaction as the Engineer considers necessary , both of the trails and of the Permanent Works , to ascertain to his satisfaction that the degree of compaction specified is attainable with the methods and equipment proposed and is attained .

The Contractor shall exercise careful control of the moisture content of the backfill or fill material prior to and during compaction so that it lies within a range of values established during the said trials to the approval of the Engineer as suitable for the material and the method of compaction adopted .

2.14 Location Of Borrow Areas

The Contractor shall select for himself the sites for borrow areas from within the Site or from other areas indicated or approved by the Engineer. With approval the borrow area will become part of the Site if worked by the Contractor.

The Contractor shall undertake no work on borrow areas until confirmation is given by the Engineer that the Employer has reached agreement on any royalties or compensation payable. The cost of such royalties or compensation shall be a charge on the Employer. The cost of winning material from the borrow areas and of making good on completion of the work in the area shall be deemed to have been included in the contractor's rates and prices in the Bill of Quantities.

2.15 Work at Borrow Pits

The Contractor shall excavate at the sites of the borrow areas to expose the material required for fill and shall select and excavate the said material. After the required amount of material has been won from each area the Contractor shall reinstate the area by spreading the previously removed superficial materials in layers not

exceeding 250 mm deep over the area of the excavation and grading and trimming to the satisfaction of the Engineer. Where practicable such grading shall be made to prevent the accumulation of surface water.

The Contractor shall prepare and submit in detail for the approval of the Engineer his proposals for the use of borrow areas and shall give notice to the Engineer in writing at least one month before the proposed date of starting work at each borrow area.

2.16 Scarification

The Contractor shall scarify to a depth of 150 mm the ground to accept specially compacted fill. The Contractor shall ensure that no vegetation remains in the area to be covered by the fill and shall bring the moisture content of the surface material to its optimum value as specified for special compaction before placing and compacting any fill thereon.

The Contractor shall similarly treat the surface of any partially completed area for fill which in the opinion of the Engineer has been left exposed too long before the placing of further layers of fill thereon.

2.17 Allowance for Settlement of Fill & Backfill

The Contractor shall make due allowance for consolidation and settlement of fill and backfill so that the levels and dimensions of the finished surfaces at the end of the Defects liability period are not less than those shown on the Drawings or ordered by the Engineer.

2.18 Finish of Embankments

Except where otherwise specified or ordered by the Engineer, the tops and side slopes of fill placed in embankments shall be neatly trimmed equal to the best practicable finish which in the opinion of the Engineer can be obtained by the skilled use of the earthmoving equipment used in the placing and, where specified, compacting of fill.

Where precise lines and levels of embankments are not specified or ordered by the Engineer, the Contractor shall construct embankments in straight lines between smooth curves to give a pleasing appearance. The tops of embankments shall be finished reasonably level and even.

The widths of embankment tops shall not be less than the width specified or shown on the Drawings and shall not, without the approval of the Engineer, be more than 300mm greater. The faces of embankments shall be to the slopes specified with no abrupt changes.

2.19 Disposal Generally

The contractor shall transport and dispose of all excavated material not required for the works. The locations proposed by the Contractor for disposal or storage of excavated materials, whether temporarily or permanently, shall be subject to the approval of the Engineer.

2.20 Disposal in Embankments of Bridge

Unless otherwise specified or ordered by the Engineer, the material excavated during the construction of bridge shall be disposed of in embankments (if suitable) constructed in approaching bridge sides as indicated on the Drawings.

The Contractor shall leave or make gaps in the embankments for the construction of structures after the completion of which he shall reinstate the embankments to conform to and marry in with the embankments associated with the structures.

2.21 Surplus Spoil Dumps

Unless otherwise approved, spoil dumps shall, on completion, be graded to slight crossfalls and even side slopes; the maximum height of such dumps shall be 2 m.

2.22 Rock Excavation

Rock shall be interpreted as meaning natural bedrock which can only be dislodged by wedges and sledgehammers, rock hammers, pneumatic tools or blasting; and boulders and blocks of similar or other material exceeding 0.1m³ in size which cannot be fractured except by the same means.

2.23 Preparation of Formation for Pitching

The contractor shall prepare the formation for pitching or rip-rap by trimming accurately to the specified dimensions. Where over excavation occurs it shall be backfilled with gravel backing, material all to the approval of the Engineer.

2.24 Sand/Gravel Backing for Pitching

Sand/gravel backing for pitching and as a filter layer below terram and rip-rap shall be clean natural gravel and sand (hoggin) well graded from 30mm down and it shall be laid to the thickness shown in the Drawings.

2.25 Geotextile Filters

Where shown on the Drawings geotextile filters such as Terram 2000 or equivalent (e.g. Netion multi-layer) shall be placed in position with overlaps of not less than 100mm and held firmly in place until covered with rip-rop or such other material as may be shown. No mechanical equipment shall work on such filter fabric and boards shall be provided for labour.

2.26 Dry Stone Pitching

Where shown on the Drawings or detailed in the Bill of Quantities, the Contractor shall supply and lay on such prepared abutments or zones as is shown, dry stone pitching consisting of stones of random size roughly dressed so that they will fit closely together. Each stone shall have a mass not less than 25 kg and depth not less than as shown on the Drawings or detailed in the Bill of Quantities and shall not be less than 200mm x 200 mm on the exposed face.

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The stones shall be selected to fit together and shall be packed and supported with progressively smaller stones to give the minimum of voids.

Chapter 3: Concrete & Reinforcement

3.01 Cement

Unless otherwise specified the cement used in the Works shall be Ordinary Portland Cement (OPC) complying with BS 12 (1997).

The Contractor shall supply samples of cement, when requested to do so by the Engineer, from deliveries to the port or to the Site and from the Contractor's store.

The Contractor shall supply the manufacturer's test certificate for each consignment of cement received at Site as provided for in Clauses 10 and 12 of BS 12. He shall maintain a record, available for inspection by the Engineer of the location in the Works of concrete made from each consignment.

For the purposes of BS 12, the Site shall be deemed to have a tropical climate.

Where specified or ordered, Sulphate Resistant Cement (SRC) complying with BS 4027 shall be used in place of Ordinary Portland Cement.

3.02 Aggregates

Aggregates for concrete and mortar shall comply with BS 882, 1201 at the time of use.

