Bangladesh Water Development Board

Technical Specification for Civil Works

Design Circle -II, BWDB

72 Green Road, Dhaka

Second Edition

January 2019

Preface

. "Technical Specification for Civil Works" is a very important document for a large organization like BWDB. First Edition of "Technical Specification for Civil Works" was published in 1995. But that "Technical Specification for Civil Works" is not available now in the field office, in the Design Office and other offices of BWDB. For non-availability of "Technical Specification for Civil Works", design office faces difficulties in design. Similarly, field faces difficulties office during preparation of tender and implementation of their work. This "Technical Specification for Civil Works" is a re-print and updating of first edition with inclusion of some new items.

Technical Specification is closely related to Design, Construction and Tendering of Civil works. Technical Specifications of Civil works are described in brief in the item description of items of "Schedule of Rates of BWDB". In "Technical Specification for Civil Works", Technical Specification are described in more detail.

A draft copy of "Technical Specification for Civil Works" was circulated to different Project Director, all Design Circle, all Field Circle and Director, Contract & Procurement Cell through e-mail for their suggestion and comments. The suggestions and comments helps in updating of this report.

This "Technical Specification for Civil Works" will assist the Design Office and field office for their day to day work and will bring uniformity in their work. Any error or inconsistency are observed in this report, it may be send to this office, which will be corrected accordingly. This "Technical Specification for Civil Works" will be reviewed and updated time to time as per requirement.

01.01.19

(Md. Harun ur Rasheed)
Superintending Engineer
Design Circle - 2
BWDB, Dhaka

Personnel who were contributed in updating of this Technical Specification

1	Motaher Hossain	Chief Engineer, Design, BWDB, Dhaka
2	Md. Harun ur Rasheed	Superintending Engineer, Design Circle-II, BWDB, Dhaka
3	Md. Monirul Islam,	Director, Contract & Procurement Cell, BWDB, Dhaka
4	Md. Ajfar Imam,	Superintending Engineer, Design Circle-III, BWDB, Dhaka
5	Nasima Jahan	Executive Engineer, Design Circle-II, BWDB, Dhaka
6	Md. Hafizur Rahman,	Executive Engineer, Contract & Procurement Cell
7	Md. Golam Rubbani,	Executive Engineer, Design Circle-III, BWDB, Dhaka
8	Md. Aminul Islam	Executive Engineer, Design Circle-II, BWDB, Dhaka
9	Md Abdullah Al Mamun	Executive Engineer, Design Circle-II, BWDB, Dhaka
10	Poly Das	Sub-Divisional Engineer, Design Circle-II, BWDB, Dhaka
11	Hasnin Fatema Kanon	Sub-Divisional Engineer, Design Circle-II, BWDB, Dhaka
12	Saida Afrose	Sub-Divisional Engineer, Design Circle-II, BWDB, Dhaka
13	Md. Masbahul Islam	Sub-Divisional Engineer, Design Circle-II, BWDB, Dhaka
14	Shekh Istiaq Ahmed	Sub-Divisional Engineer, Design Circle-II, BWDB, Dhaka
15	A.K.M. Maminul Islam	Sub-Divisional Engineer, Design Circle-II, BWDB, Dhaka
16	Asif Mahamud	Assistant Engineer, Design Circle-II, BWDB, Dhaka
17	Mirza Asiful Islam	Assistant Engineer, Design Circle-II, BWDB, Dhaka
18	Sanzida Islam Orchi	Assistant Engineer, Design Circle-II, BWDB, Dhaka
19	Kashfia Najnin	Assistant Engineer, Design Circle-II, BWDB, Dhaka
20	Kamrul Hassan	Assistant Engineer, Design Circle-II, BWDB, Dhaka

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ABBREVIATION	ELABORATION
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
ADRC	Asian Disaster Reduction Centre
AFD	Armed Forces Division
APD	Academy for Planning and Development
ASEAN	Association of South East Asian Nations
BARD	Bangladesh Academy for Rural Development
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BCS	Bangladesh Civil Service
BDRCS	Bangladesh Red Crescent Society
BFS&CD	Bangladesh Fire Service and Civil Defence
BGD	Bangladesh
BGS	British Geological Survey
BMD	Bangladesh Meteorological Department
BNBC	Bangladesh National Building Code
BNDV	Bangladesh National Disaster Volunteers
BPATC	Bangladesh Public Administration Training Centre
BS	Bangladesh Scouts
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CBO	Community Based Organization
CCC	Climate Change Cell
CCDMC	City Corporation Disaster Management Committee
CDMP	Comprehensive Disaster Management Programme