- (i) Fine aggregate shall be derived from natural river or pit sand. The Engineer will permit the addition of suitable crushed rock fine aggregate, as necessary, to the river or pit sand here, in his opinion, it is impracticable to obtain the required grading of the combined aggregates otherwise than by such addition. The maximum quantities of clay, silt and fine dust shall, in any event, not exceed 3 per cent by weight when using the test given in Clause 13 of BS 882.
- (ii) Coarse aggregate shall comply with the requirements in table of BS 882, 1201 for graded aggregate to the nominal maximum size specified for the appropriate class of concrete.
- (iii) The aggregates shall be such that concrete when made and tested in accordance with the Building Research Station Digest 35 (2nd series) shall not show a drying shrinkage greater than 0.065 per cent.
- (iv) Immediately after commencement of the Works, the Contractor shall make tests to the satisfaction of the Engineer before the Engineer will give approval to the sources of aggregates proposed by the Contractor. Alternatively, and subject to the approval of the circumstances by the Engineer, the Contractor may submit a certificate from an independent laboratory.
- (v) Unless otherwise specified, separate fine aggregate and 20 mm nominal maximum size coarse aggregate shall be used. where 40 mm nominal maximum size coarse aggregate is specified or approved, it shall be a separate grading additional to the 20 mm aggregate added at the time of batching the concrete ingredients.

(vi) During the performance of the Contract, the Contractor shall supply samples of aggregates when required by the Engineer (the samples shall be taken in accordance with BS 812 and shall make regular tests of the aggregates in accordance with BS 812, 882, 12C and BS 177 [Test (1b)] in a pattern and at a frequency (at least once a week) at each source of each grading as may be required by the Engineer and shall furnish the Engineer with a copy of each test result.

3.03 Water

The water for concrete work shall be from a source approved by the Engineer shall be free from suspended matter, floating or any pollutant which:

- (i) Affects the setting time by more than 30 minutes or reduces the attainable compressive strength by more than 2C;
- (ii) Prevents the achievement of the specified cube strength,
- (iii) Produces discoloration or efflorescence on the surface of the hardened concrete,
- (iv) Promotes or aggravates an alkali aggregate reaction.

Generally water from Khors will not be approved as it has an excess of suspended matter, which does not settle out. The Contractor may rent wells or construct wells (or provide water by any means) and these shall, either be handed over to the landowner or filled in to the satisfaction of the Engineer when no longer required by Contract.

The water shall be free from hydrocarbons and from suspended organic matter. Inorganic matter in solution shall not exceed 500 parts per million by weight and in suspension shall not exceed 30 parts per million by weight.

The Contractor shall test the water, which he proposes to use, and shall submit the records of such tests to the Engineer before placing any concrete in the Permanent Works.

The Contractor shall make regular tests of the water taken from the points of delivery into the other constituents of the concrete and mortar in a pattern and at a frequency approved by the Engineer and shall furnish the Engineer with a copy of each test result.

3.04 Concrete Admixtures

Concrete shall be made from cement, aggregates and water and no other ingredient shall be mixed in. However, concrete admixtures can be used provided the written approval of the Engineer is obtained.

3.05 Chemical Content

The total Sulphate content, whether as gypsum or more soluble salts, of concrete ingredients when measured as SO_3 , shall together not exceed 6.0 per cent of the weight of cement in the concrete.

The chloride content of concrete ingredients when measured as Cl shall together not exceed 0.2 percent of the weight of cement in the concrete.

3.06 Storage of Materials

The Contractors arrangements for the storing and handling of materials for concrete shall be to the approval of the Engineer. Such arrangements shall be directed towards preventing deterioration, adulteration or segregation of the various materials and shall ensure ready identification and the orderly use of cement.

Cement shall be used only from the manufacturer's sealed bags. Cement from torn bags shall only be used with the permission of the Engineer. Cement sweepings shall not be used in concrete.

3.07 Shuttering

Shuttering shall be constructed to obtain the required surface textures to the structures and shall be such that it does not permit the loss of any of the ingredients and remains rigid during the placing and setting of the concrete.

Shuttering shall be fixed in perfect alignment and to the true shape and dimensions of the Permanent Work shown on the Drawings. Method of support, which would result in tie wires holes extending the width from face to face of the work or would leave-wire supports showing on the surface will not be permitted.

Notwithstanding the general restriction on the methods of support, methods using through bolts which are subsequently removed may be employed provided that such bolts have purpose made conical spacers on each face and provided that no release agent is used. As may be instructed by the Engineer such fixings shall be removed before the concrete has fully hardened and the holes shall be hacked back and plugged with concrete.

Unless otherwise approved top shuttering shall be provided to concrete faces where the slope exceeds one vertical to three horizontal.

Except where otherwise specified shuttering for concrete faces which will remain exposed in the Permanent Work shall be wrought such as will prevent the loss of any ingredients from the concrete and will produce a dense smooth concrete surface without discontinuities of line texture or appearance.

Except where otherwise specified, shuttering for concrete faces which will remain hidden including faces which will be plastered shall be back shuttering such as will prevent the loss of any ingredients from the concrete and will produce a dense concrete surface.

Unless otherwise shown on the Drawings exposed arises shall be formed with a 25mm x 25mm chamfer

For concreting in hot or drying weather the Contractor shall design and strike the shuttering so that the concrete surfaces can be exposed for curing as soon as practicable.

When so instructed by the Engineer the Contractor Shall submits the design and details of shuttering for the Engineers approval.

No concreting shall begin until the Engineer has inspected and approved the erected shuttering.

Shuttering shall only be removed from the cast concrete with the permission of the Engineer and the Work of removing it after the receipt of such permission shall be carried out under the personal supervision of a competent foreman. Great care shall be exercised during the removal to avoid shocks to or reversal of stress in, the concrete.

3.08 Surface Finishes

Concrete surfaces of the carriage ways of roads and bridges shall have a finish similar to that left by a vibrated hardwood board, 50mm thick, when used for screening concrete to its proper level and profile immediately after placing Unsheltered exposed upper surfaces of water retaining concrete shall be floated with a steel float to a smooth finish. Other exposed surfaces shall be floated with a wood float to a smooth finish. Floating shall be done so as not to bring excess laitance or fine material to the surface.

Except at movement joints concrete surfaces which are to be covered by further concrete or cement mortar shall be thoroughly cleaned to expose the surface of the aggregate and to remove any laitance, by hacking, wire brushing, washing with water or air under pressure or other approved means.

The surface finish of precast work, which is to be exposed, shall be made smooth and dense by casting against steel or resin impregnated shuttering or by reworking the surfaces not cast against shuttering

3.09 Classes of Concrete

Except where otherwise specified herein, the concrete constituents, manufacture, testing and workmanship shall conform with the recommendations of BS 8110.

Unless otherwise specified, Class A shall be used for precast work, for columns and for thin sections, Class B for general structural work, Class C for mass concrete and Class D for buildings and for fill where excavated material is unsuitable, as directed by the Engineer.

Class of Concrete	Min. Strength (N/mm²)	Max. Free Water/Cement Ratio	Min. Cement (kg/m³)	Max. Size of Aggregate (mm)	Slump (mm)
A	30	0.50	360	20	40-60
B	25	0.50	320	20	40-60
C	20	0.55	280	40	50-100
D	15	0.55	200	40	-

The strengths quoted are for slumps in the range given. These slumps could be increased with the use of an approval Concrete Admixture, subject to the approval of the Engineer, and provided compaction of the Concrete is satisfactory.