CEGIS	Centre for Environmental and Geographical Information Services
CPP	Cyclone Preparedness Program
CPPIB	Cyclone Preparedness Program Implementation Board
CRA	Community Risk Assessment
CSDDWS	Committee for Speedy Dissemination of Disaster Related Warning/ Signals
DAE	Directorate of Agricultural Extension
DC	Deputy Commissioner
DDMC	District Disaster Management Committee
DDMP	District Disaster Management Plan
DESA	Dhaka Electric Supply Authority
DFID	Department for International Development
DGOF	Director General of Food
DIRA	Disaster Impact and Risk Assessment
DMB	Disaster Management Bureau
DMC	Disaster Management Committee
DMIC	Disaster Management Information Centre
DMTATF	Disaster Management Training and Public Awareness Building Taskforce
DoE	Department of Environment
DPHE	Department of Public Health Engineering
DM&RD	Disaster Management & Relief Division
DRR	Directorate of Relief and Rehabilitation
DRRO	District Relief and Rehabilitation Officer
ECNEC	Executive Committee of the National Economic Council
EIA	Environmental Impact Assessment
EOC	Emergency Operation Centre
FBCCI	Federation of Bangladesh Chamber of Commerce and Industries

FFE	Food for Education
FFW	Food for Works
FFWC	Flood Forecasting and Warning Centre
FPMU	Food Planning and Monitoring Unit
FPOCG	Focal Point Operation Coordination Group
GDACS	Global Disaster Alert and Coordination System
GDP	Gross Domestic Product
GIS	Geographical Information System
GOB	Government of Bangladesh
GSB	Geological Survey of Bangladesh
HFA	Hyogo Framework for Action
HIPC	Heavily Indebted Poor Countries
HIV/AIDS	Human Immune Virus/Acquired Immune Deficiency Syndrome
ICT	Information Communication Technology
IFRC	International Federation of Red Cross
IMDMCC	Inter-Ministerial Disaster Management Co-ordination Committee
IMF	International Monetary Fund
INSARAG	International Search and Rescue Advisory Group
ISDR	International Strategy for Disaster Reduction
IWM	Institute of Water Management
JPOI	Johannesburg plan of Implementation
LGD	Local Government Division
LGED	Local Government Engineering Department
LGRD	Local Government and Rural Development
LRP	Land Reclamation Programme
MDGs	Millennium Development Goals
MES	Meghna Estuary Study

MoD	Ministry of Defence
MoEd	Ministry of Education
MoEF	Ministry of Environment and Forest
MoFA	Ministry of Foreign Affairs
MoFDM	Ministry of Food and Disaster Management
MoF&L	Ministry of Fisheries and Livestock
MoH&FP	Ministry of Health and Family Planning
MoHA	Ministry of Home affairs
MoP&T	Ministry of Post and Tele-communication
MoPME	Ministry of Primary and Mass Education
MoRA	Ministry of Religious Affairs
MoS&T	Ministry of Science and Technology
MoW&CA	Ministry of Women and Children Affairs
MoWR	Ministry of Water Resources
MPO	Master Plan Organisation
MSL	Mean Sea Level
NAEM	National Academy for Educational Management
NDMAC	National Disaster Management Advisory Committee
NDMC	National Disaster Management Council
NDMTI	National Disaster Management Training Institute
NEC	National Economic Council
NGO	Non Governmental Organization
NGOCC	NGO Coordination Committee on Disaster Management
NWMP	National Water Management Plan
NWRD	National Water Resources Database
PCP	Project Concept Paper
PDMC	Pourashava Disaster Management Committee

PDMP	Pourashava Disaster Management Plan
PIO	Project Implementation Officer
POA	Plan of Action
PP	Project Proforma
PPRR	Prevention, Preparedness, Response and Recovery
PRSP	Poverty Reduction Strategy Paper
PWD	Public Works Department
RAJUK	Rajdhani Unnayan Katripakhaya
RCC	Regional Consultative Committee
RDA	Rural Development Academy
RRAP	Risk Reduction Action Plan
SAARC	South Asian Association for Regional Cooperation
SARDI	Soil and Agricultural Research and Development Institute
SDMC	SAARC Disaster Management Centre
SFA	SAARC Framework for Action
SMRC	SAARC Meteorological Research Centre
SOD	Standing Orders on Disaster
SPARRSO	Space Research and Remote Sensing Organisation
TAP	Technical Assistance Project
TAPP	Technical Assistance Project Proforma
TOT	Training of Trainers
TR	Test Relief
UDMC	Union Disaster Management Committee
UDMP	Union Disaster Management Plan
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for

	Disaster Reduction
UNO	Upazila Nirbahi Officer
UZDMC	Upazila Disaster Management Committee
UZDMP	Upazila Disaster Management Plan
VDP	Village Defence Police
VGD	Vulnerable Group Development
WARPO	Water Resources Planning Organization
WASA	Water and Sewerage Authority
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

Chapter 1

100 GENERAL
DESCRIPTION OF WORKS

101 DEFINITIONS

(1) “Engineer” means Executive Engineer of BWDB.

(2) "Revetment" and "Slope Protection" are layered systems placed on a sloping or horizontal surface as protection against hydraulic forces and scouring.

(3) "Geo-textile" is a synthetic fabric (woven, non-woven, needle punched) applied as a filter or used in tailored geo-textile systems (bags, containers, mattresses, etc.)

(4) "Top Soil" is the top layer of soil containing a lighter proportion of organic material.

(5) "Suitable material" comprises all material obtained from excavation within the site or from borrow pits which is approved by Engineer accepted for use in the work.

(6) "Unsuitable material" is any material other than suitable material and shall comprise high organic content; peat, stamp, clay of liquid limit exceeding 90%, plasticity index exceeding 65%.

(7) "Soft" material shall mean all material, whether suitable or unsuitable, but other than that defined as rock.

(8) "Subsoil" is naturally deposited or filled and compacted soil material on which a structure such as building, bridge, regulator, embankment, revetment, bed protection or a falling apron etc. is constructed.

(9) “Flood season” may be defined as a period between 15 June to 15 October, characterized by high water levels and strong currents, accompanied by fast morphological changes.

(10) “CC block” is a hard form of definite proportion of mixture of sand, cement and coarse aggregate to a desired strength and size after 28 days of curing.

(11) “Placing” is defined as controlled lying of concrete blocks at the bank slope from Design Low Water level (or as directed) upward in brick bond manner over filter layers for example sand, khoa and geo-textile.

(12) “Power driven flat top country boat/Pontoon” is floating equipment with the capacity to carry a weight e.g. number of bags, CC blocks, boulders, hard rock etc. as per Contractor’s work methodology, loaded for the transport to the work site and subsequent dumping after positioning by anchors and Total Station.

(13) “Dumping” is defined as controlled under-water placing of concrete blocks, boulders, hard rock, geo-bags etc. at the berm from toe towards river.

(14) "Steining" means a lining (as for a well) of stone, brick, or other hard material to prevent caving in or washing away of soil

102 DRAWING

WORKING DRAWING

(1) Work must be implemented according to the Drawing approved by concern Design Circle of BWDB. If any change or modification in approved drawing is needed, it must be referred to concern BWDB Design Circle. If any change or modification in approved drawing is needed, it must be approved from concern Design Circle of BWDB. Work can not be executed unless such change or modifications are approved from concern Design Circle of BWDB. Engineer will supply the approved Drawing to the contractor.

CONSTRUCTION DRAWINGS

(2) Drawings of temporary buildings, godowns, workshops and lobour shed that contractor proposes to construct or rent, including his proposals for water and power supply and sewage facilities.

(3) Construction Drawings includes Drawings of shuttering, foundation trench, shoring (if needed), bar bending schedule, dumping plan, sub-surface dewatering etc.

(4) In the name of Construction Drawings, contractor cannot change the approved drawing of BWDB. If any change or modification in approved drawing is needed, it must be referred to concern BWDB Design Circle. Engineer will take necessary steps, if any change or modification in approved drawing is needed.

AS BUILT DRAWINGS

(5) The Contractor shall submit whole sets of as-built drawings of the completed works, one set comprising one negative drawings of high quality reproducible polyester transparent "Mylar" film (or similar material) from which clear copy can be produced and three clearly printed drawings, to the owner before the expiration of period of Maintenance.

(6) The as-built drawing shall clearly show the lines and dimensions of the permanent construction actually made based on the approved design.

(7) The design drawings will be lent to the Contractor upon request by him in not more than 3(three) copies free of charge.

103 STANDARDS & SPECIFICATION

(1) For all work, Standards & Specifications of BWDB shall be followed. If nothing mentioned in the Standards & Specifications of BWDB, then other Standards & Specification or code such as ASTM, NBC, ACI, AASHTO, BNBC, British Standard or Cod of Practices or normal practice etc. may be followed.