The coarse aggregate for Class C and Class D concretes shall all pass a 38mm sieve and none shall pass a 14 BS sieve and shall be well graded between these limits .

The fine aggregate shall be according to BS, Zone (2), unless otherwise specified by the Engineer.

3.10 Mix Proportions

The Engineer will determine the actual proportions of ingredients for each class of concrete. Such determination will generally be in accordance with BS 8110 and as specified herein.

All visible concrete not plastered or rendered shall be fair faced and shall be smooth and dense. Any fair faced concrete not to this standard shall be broken out and recast, save that on the instruction of or approval by the Engineer it may be hacked back or bush hammered and rendered all at the Contractor's expense and the work shall not be included in the measured work .

Where a decorative finish can be obtained by bush hammering or other treatment of dense but not smooth concrete the Engineer may approve such treatment but may require that it be in panels extending over otherwise satisfactory areas

3.11 Control of Mixing of Concrete

The Contractor shall make trial mixes for each class of concrete using the same Contractors Equipment and same materials as are proposed for the Permanent Works. The trial mixes shall have not less than the minimum cement content specified. For each trial mix three separate batches of concrete shall be made. The trial mixes shall be designed to have a compacting factor not exceeding 85 when determined in accordance with BS 1881. From each batch of concrete three 150x150x150 mm concrete cubes shall be made and tested at 28 days all in accordance with BS 1881. If no cube has a compressive strength less than the minimum permitted and the average compressive strength of all nine cubes is equal to or in excess of the required mean the trial mix proportions and materials will be approved by the Engineer and adopted by the Contractor for the purposes of the Contract as if it had been proposed by him and warranted by him to satisfy the requirements of the Specification

The Contractor shall proportion the ingredients of each batch of concrete accurately by weight. The water shall be added to the aggregates and cement in a mechanical batch mixer it shall not exceed the amount specified as the maximum water content and it should be added from a calibrated measuring reservoir or from a device that automatically stops after discharge of the preset quantity of water. The quantity of water shall take account of any water content of the aggregate.

In special exceptional circumstances, at the sole discretion of the Engineer, the proportioning of materials by volume may be approved. In such circumstances the Engineer may require the cement content to be increased by up to 10 percent over the amount in the approved mix. The gauging boxes for such volume working shall be in accordance with the requirements of this Specification.

Stockpiles of aggregate shall be kept separated so that there is no confusion between them.

Each mixer shall supply only one class of concrete in a run and shall be clearly marked with the class of concrete being mixed and the mix proportions. To change the class of concrete being mixed there must be a definite break in operations. The Contractor shall employ at each mixer one man whose only task is the checking of the quality and quantity of the constituents and of the mix and to keep records of the work, which records shall be available for the inspection by the Engineer.

The Contractor shall regularly carry out, at the start of each run and during the work, the following tests the results of which shall be recorded in a form approved by the Engineer and which shall be immediately available to him:

Slump test of freshly mixed concrete,
Net weight of the wet mix in a 150 mm cube.

The Contractor shall adjust the mix if the Engineer considers that there is an unacceptable variation from the approved mix data.

3.12 Concrete Sampling & Testing

All sampling and testing of constituent materials shall be carried out in accordance with the provision of the appropriate British Standard, and all sampling and testing of fresh and of hardened concrete shall be carried out in accordance with the provision of BS 1881 unless such provision is at variance with this specification.

Concrete shall be of the strengths detailed for each particular class. Compliance shall be judge by tests made on cubes at an age of 28 days unless there is evidence to the satisfaction of the Engineer and at his sole discretion that a particular testing regime proposed and executed by the Contractor is capable of predicting the strength at 28 days of concrete tested at a lesser time.

The Contractor shall on the instruction of the Engineer, make 150 mm test cubes and shall arrange for storage and testing of such cubes. The Contractor shall be deemed to have included in the rates and prices for his concrete work for tests on up to one such cube for every 10m³ of concrete in measured work. In addition to those for trial mixes.

Samples shall be taken at each batching plant and for each class of concrete at random not less frequently than:

For Classes A and B From one batch per 40 batches or 20m³ whichever is the lesser.

For other Classes From one batch per 40 batches or 30m³ whichever is the lesser. The event of any cube failing to reach the minimum specified strength the concrete that it represents may be rejected by the Engineer and it shall then be broken out and removed.

If the average compressive strength of four consecutive cubes shall fail to exceed the mean strength as specified no more concrete of that class shall be placed in the Permanent Works until the Contractor shall have discovered the cause of the failure and shall have rectified it to the satisfaction of the Engineer. The Contractor

shall make new determinations of the proportions of concrete ingredients and new trial mixes all as specified until the concrete produced for the Works satisfies the requirements of the Specification.

At the commencement of the Works the Contractor shall supply the apparatus, materials and facilities for the Site sampling and testing of concrete and concrete ingredients as specified, all to the approval of the Engineer. The Contractor shall supply the necessary technical and unskilled labour and shall operate and maintain the apparatus to the approval of the Engineer for as long as concreting work is in hand.

The Contractor may subject to the prior approval of the Engineer, use the laboratory of the University of Khartoum for check and testing of samples.

3.13 Reduction in Cement Content

If the Contractor's quality control of concrete is shown, by a sufficiently large number of tests to the approval of the Engineer, to be such that the mean and the minimum strengths are consistently exceeded the Engineer may, upon application by the Contractor, allow the Contractor to re-determine the proportion of ingredients and make fresh trial mixes all as specified herein to meet the required strengths.

By arrangement, and at the Contractors risk, trial mixes may be made from concrete for the Work.

The minimum cement content must not be less than that given in the table in Clause 3.09

3.14 Transporting, Placing and Compacting Concrete

Concrete shall be handled so that at the point of placing in the Works it is of the specified quality and approved consistency not having, been added to it or lost from it since leaving the mixer.

The Contractor shall obtain the approval of the Engineer for his proposed arrangements before the start of concreting.

The Contractor shall regard the compaction of the concrete as a work of fundamental importance and shall produce a watertight concrete of maximum density compatible with the approved mix design. Compaction shall be assisted by mechanical vibrators but shall not involve the vibration of reinforcement or shuttering. Slabs shall be compacted using vibrating beam type vibrators or immersion vibrators and a screeding beam. The number and type of vibrators shall be to the approval of the Engineer which will not be given if sufficient vibrators are not available to ensure that there shall be no delays caused by breakdowns.

3.15 Construction Joints

Where not shown on the Drawings the details and positions of construction joints shall be submitted to the Engineer for approval before concreting starts.

They shall be located so that, in conjunction with the programme for concreting, the effects of shrinkage and temperature are minimized. Where long lengths or large areas of work are to be concreted and where in the opinion of the Engineer it is practicable the Contractor shall so arrange his programme of construction that concrete is four weeks old before new concrete is placed against it, where it is not practicable for work to be done progressively and a chequer board pattern is proposed the infill sections shall be short relative to the main panels.