104 PROGRAMME

CONSTRUCTION PROGRAMME

(1) Within 7 days of the Notice of Award being issued or within the time limit laid down in the tender document, the Contractor shall submit to the Engineer for his approval a bar-chart programme showing the sequence in which he proposes to carry

out the Works, including the procurement and delivery of equipment and material. He should also submit implementation matrix and CPM as directed by the Engineer.

(2) The Contractor shall, whenever required by the Engineer, also provide in writing of his information a general description of the arrangements and methods which the Contractor proposes to adopt for the execution of the Works.

(3) If at any time it would appear to the Engineer that the actual progress of the works does not conform to the approved programme, the Contractor shall be obliged to produce for the approval of the Engineer, the reasons for any change and a revised programme showing the modifications to the approved programme necessary to complete the works within the scheduled time for completion. The submission to and approval by the Competent Authority of such programme or the furnishing of such particulars shall not relive the Contractor of any of his duties and responsibilities under the Contract.

NOTICE OF OPERATION

(4) The Contractor shall give full and complete written notice of all important operations, including setting out, to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

105 MONITORING PROGRESS

MONTHLY REPORTS

(1) The Contractor shall furnish the Engineer, without cost to the Owner at regular monthly interval and in a form and number of copies determined by the Engineer, with the following:

(a) Monthly Physical Progress for every month within 7 days of next month;

(b) Completion schedules (target and actual) based on the approved construction programme;

(c) A tabulation of construction equipment, listing the major items and pieces of equipments comprising the Contraction plant which were utilized for performance of the Works during the preceding month;

(d) A tabulation of employees countersigned by the Engineer's Representative, showing the supervisory staff and the numbers of the several classes of labor employed by the contractor in the preceding month;

(e) Any report which may be specifically requested by the owner and/or the Engineer.

SITE VISIT

(2) BWDB officials may visit the site at any time. The Contractor or his representative shall accompany BWDB officials during such visit and shall provide the information which will be needed.

SITE MEETINGS

(3) The Contractor shall make necessary arrangement for site Meetings if it is needed during site visit of BWDB officials or as requested by the Engineer.

(4) The Contractor shall provide attendance at progress and other meetings on site as requested by the Engineer.

106 CONTRACTOR'S SITE FACILITIES

(1) The Contractor shall be responsible for the provision, maintenance, operation and subsequent removal of the following facilities and services on site at his own expenses:

(a) Temporary stores (including godowns for cement and other perishable materials), warehouse and workshop;

(b) Temporary buildings for office accommodation for his staff and a meeting room for Site Meeting;

(c) Living accommodation for his staff outside site limits;

(d) Fencing, Lighting and guarding;

(e) Carnage or other means of off-loading plant and equipment, placing in temporary storage and moving from storage to equipment locations;

(f) Site transport for his staff;

(g) Electric supply for temporary building and tools;

(h) Raw water from site tube-wells and provision of adequate potable water.

(2) The labor camp shall be at a location approved by the Engineer and conform to all of the requirements required by the local law. It shall be laid out and constructed in accordance with a drawing prepared by the Contractor and approved by the Engineer.

(3) The Contractor shall be responsible for acquiring the land he deems necessary at his own expenses for works beyond the owner's land and for his temporary buildings, godown, workshops, staff quarters, labour camp and any temporary access roads. The Contractor shall maintain the Site and all working areas in a safe and sanitary condition and in all matters of health and sanitation shall comply with the requirements of the local medical officer of health or other competent authority.

107 SUFFICIENCY OF MEANS EMPLOYED

The Contractor shall have upon himself the full and entire responsibility for the sufficiency of his supervisory and other personnel, plant, machinery, tools or implements, scaffolding, timbering and generally for all means used for the fulfillment of the Contractor. In the event of any of these means proving

insufficient, the Contractor is still fully and entirely responsible for the sufficiency of these means notwithstanding any previous approval or recommendation that may have been given by the Engineer.

108 CARE OF WORKS

MOVEMENT OF PLANT

(1) The Contractor shall exercise diligence and care in the movement of all plant within the Contract area so as not to cause injury or damage to life or property. The Contractor shall be responsible for restoring any roadway, bridge, culvert etc. damaged by his plant to the satisfaction of the Engineer or appropriate Authority.

KEEPING WORKS FREE OF WATER

(2) The Contractor Shall Construct the ring dykes, cofferdams, temporary bulkheads, watercourses and other works and supply and operate such pumping plant as may be necessary for the construction of the works.