Construction joints shall be watertight. They shall be formed in straight lines with rigid shuttering perpendicular to the principal line of stress and as far as practicable at points of least shear. They shall be plain butt type unless otherwise specified or approved.

Before placing new concrete against that which has already set the latter shall be treated carefully by wire brushing immediately the shuttering is removed or by light hammering or scabbling to expose aggregate over the full section and to leave a sound, irregular clean surface free from laitence.

Unless otherwise approved or specified, concrete placed in one operation shall not exceed a vertical dimension of 3m or a horizontal dimension of 7m, save that the Employer requires that the base slab of each pump house be cast as one pour.

3.16 Expansion Joints

Where shown on the Drawings expansion Joints shall be constructed using lecotri 1 NT 24 PVC water stop or equal approved.

The water stop shall be in a continuous length and placed sharp corners requiring prefabricated joints. the water stop maintained in position by accurately shaped boards and to distortion shall be supported when concrete is being placed.

Waterstop shall be stored in the manufacturer's original packing until required for use and shall be protected from damage and sun at all times.

3.17 Joint Sealers

The Contractor shall construct tapered recesses at the expansion joints and the faces shall be brushed on removal of shuttering to remove surface laitence.

The Contractor shall fill the recesses completely with a polysulphide sealer compound to BS 4254 gun grade used in accordance with the manufacturers instructions with a properly applied primer if this is recommended.

Particular care shall be taken at the ends of the joint to ensure that the sealer is carried round to the underside until the joint is supported by the blinding concrete.

The approval of the Engineer shall be obtained before any joint sealing work is started.

3.18 Concreting in Unfavourable Weather

The Contractor shall not place concrete in the Permanent Works:

- (i) During heavy rains or dust storms
- (ii) When the air temperature is equal to or more than 30⁰C.

When the air temperature exceeds 30⁰C the Contractor shall not place concrete in the Permanent Works without the approval of the Engineer and without taking such precautions as may be required to keep the temperature of the concrete during mixing and setting below 38⁰ C, e.g. by keeping the concrete, materials and shuttering shaded from the sun and by spraying the coarse aggregate with water.

Concrete shall not be placed against shuttering that is hotter than, 30⁰C without the approval of the Engineer.

3.19 Curing of Concrete

The Contractor shall, until it has thoroughly hardened and for not less than eight days, or longer as may be required by the Engineer, protect the concrete from the harmful effects of rain, flood, wind, sun, high temperature, variation or reversal of temperature gradient, premature loading, deflection or impact and aggressive groundwater.

Unless otherwise approved by the Engineer, exposed concrete surfaces shall be kept continuously moist after casting for not less than seven days. Such surfaces, immediately upon exposure, shall be covered with thick hessian or sand or other material as may be approved by the Engineer, which shall be kept wet to the satisfaction of the Engineer. A minimum thickness of 50mm of sand shall be used for curing purposes and it shall not subsequently be used for concrete or mortar. If curing membranes are proposed by the Contractor and approved by the Engineer they shall be applied in conformity with the manufacturer's recommendations. Such membranes shall be applied to the unsheltered surfaces within one hour of the placing of the concrete forming the surface.

3.20 Reinforcing Steel

Mild Steel reinforcement shall be in accordance with BS 4449 (metric). The Contractor shall supply the Engineer with the certificate of the manufacturer issued in accordance with Clause 12 of BS 4449 for all the required tests including the rebend test in respect of each consignment delivered to the Site.

Additionally the Contractor shall provide, as instructed by the Engineer, up to five samples to be tested at an independent laboratory approved by the Engineer for tensile strength, yield strength, elongation and rebend and the cost of making the tests shall be deemed to have been included by the Contractor in his rates and prices for reinforcement.

Steel reinforcing bars of nonstandard diameters but otherwise in accordance with the Specification may, with the approval of the Engineer, be used with adjusted spacings provided that the clear space between bars is not reduced to less than

5mm more than the nominal size of aggregate and provided there is adequate bond length for the bars.

The Contractor will be permitted to use deformed steel reinforcing bar if approved by the Engineer.

3.21 Steel Fabric Reinforcement

Steel fabric reinforcement shall comply with BS 4483 reference BS 196 and shall be plain wire welded mesh fabric of hard drawn wire complying with BS 4482 or cold worked steel bars complying with BS 4461. Records of the manufacturer 5 tests in compliance with Clauses 14 and 15 of BS 448 shall be available for inspection by the Engineer.

The manufacturer's identification tag shall be securely fastened to each bundle when delivered to the Site.

3.22 Tying Wire for Reinforcements

Tying wire shall be soft iron 1.6mm diameter or steel wire 0.80mm diameter in prefabricated ties fixed with a special tool.

3.23 Storage of Reinforcement

All reinforcement shall be stored clear of the ground and supported to prevent distortion. Before being placed in position it shall be clean and free from loose rust mill scale, oil grease, paint and any other matter liable to weaken the bond of concrete to the steel and it shall be maintained in this condition until the concrete is placed. Bars which have become bent shall not be straightened or rebent for incorporation in the Works without the approval of the Engineer.

3.24 Bending Schedules

The Contractor shall ascertain for himself from the information given on the Drawings and in the Specification the precise requirements of reinforcement to be obtained for and fixed in the Works. The accuracy of any Bending Schedule which may be supplied by the Engineer to the Contractor is not warranted.

3.25 Bending of Reinforcement

Reinforcement shall be bent on a purpose made bar bending table with rotating mandrels and bending wheels and adjustable bar steadies.

Bending using cranking bars or by hammering will not be permitted.

Reinforcement shall be cut and bent cold in accordance with BS 4466 unless otherwise specified, ordered or approved by the Engineer.

3.26 Fixing Reinforcement

Steel bar reinforcement shall not be lapped except where shown on the Drawings

without the approval of the Engineer. Where such laps are approved no additional payment will be made for the extra steel required. When lapping is approved the lap length shall be in accordance with BS 8110.

The Contractor shall place and fix steel reinforcement accurately in the positions shown on the Drawings and shall ensure that it remains rigidly in those positions during the placing of the concrete. Tack welding will not be permitted. Supports, spacers and ties shall be subject to the approval of the Engineer. Concrete spacers shall be made of similar quality concrete to that for the work in which they will be embedded. Metallic spacers, chairs, fixing clips and tying wire shall be compatible with the material of the reinforcement and the specified cover shall be maintained. All crossings of reinforcing bars in contact shall be wired with two turns of soft iron tying wire or with preformed steel wire ties fixed with a standard tying tool. Fixing wires shall be clipped off and the tails angled into the body of the concrete. No fixings shall deface visible concrete faces

Reinforcement projecting from previously cast concrete and not wholly embedded in concrete shall not be bent or rebent or reshaped without the prior approval of the Engineer.

The main wires of adjacent sheets of steel fabric reinforcement shall be lapped at least 300mm and the traverse wires at least 150mm.

Shuttering shall be cleared of all shavings, sawdust, clips nails and other things by sweeping, air blast or washing before placing and fixing of reinforcement. Shuttering shall be cleared of all wire ends, clippings and other debris immediately before placing concrete this shall be done without causing shutter oil to be left on reinforcing bars. All timber shuttering shall be washed down with fresh water before concrete is placed.

The Contractor shall not place concrete around reinforcement until the Engineer has inspected it and approved the reinforcement and the placing of concrete.

Gang boards and supports shall be laid over reinforcement to prevent, damage and bending down after it has been placed in position.

Where concrete has to be transported across areas prepared for concreting such areas shall be protected from drips and spillage from the transported concrete.

3.27 Cover to Reinforcement

Except where otherwise shown on the Drawings the concrete cover to the nearest reinforcement (exclusive of concrete blinding decorative finishes) shall be 25mm for faces not normally in contact, with water. Cover for faces in contact with water shall be 50mm These requirements do not apply to box outs left for the installation of pipes gates, etc..

The clear distance between any two parallel bars shall be at least 5mm more than the nominal maximum size of aggregate except at approved laps.

Where stub bars are left for future extensions they shall be protected by a cement/sand mortar giving not less than 50mm over.

3.28 Box-outs and Building-in

Openings left in concrete for subsequent fitting and concreting in of pipe work and fixtures shall be carefully boxed-out to permit the placing of the pipe or fitting without the necessity to break away concrete. The soft of box-outs shall have an inclination of not less than one in four to the horizontal towards the low pressure face.

If necessary reinforcing bar shall be allowed to stand clear within the box-out.

The faces of the box-out shall be treated carefully by early removal of the boxing out shuttering and dressing of the concrete to expose the aggregate and to leave sound, irregular, clean surfaces free from laitance.

The pipe or fixture shall be placed and held rigidly in position observing any special manufacturers instructions. Formwork shall be placed to marry with the faces of the body of the concrete leaving sections to be built up as concreting proceeds.

If so shown on the Drawings or instructed by the Engineer, where a face of the area of the box-out is not exposed to view an area of that face shall be dressed to expose the aggregate and shuttering shall be fixed to fill the box-out and to stand proud of the face of the body of the concrete and thus to facilitate the placing of concrete and to increase the area of contact of the box-out concrete and the body of the concrete.

The box-out shall be thoroughly wetted and then filled carefully with concrete of the correct class with compaction with vibrator poker or by thorough punning to produce a watertight joint

Where fixing bolts are positioned by means of a template they shall be supported and braced to maintain perfect alignment during the placing and setting of the concrete or grout. The Contractor shall, if so instructed by the Engineer weld reinforcing bar to the fixing bolts to maintain them in the correct relative position to each other.

3.29 Grouting of Fixing Bolts

Where fixing bolts are to be grouted in, they shall be obtained from an approved source as a complete package with a polyester resin grout and snail be fixed with holes drilled to the correct diameter and depth all according to the manufacturers instructions.

3.30 Waterproof Membrane

Where waterproof membranes are shown beneath concrete they shall be of polythene sheeting not less than 0.25 mm in thickness. The sheeting shall be carefully laid over fine sand, care being taken not to puncture the sheet and there shall be laps of not less than 250 mm with adjoining sheets. Care shall be taken when placing concrete that the sheeting is not lifted or punctured.

3.31 Bitumen Painting of Concrete

All concrete shown as bitumen painted shall be painted with a bituminous emulsion prime coat applied by brush at a rate of not less than 0.25 kg of 57 bitumen emulsion per square meter, followed by a second similar coat after the emulsion has broken.

Emulsion which has started to break shall not be used, but clean water may be added to emulsion to keep it fluid.

Chapter 4: Brickwork & Rendering Bricks

- 4.01** Bricks shall be obtained from sources approved by the Engineer. The Contractor shall supply to the Engineer samples of selected fair faced bricks and when approved these shall be the standard for bricks supplied for the Works and no bricks supplied for the Works shall be of lesser standard.

All bricks shall be new clean, hard sound and well burnt, equal in size, straight and sharp in the arises. The colour shall be red but uniformity of colour is not essential provided that fair faced work is of uniform general appearance.

Fair faced quality bricks are to be used even where fair faced brickwork is not required because the initial grading classifies the better quality of bricks as fair faced.

Bricks delivered to the Site or distributed to different parts of the Site shall be unloaded by hand and not tipped.

4.02 Cement, Sand & Water

Cement and water shall be as specified for concrete work. Sand shall be to BS 1200.

4.03 Mortar

Mortar for brickwork shall be made of one part of cement to four parts of sand by volume (cement shall be taken as 0.035 m³ per 50 kg bag). The mortar shall be machine mixed or, with the approval of the Engineer, mixed by hand labour on a specially prepared mixing floor. Cement mortar shall be protected from the sun and wind by a wet hessian cloth and shall be used, within one hour of mixing. Any mortar not used within one hour of mixing shall be discarded and not used in the Permanent Works.

With the approval of the Engineer and in work not under water, lime may be added to the mix to improve workability and to increase the permitted time for use.

Mortar for masonry shall be as for brickwork.

4.04 Course Heights

The Engineer's instructions shall be obtained and followed with regard to the height of courses for brickwork but in general course height shall be 75mm approximately and mortar joints 10mm approximately; The courses shall be set out so that bed joints are in line with features and cut courses shall be avoided as far as possible. Course heights shall not vary throughout any work and each course shall be level throughout.

Levels shall not be made up by varying the thickness of mortar joints without the approval of the Engineer. To avoid cut courses the Engineer may approve deviation from the Drawings in which case no additional payment will be made to the Contractor on account of variation may solely to avoid cut courses.

4.05 Workmanship of Brickwork

Concrete foundations or concrete floors to receive brickwork shall be cleaned of earth, dust, debris etc and shall be wetted before bricks are laid. Where brickwork beds or butts against concrete and there is no provision for a joint the concrete shall be brushed to expose the aggregate after the initial set of the concrete or immediately after the Formwork is stripped. If this cannot be done satisfactorily the surfaces shall be hacked back to ensure that there is a bond between the brickwork mortar and the concrete.

Immediately before being laid bricks shall be thoroughly soaked in clean water and before continuing partly completed work the exposed bed joint shall be likewise soaked.

Brickwork shall be carried up evenly and uniformly, no one portion being raised more than 900mm above the other at any time. No face work shall be built overhand.

Single frog bricks shall be laid with the frog up. Bricks forming reveals and intern and external angles shall be specially selected for square edges and shall be built plumb.

Brickwork in solid walls shall be in Flemish or other approved bond and each course shall break joint correctly with bricks of the previous course. The courses shall be laid level and with parallel, neat and regular joints. Joints shall generally be not more than 10 mm thick in the beds. Perpend shall be truly kept.