(3) Notwithstanding any approval by the Engineer of the arrangements made for the exclusion of water from the works, the Contractor will be held responsible for the sufficiency thereof and will be liable for keeping the works safe during water fluctuations and floods and shall make good any damage to the works that may be attributable to them at his own expense. Any loss of production, additional overheads or additional costs of any kind that may result from floods are at the Contractor's risk.

MATERIAL ON AND UNDER THE SITE

(4) All Soil, turf, gravel, stone, timber, or other materials obtained in the excavations, clearing of the Site of the works and soil stripping, shall belong to the owner and must not be removed from the works site without the written consent of the Engineer. The Contractor, however, may use for the construction of the works timber felled on the site and any of the materials excavated under the Contract which the Engineer may determine to be fit for such use and shall use such materials if directed by the Engineer. In such case an adjustment of rate of that particular item shall be made in accordance with BWDB's guidelines.

109 SURVEY WORKS

SYSTEM OF UNITS

(1) The metric system of units shall be used unless otherwise instructed by the Engineer or shown in the approved drawing.

SURVEY AND DATUM FOR LEVELS

(2) The levels shown on the Drawing are referred to Public Works Department (PWD) datum or otherwise mentioned.

(3) Prior to the start of the Works, the Contractor will receive from the Engineer a list of Project Bench Marks and their values and reference points on the Site. The Contractor shall be responsible for checking the level of these bench marks prior to their use. Levels shall close within 10 mm multiplied by the square root of the length of the circuit in km. thereafter, the Contractor shall establish all setting out necessary for the performance or the work, to the approval of the Engineer including levels of

the original ground surface at the site and final survey of the completed works for the final measurement.

(4) From the centre line and grades established, the Contractor shall furnish and place all additional stakes, templates and bench mark necessary for marking and maintaining points, lines and sections for layout of the works.

(5) The Contractor's methods of recording survey data shall be subject to approval and field books and tabulated data shall be well maintained and made available for inspection and checking by the Engineer when ordered.

(6) Instruments and equipment for surveys shall be subject to rigorous inspection by both the Contractor and the Engineer and any item found to be defective, in the opinion of the Engineer, shall be promptly replaced, repaired or adjusted as directed. All surveying shall be directly supervised by a qualified surveyor or Engineer.

(7) The checking of the setting-out of the Works by the Engineer's staff shall not relieve the Contractor of any of his liabilities or responsibilities under the Contract.

110 FABRICATED ITEMS INCORPORATED IN WORKS

a. Whenever required by Specification to fabricate or manufacture and furnish equipment for incorporation in the permanent works, the Contractor shall submit to the Engineer for his approval the names of the manufacturers or fabricators he proposes to use and also his detailed shop drawings for approval before proceeding with the work. All such drawings shall be adequately and properly checked before being submitted to the Engineer for approval and shall be so designated.

b. Any fabricating or manufacturing undertaken during or before the approval of the drawings will be at the Contractor's risk. The Engineer shall have the right to require the Contractor to make any changes in the design which may be necessary, in the opinion of the Engineer, to make the equipment or component materials conform to the requirements and intent of these Specifications without additional cost to the Employer.

c. Approval of the Contractor's drawings shall not be held to relieve the Contractor of any part of his obligation to meet all of the requirements of these Specifications or of the responsibility for the correctness of his drawings. At the time of delivery of the equipment, the Contractor, if requested to do so, shall furnish to the Engineer two complete sets of negatives of the final approved Drawings.

111 INSPECTION/TESTS AT FABRICATOR'S WORKSHOP

d. All equipment furnished under these specifications and all work performed in connection therewith will be subject to inspection by the Engineer or his authorized representative. Inspection at the manufacturer's plant will be made to determine that the equipment and the materials used for their manufacture meet the requirements of the technical Specification.

e. The Contractor shall notify the Engineer not less than 15 days in advance of the date and place equipment/material will be available for inspection. No equipment

or material shall be transported to site until the Engineer's inspection at the manufacturer's plant has been made, the Engineer's approval is given, final drawing has been furnished by the Contractor and the Contractor's responsibility for furnishing equipment and materials meeting the requirements of the Contract Document are complied with; the cost of the Engineer's necessary inspection shall be borne by the Contractor.

112 MATERIAL AND WORKMANSHIP

GENERAL

(1) Workmanship shall be of the best quality appropriate to each category of work. Materials used in the Works shall be of the best quality of their respective kinds as specified or described in the Contract. All workmanship and materials shall be to the approval and entire satisfaction of the Engineer. The Contractor shall supply copies of orders or sub-contracts placed by him for materials for the Works.