Brickwork in solid walls shall be fair faced on one side. Where 240 mm thick walls are ordered to be fair faced on both sides they shall be constructed solid in stretcher bond with British standard wall ties type "b" (or with 40 mm x 1.6 mm galvanized iron ties 150 mm long or with butterfly tie of 4 mm MS bar) staggered at every six courses vertically and = mm horizontally.

The Contractor shall protect and keep clean all face work.

The precautions to be observed in laying and protecting brickwork in adverse weather conditions shall be as specified for concrete.

Contractor shall if necessary build further samples of wall until the quality and appearance required by the Engineer is achieved. After approval the selected sample shall be retained as a sample to which all brickwork in the Works must conform.

4.06 Pointing

All internal and intern brickwork, where left exposed,, shall be fine finished to an even , true fair face and Pointed as detailed on the Drawings or, failing such detail, with a slightly recessed joint formed by a specially shaped tool forced against the mortar in the joint. Where brickwork is to be rendered the joint shall be un pointed and recessed to 10mm below the face.

4.07 Rendering

Unless otherwise specified, rendering shall be applied in accordance with the recommendations of British Standard Code of Practice 221: where surfaces to

be rendered are particularly uneven rendering shall be in two coat - work. with the first coat to include dubbing out to a maximum of 15mm. Where there are only minor areas below the general surface dubbing out may be in patches and a single finishing coat with a minimum thickness of 15mm will satisfy a requirement for a nominal 25mm rendering coat.

Before rendering commences all joints in brickwork shall be raked out to a depth of 10mm, the surface of the wall shall be cleaned and any foreign matter removed.

Undercoats and dubbing out shall be thoroughly applied into the brickwork joints, brought to a true surface scratched and striated to form a key for the finishing coat.

The finishing coat shall be finished to true planes and where shown on the Drawings, regular curves. Arises shall be rounded and line able. A shallow fillet shall be formed at internal angles. Plane surfaces shall be such that with a 2m straight edge laid in any direction no part of the surface is more than 3 mm from the edge. For water retaining surfaces a steel float shall be used to give a smooth and polished surface.

Concrete surfaces to be rendered if not brushed after initial set to expose the aggregate shall be scabbled or hand chipped to remove all laitence and to provide a rough surface for rendering.

Mortar for rendering shall be composed of one part of cement to four parts of sand.

4.08 Plastering

Surfaces shall be prepared and plaster applied as specified for rendering. Where the soffits of slabs are shown on the drawings as plastered the Contractor may prepare for the Engineer complete same soffits of fair faced concrete in which the only shuttering marks are to a balanced uniform pattern. If approved by the Engineer this finish may, be adopted throughout the Works and, for the purpose of measurement, shall be treated as plastered.

Soffits generally and concrete surfaces which are to be plastered shall be brushed with wire brushes worked over with light scabbling hammers or hand chipped to remove all traces of laitence and to provide a rough surface for plastering.

4.09 Fixing Doors & Windows

The frames for main access doors shall be built in

The Contractor shall build in, before or after completion of the brickwork, the frames of doors and windows with a 3 mm clearance all round from the finished brickwork. Fixing lugs shall be built in fixed in raked courses or fixed to hardwood dovetailed blocks. alternatively when fixing to a firm base approved purpose manufactured plastic or fiber plugs shall be used; substitute softwood plugs are not acceptable. The screws, plugs and masonry drill used shall be according to the manufacturers instruction. The holes, after drilling with a sharp masonry drill, shall be cleared of all drilling dust before fixing the plugs

4.10 Window Sills

Windows Sill shall be set on sills cells purpose made and projecting inside and out with externally a sloping top face and a drip edge.

4.11 Painting of Concrete, Plasterwork & Rendering

Where particularly specified or detailed in the Bill of Quantities. concrete and rendering shall be painted with an approved proprietary brand of cement paint. This paint shall not be an impermeable variety.

Cement paint shall not be applied to hot or dry surfaces and, if necessary, surfaces shall be washed down and the work shall be done when not exposed to the sun.

Internally, unless otherwise specified or shown on the Drawings, surfaces shall be coated with two coats of P.V.A. of Emulsion Paint of a colour approved by the Engineer.

Chapter 5: Irrigation Works

5.01 Location of the Irrigation & Drainage Networks

The irrigation and drainage network must be executed on the specified area shown on the corresponding map and within the boundaries of the Scheme.

5.02 Longitudinal Profiles & Cross-Sections

The longitudinal Profiles and cross-sections of the irrigation and drainage network must be executed as indicated in the corresponding drawings and setting out sheets.

5.03 Hydraulic Structures

These are structures required to regulate and control the amount and levels of the flow within the conveyance system. They also work as safety structures. The hydraulic structures shall be constructed as shown in the corresponding drawings and tables. Construction materials must be provided according to their technical specification mentioned elsewhere in this document. The concrete and brick works of the hydraulic structures shall be finished to give smooth uniform surfaces.

5.04 Structures Gates & Pipes

The hydraulic structure pipes shall be made from steel (4 mm thick) with inner diameter as specified in the Bill of Quantity and Tables. The length of the pipes for each structure is in the range (15m-20m). The pipes must be made out of connected flanged pipes each of length 2.5m. The flange thickness must not be less than 8mm. Angles shall be (51x51x5) mm made from steel according to BS445. The steel pipes and gates shall be made from sheet steel and steel angle conforming to BS 4, BS 449, BS 4848 and electrons to BS 659 and shall be joined using black bolts and nuts conforming to BS4190.

The steel gates (5 mm thick) shall be constructed as shown in the corresponding drawings and according to the specifications and instructions of the Engineer. Angles shall be (76x76x5) mm made from steel according to BS449.

5.05 Roller Sluice Gates (RSG)

The dimensions of the roller sluice gates are given in the bill of quantity and drawings.

The RSG shall generally consist of framing and embedded parts, gate with roller and axles and hand operated gear.

The gates to be of the vertical lift roller type and suitable for withstanding and operating against a minimum head of water on the upstream side with no water on the downstream side.

The supplier shall pack, mark, and as necessary protect all plant for delivery, Unloading, handling, storage in the open, and subsequent transport to Site.

Small parts shall be boxed & suitably marked on the outside, larger parts shall be protected as necessary and shall be suitably marked and listed. Lists of contents of crates boxes and bundles shall be supplied and shall be handled over to the Engineer on delivery of each consignment.

Inspection of material, workmanship, manufacture and the trial assembly of components at the manufacturer works, in accordance with the specifications, shall be carried out at the Engineer's discretion and will include the following:

- (i) Check on steel and other materials used to ensure compliance with accepted standards, Manufacturer's chemical analysis sheets and report sheets showing the result of tests shall be supplied by the supplier when requested.
- (ii) Dimensional checks to ensure conformity with approved drawings.
- (iii) Inspection of Weld, cleaning and painting of steel works.
- (iv) Witnessing trial assembly and testing at manufacturer's works.
- (v) Inspection of method of packing components for shipment.