STANDARDS

(2) For all work, BWDB Standards & Specification shall be followed. If nothing mentioned in BWDB Standards & Specification, then other Standards & Specification or code such as ASTM, NBC, ACI, AASHTO, BNBC, British Standard or Cod of Practices or normal practice etc. may be followed.

(3) Any standard or Code of Practice referred to in the Documents relating to the Contract or any other Standard or Code of Practice that may be substituted therefore shall be held to be the latest edition published 3 months prior to the date for submission of Tenders.

(4) All relevant particulars and conditions in Standards relating to the Contract or any other Standard or code of Practice that may be substituted therefore shall be held to be the latest edition published 3 months prior to the last date for submission of Tenders.

(5) All relevant particulars and conditions in Standards relating to standard of material, quality and workmanship shall be complied with and all tests specified shall be conformed to BWDB Standards & Specification.

MATERIALS

(5) Materials shall be delivered to the Site with a sufficient Period before they are required to be used to enable the Engineer to take such samples as he may think proper for testing and examination and the Contractor shall supply such information as to their quality, weight and strength and other particulars as may be required. Any materials condemned by the Engineer shall be removed immediately from the site.

(6) All materials stored on the site shall be adequately protected against contamination or deterioration.

TESTS

(7) The Contractor shall arrange for the tests required by the Technical Specification or as directed by the Engineer to confirm the quality of construction materials and work at no extra cost to the Contract. Test and number of tests shall be done in accordance with relevant BWDB Standards & Specification. If nothing mentioned in BWDB Standards & Specification, then other Standards & Specification or code such as ASTM, NBC, ACI, AASHTO, British Standard or Cod of Practices or normal practice etc. may be followed.

Material shall be tested in a testing laboratory and manner approved by the Engineer. Test results shall be submitted expeditiously, in an approved form, to the Engineer.

113 TOLERANCES

All works shall be constructed within the tolerance shown in Appendix A.

114 MEASUREMENT AND PAYMENT

INTRODUCTION

(1) The Conditions of Contract, Technical Specifications and Contract Drawings, which are to be read in conjunction with the schedule of Rates.

(2) The Contractor shall have been deemed to have taken full account of all information contained in the Tender Documents and made available during the tender period as affects, inter alias, working methods, haulage requirements and sequence of operations and have made full allowance for the same in the rates and sums entered against the various items in the Schedule of Rates.

(3) The specified measurement and payment clauses shall apply to any additional or varied work which the Contractor may be required to execute under the Contract except where specifically varied therein.

QUANTITIES

(4) The quantities given in the Schedule of works or BOQ are estimated and provisional, and are given to provide a common basis for bidding and the Owner does not expressly not by implication agree that the actual volume of work to be performed will correspond therewith.

(5) The basis of payment will be the actual quantities of work ordered and carried out, as measured by the Engineer (based on approved drawing) and valued at the rates and prices tendered in the priced Schedule of Rates, where applicable, or otherwise at such rates and prices as (in case of non-tendered/non-scheduled items) the Competent Authority may fix within the terms of the contract.

RATES AND SUMS

(6) Notwithstanding any limits which may be implied by the working of the individual items and or the explanations in this section, it is to be clearly understood by the contractor that the rate that quotes in the Schedule of Rates is to be for the work finished completely in every respect; the contractor will be deemed to have taken full account of all requirements and obligations, whether expressed or implied, covered by all parts of this Contract. The rate must therefore include for all incidental and contingent expenses (including all taxes) and risks of every kind necessary to construct, complete and maintain the whole of the works in accordance with the Contract. Full allowance is to be made in the quoted rate in the Schedule of rate for all costs involved in the following, inter alia, which are referred to and/or specified herein:

(i) all setting out and survey works;

(ii) temporary access unless separately billed, fencing, guarding, lighting, and all temporary works, including their removal on completion;

(iii) paying fees and giving notices to Authorities;

(iv) reinstatement of the Site;

(v) safety precautions and all measures to prevent and suppress fire and other hazards;

(vi) interference to the works by persons or vehicles being legitimate users of the facilities on or in the vicinity of the Site;

(vii) the protection and safety of adjacent structures in so far as they may be affected by the Works or Temporary works;

(viii) Supplying, maintaining and removing on completion the Contractor's own housing for staff and labour, offices, workshop, plant yard, transport, welfare, services in connection other with and other facilities required by the Contractor unless separately billed;

(ix) Working in the dry except where otherwise permitted by the Specification;

(x) The supply, inspection and testing of materials intended for use in the works including the provision and use of equipment;

(xi) Maintaining public roads and footpaths and maintaining access upon existing roads or recognized routes;