The gates shall be cleaned and painted as follows:

- (i) Wire brushing
- (ii) Two coats of Micaceous Iron oxide or two coats of Aluminum.
- (iii) Two coats of primer suitable for use under coating selected in (ii) above.
- (iv) Two coats of High Build bituminous paint or two coats of epoxy Resin paint or two coats of chlorinated Rubber paint or two coats of coal Tar Epoxide paint. Moving parts and guide channels should be kept clean of paint so as not to be obstructed.
- (v) The screws & nuts should be covered with grease or heavy oil protection.

For the framing and embedded parts:

- The sluice framing and embedded parts shall consist of vertical steel side frames forming the gate groove, overhead cross members and gear bearers attached to the tops of the side frames and a sill member attached to the lower ends of the grooves.
- The side members shall consist of roller steel channels and angles of riveted construction and shall extend to support the operating gear. The sill shall consist of rolled steel channel complete with leveling flats screws.
- The side frames shall extend upwards from sill level to guide the gate throughout its travel and shall incorporate pathways upon which the gate wheels shall bear and also side sealing surfaces. The built-in parts (side and sill members) shall be suitably arranged for fixing to the concrete work.

For the rollers and axles the gates shall be of riveted construction of mild steel skin plate supported on the downstream side by horizontal rolled steel beams connected to vertical members arranged to carry the roller axles on rollers.

The gates shall incorporate side seals consisting of vertically hung mild steel rods and a bottom seal consisting of a rectangular flat attached to the lower edge of the skin plate.

The sluice framing and gates shall be fabricated from mild steel materials conforming to the Current Edition of BS Iron Grade 43 A or equivalent. The rollers shall be of cast iron, of adequate diameter, conforming with the Current Edition of BS 1450 Grade 12 or equivalent.

The rollers shall be adequately machined around the outer periphery and shall be brushed with phosphor bronze. The rollers shall be mounted on mild steel axles, located in the gate side structure and retained by means of keep plates.

The hand operating gear shall consist of a worm gear –box driving across shaft connected to two rope winding drums. The worm gear shall be operated manually by means of chain wheel and hand chain.

The cross shaft supported on suitable end bearings and the gate shall be suspended from the windings drums by galvanized steel wire lifting ropes.

The rope winding drums, bearings, gear box castings and drum wheel shall be manufactured from cast iron conforming with the Current Edition of BS. 1450 Grade 12 or equivalent and the cross shafting manufactured from material conforming with current edition of BS. 970 Grade EN3 or equivalent.

5.06 Operation Test for the Canals & Hydraulic Structures

An operation test for the canals must be executed in order to verify that they are working properly without any seepage. Also the Hydraulic Structures must be functioning efficiently. All necessary precautions for this test must be taken.

5.07 Leveling of Isolated High Lands

The relatively high lands which are shown in the project Map shall be leveled even with surrounding ground levels or as directed by the Engineer.

5.08 Masonry Work and Pitching

(a) General

Material used for Masonry or stone pitching shall be clean, natural, hard, durable homogeneous, and free from iron bands, spots, sand holes, faults or other imperfections. It shall be obtained from sources approved by the Engineer.

(b) Stone

Random rubble masonry shall consist of stones of random size roughly hammer dressed so that they fit closely together. Each stone shall have a mass of between 20 and 50 kilograms, but smaller stones may be used at the discretion of the Engineer. Bond stones shall measure not less than 150 mm square of the face and not less than 500 mm long, or the thickness of the wall, whichever is the least.

(c) Bedding & Jointing

Each stone for masonry work shall be thoroughly wetted immediately before use and shall be laid with its natural bed perpendicular to the direction of principal stress. Each stone shall be bedded in cement-sand mortar (1:6), all joints being filled solid with mortar as the work proceeds. No joint shall be more than 50 mm wide.

(d) Face-Work & Curing

Masonry face-work shall incorporate random rubble stones set with at least one bond stone every square meter. Stones shall be picked and laid carefully so that the exposed joints are not less than but as nearly as practicable 10 mm thick. The face joints shall be raked clean to be flush with the adjacent stone surface and shall be trowled to a smooth even surface. In constructing masonry work, the Contractor shall cure the works in a similar manner to the concrete work.

(e) Pitching

The Contractor shall prepare the formation for pitching by trimming the excavation accurately to the specified dimensions. Well graded gravel backing as specified shall then be supplied and placed on formation to the thickness shown on the drawing to give an even surface parallel to the finished surface of the pitching. Block pitching shall consist of cement mortared rubble masonry and shall be formed in-situ with their adjacent faces pointed with two coats of Bitumen. Dry pitching shall consist of stones of random sizes roughly hammered dressed so as to fit closely together. Each stone shall have a mass not less than 25 kg and a depth not less than that shown on the drawing nor less than 200 mm long and 200 mm wide. The stone shall be picked and laid on their natural bed so that the surface is finished to even true planes.

5.08 Commencing Earthworks

The Contractor shall give to the Engineer at least seven day notice of his intention to commence earthworks on each of the separate parts of the Site. The written notice will include details of dewatering proposals, borrow areas, use of excavated material, disposal of surplus material and the shoring of excavations. Earthworks on each site shall not be started without the written approval of the Engineer.

5.10 Essential Equipment for Earthwork Construction

5.10.1 General

The Engineer must approve the machinery and tools utilized in carrying out earthworks. These equipments shall be in good working condition during the all duration of execution. The contractor shall supply an adequate number of tools and machinery as deemed necessary by the Engineer for the proper execution of the work with the speed and precision and shall by no means be limited to the minimum number required.

5.10.2 Type of Equipment

The earthwork equipment needed for execution of the work shall include, but not limited to, the following:

- Bulldozers
- Motor Graders
- Scrapers
- Water Sprinklers
- Roller Compactors
- Mechanical & Hand Compactors
- Shovel Tractors
- Rotary Cultivators

5.11 Location Of Borrow Areas

The Contractor shall select for himself the sites for borrow areas from within the Site or from other areas indicated or approved by the Engineer. With approval of the Engineer, the borrow area will become part of the Site if worked by the Contractor.

The Contractor shall undertake no work on borrow areas until confirmation is given by the Engineer that the Employer has reached agreement on any royalties or compensation payable. The cost of such royalties or compensation shall be a charge on the Employer. The cost of winning material from the borrow areas and of making good on completion of the work in the area shall be deemed to have been included in the contractor's rates and prices in the Bill of Quantities.

5.12 Work at Borrow Pits

The Contractor shall excavate at the sites of the borrow areas to expose the material required for fill and shall select and excavate the required material. After the required amount of material has been won from each area the Contractor shall reinstate the area by spreading the previously removed superficial materials in layers not exceeding 250 mm deep over the area of the excavation and grading and trimming to the satisfaction of the Engineer. Where practicable such grading shall be made to prevent the accumulation of surface water.