(xii) Maintaining public roads opening quarries and borrow pits, including all survey, site investigations, removal and disposal of overburden, trimming of quarry or borrow pit faces and floors and all measures necessary to render quarries or pits safe and free draining on completion;

(xiii) Providing, transporting to site, setting work, operating (including all fuel and consumable stores), maintaining and removal from the site upon completion all construction plant and equipment necessary for the execution of the work and including the cost of all test and other requirements in respect of such plant and equipment;

(xiv) The requirements and all incidental costs and expenses involved in the provision of all necessary skilled and unskilled labor and supervision;

(xv) Protecting Completed work from following operations, making good damage to completed work due to any cause whatsoever, for clearing away rubbish as it accumulates and leaving the site in a tidy condition;

(xvi) All cost associated with the provision and submission of progress Reports, record photographs, preparation of the necessary shop and working drawings etc. except for those provided in the Schedule of Rates.

(xvii) Workmen's compensation and Owner's liability insurance.

(xviii) Office, store, shed or laboratory etc. which was made under the contract need not to be dismantled, if it is required by the Engineer for their use after completion of contract. It shall be handed over to the Engineer after completion of contract.

BREAKDOWN /ANALYSIS OF RATE

(7) The Contractor shall, when directed by the Engineer, submit detail breakdown for the rate entered in the Schedule of Rates for composite units of work into their component elements in such detail as may be required by the Engineer in accordance with the provisions laid down in the tender/bidding document.

METHOD OF MEASUREMENT

(8) In general, the Schedule of rates has been drawn up in accordance with the standard method of measurement of Civil Engineering rate currently used by Bangladesh Water Development Board for preparation of Schedules of Rates in individual O & M Circle or Water Development circle. Any clarification regarding Schedule of Rates, Method of Measurement and payment shall be judged by the Engineer in accordance with the BWDB Standards in conjunction with the Technical Specification, clauses, Schedule of rates and other Tender Documentation.

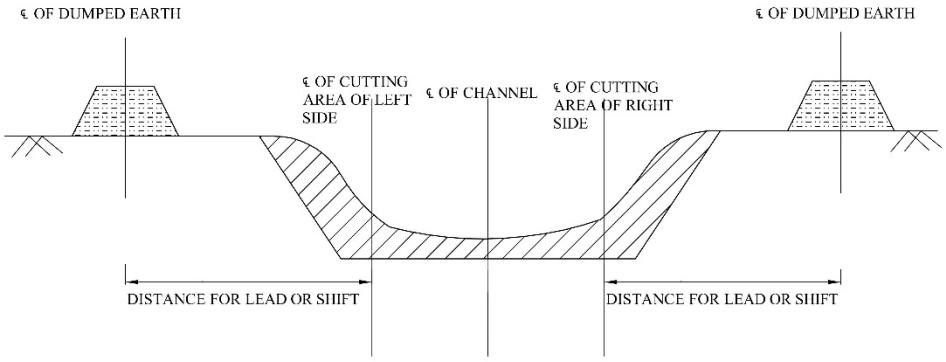
(9) The works as executed complying Drawings and Instructions of the Engineer will be measured for payment in accordance with the method adopted in the Schedule of Rates and the item therein set forth notwithstanding any custom to the contrary. The net quantity of the finished work in place will always be taken except where otherwise specified.

(10) Payment of Royalties for fill material obtained from privately owned land shall be at the contract rates. The volume of borrow material for payment of royalties mentioning specific kilometer in the Measurement Book shall be calculated on the basis of pre-Work and post-work measurements. Finished section as per drawing will be the basis for post-work measurement while the work completes as per specification.

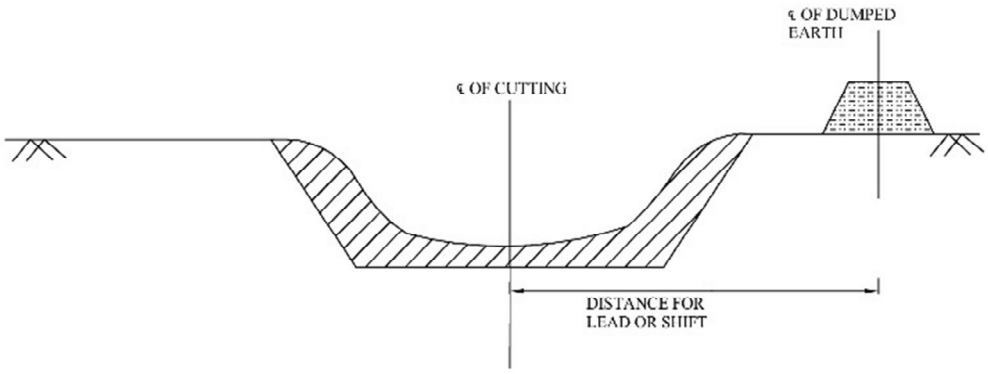
(11) For execution of earth works on payment of royalties, specific order mentioning kilometer and quantity (based on pre-work survey) shall be obtained by the contractor from the Engineer prior to the execution of such work.