The Contractor shall prepare and submit in detail for the approval of the Engineer his proposals for the use of borrow areas and shall give notice to the Engineer in writing at least one month before the proposed date of starting work at each borrow area.

5.13 Stripping Waste

The Contractor shall carefully strip the sites of designated borrow pits of top soil, sod, loam and other matter which is unsuitable for the purposes for which the borrow pit is excavated. The Contractor shall maintain the stripped surfaces of borrow pits free of vegetation until excavation operations in the borrow pit are completed. Material from stripping which are suitable for top soil for seeding shall be moved to borrow areas for future use. Materials from stripping which are not suited for top soil for seeding shall be disposed of at unexhausted borrow pit, or unapproved areas adjacent to borrow pits.

5.14 Material to be Excavated

The Contractor shall excavate any material for the execution of the works and shall dispose off the excavated materials as specified, detailed in the Bill of Quantities, shown on the Drawings or ordered by the Engineer .

If the contractor encounters any material which in his opinion may be unsound he shall immediately inform the Engineer who will instruct the contractor in writing as to whether or not the material is to be treated as unsound.

The omission by the Engineer to give any instruction shall not relieve the contractor of any responsibility for the works if, prior to construction, the contractor shall have failed to request the Engineer to inspect the exposed areas to receive foundations or fill. Unsound material shall be removed and disposed off to the satisfaction of the Engineer.

The voids so formed shall be filled as instructed by the Engineer. The extent of the excavations shall be the minimum practicable for the construction of the permanent

works. Excavation for structures shall consist of net excavation on the plan area of the foundation measured horizontally at the foundation level or levels.

The contractor shall be deemed to have allowed in his rates for any additional construction and working space which he considers necessary.

For excavation for canals or structures the excavated material are classified as follows:

- a) Normal: this is for the type of soil that can be excavated by excavators and/or dozers machines.
- b) Hard: this for material requires the use of hydraulic hammers.
- c) Rocks: this for rock material that need to be blasted using explosives.

The Engineer will determine whether or not the material to be excavated can be excavated normally or requires different treatment and machines.

5.15 Backfill & Fill

Backfill shall mean the material required to refill, with due allowance for settlement, excavation outside the permanent work up to the ground levels prevailing at the commencement of the works .

Fill shall mean the material required above the ground levels prevailing at the commencement of the works to make the embankments comprised in the works, with due allowance for settlement.

Unless otherwise specified, the material used for fill and backfill shall be selected excavated material to the approval of the Engineer.

Backfill against the Permanent work shall be selected free form boulders, cobbles, rock fragments and the like greater than 50mm. Nominal size. Other backfill and fill shall contain no such particles which are greater than 150 mm nominal size.

After approval has been given by the Engineer for backfilling or filling of any part of the works to begin, the operation shall start with the minimum of delay and shall continue without interruption until the work is completed.

5.16 Earthworks Levels & Fill Construction

All levels shall be agreed with the Engineer. The Engineer's directive shall be sought when there is any conflict between the Drawings and the ground level as recorded and where dimensions are given relative to the ground level.

The Fill construction shall be according to the following:

(i) Clay Material

Canal embankment and main canal fill should consist of clayey material with the following properties:-

- 1- The material should have sufficient fines, not less than 40% by weight.
- 2- The fines should have low plasticity with a maximum liquid limit of 40 and a maximum plasticity index of 16.

The material, after compaction, should have the following Properties:-

- 1- Low permeability (coefficient of permeability less than 10^{-6} cm/sec).
- 2- Adequate shear strength (undrained shear strength of at least 50KN/m²).

(ii) Workmanship

- 1- The Contractor should clean the surface from organic material and debris before placement of material. Then the surface should be proof-rolled.
- 2- The clay material should be placed in layers not more than 150 mm in thickness.
- 3- Each layer should be compacted by a sheep-foot roller or equivalent compaction machine, approved by the Engineer.
- 4- The compacted material should have a dry density of at least 95% of the maximum dry density obtained in the laboratory using the Standard Proctor Compaction (SPC) Test. The moisture content should be within 2% of the optimum content obtained in the laboratory using the SPC Test.

5.17 Excavation of Canals

The Contractor shall excavate canals to the best practicable finish which, in the opinion of the Engineer, can be obtained by the skilled use of the Contractor's Equipment approved for use. At all changes of cross section or slope, the Contractor shall form transitions to give a smooth change.

5.18 Bank Forming, Shape & Geometry

The berms, top bank width, side slopes and the least width of the bank at the ground level for the secondary and branch canals are to be according to the drawings, setting out sheets and the instructions of the Engineer.

5.19 Allowance for Settlement of Fill & Backfill

The Contractor shall make due allowance for consolidation and settlement of fill and backfill so that the levels and dimensions of the finished surfaces at the end of the Defects liability period are not less than those shown on the Drawings or ordered by the Engineer.

5.20 Finish of Embankments

Except where otherwise specified or ordered by the Engineer, the tops and side slopes of fill placed in embankments shall be neatly trimmed equal to the best practicable finish which in the opinion of the Engineer can be obtained by the skilled use of the earthmoving equipment used in the placing and, where specified, compacting of fill.

Where precise lines and levels of embankments are not specified or ordered by the Engineer, the Contractor shall construct embankments in straight lines between smooth curves to give a pleasing appearance.

The tops of embankments shall be finished reasonably level and even. The widths of embankment tops shall not be less than the width specified or shown on the Drawings and shall not, without the approval of the Engineer, be more than 300mm greater.

The faces of embankments shall be to the slopes specified with no abrupt changes.

5.21 Calculations of Excavation & Fill Quantities

For the purpose of calculating quantities of excavation and fill horizontal alignment of canals will be relative to the existing centre lines but generally some variation of alignment may be instructed by the Engineer or accepted by the Engineer without this constituting a variation of the Works.

5.22 Earthworks for Pump Houses & Stilling Basins

The earth works for the Pump Houses and Stilling Basins shall be executed in accordance with the technical specifications given by the pump-manufacturing firm.

5.23 General Disposal

The contractor shall transport and dispose off all excavated material not required for the works. The locations proposed by the Contractor for disposal or storage of excavated materials, whether temporarily or permanently, shall be subject to the approval of the Engineer.

5.24 Disposal in Canal Embankments

Unless otherwise specified or ordered by the Engineer, the material excavated during the construction of open canals shall be disposed off in embankments constructed parallel with the canal as indicated on the Drawings. These embankments shall be compacted according to the satisfaction of the Engineer.

The contractor shall leave or make gaps in the embankments for the construction of structures after the completion of which he shall reinstate the embankments to conform to and marry in with the embankments associated with the structures.

The Contractor shall submit to the Engineer, at least Two Weeks before any filling commences, complete the following:

- (i) The results of not less than 3 Sieve Analysis and 3 Plasticity Tests carried out on the material he proposes to use, showing that it complies with the above requirements.
- (ii) Samples of the material of sufficient size to enable the Engineer to have check tests made.