(12) Leads and lifts shall be reckoned from the centre of excavated sections to the centre of the place of throwing the spoil. Measurement for lead(s) and lift(s) shall be based on unit of shortest distance traversed and part of units shall be counted for full unit measurement subject to the conditions that fraction of 30 (thirty) cm over the unit of lift and fraction of 3 m (three) meter over the unit of lead shall not be considered for a full unit.

(13) Shift (in case of work done by excavator) shall be reckoned from the centre of excavated sections to the centre of the place of throwing the spoil. Measurement for Shift (s) shall be based on unit of shortest distance traversed and part of units shall be counted for full unit measurement subject to the conditions that fraction of 3 m (three) meter over the unit of Shift shall not be considered for a full unit.



CASE-1: EXCAVATED EARTH DUMPED ON BOTH SIDE



CASE-2: EXCAVATED EARTH DUMPED ON ONE SIDE

(14) Payment for works of CLOSURE and DEWATERING shall be made in lump sum basis as per standard practice of BWDB.

(15) Payment shall mean gross payable amount on the rates of Schedule of Rates including retention money.

(16) No direct payment shall be made for works required under other clauses: the cost for such works shall be deemed to be included in related items of Schedule of Rates.

Chapter 2

200 SITE PREPARATION

201 COMMENCEMENT

The Contractor shall commence the work within seven days of Signing of Agreement or issue of Detail Work Order or as described in the Tender Document.

The Contractor shall give the Engineer at least seven days written notice or as described in the Tender Document, of his intention to commence work on any part of the Site. Works shall not be commenced until written approval has been received by the Contractor from the Engineer.

202 DRAWINGS

The works are to be implemented in accordance with the Approved Drawings and as directed by the Engineer. It may become necessary or desirable, during the progress of the work to change the Drawing. Under this situation, design data shall be sent to concern Design Circle of BWDB and design shall be revised from BWDB Design Circle. Whenever this occurs, the Contractor shall perform the required work according to revised Drawing with the written instruction of the Engineer.

203 SETTING OUT

(1) Prior to the commencement of the Works, the Contractor shall study the Drawings and fully understand all the aspects of the work and correlate the same with the dimensions shown in the drawings, and shall fix up the alignment, set the B.M pillars, levels, pegs etc.

(2) Before works are permitted to commence, location, levels and alignment of embankment or channel shall be accurately set out at every 100 meter and at bends to the satisfaction of the Engineer.

(3) Before works are permitted to commence, location, levels and alignment of structure shall be accurately set out to the satisfaction of the Engineer.

(4) Cutting or filling charts, prepared by the Engineer, will be given to the Contractor to sign as a token of his agreement.

204 EARTHWORKS : GENERAL

Earthworks shall be undertaken to the liners and levels shown on the Drawings unless directed otherwise by the Engineer. In carrying out earthworks the Contractor shall take all necessary precautions to avoid damage to or deterioration of the earthwork materials and existing embankment.

205 CLEARING OF SITE

The site shall be cleared as required to remove all stumps, roots, vegetable and other objectionable materials specifically within areas for embankment, channel excavations and structure excavation, structures, appurtenance and any other facilities indicated on the Drawings or designated by the Engineer. The cleared material shall be deposited in approved areas off site or burnt as directed by the Engineer.

206 DEMOLITION OF EXISTING STRUCTURES

Where directed by the Engineer, existing structures shall be removed in sections suitable for re-use. All materials shall be disposed of or stockpiled as directed by the Engineer.

Chapter 3

300 EARTHWORKS

301 EMBANKMENT : GENERAL

1. Embankment construction consists of furnishing and placing materials to the lines and grades shown on the Drawings or as directed by the Engineer.

2. Unsuitable material shall be stripped from the embankment foundation. The area shall then be scarified or ploughed prior to placing of any fill material.

3. Profiles shall be erected using full bamboo posts and pegs not less than 60 mm diameter and coir string as directed by the Engineer. Dug Bailing at the toe of embankment shall be marked by nicking out lines 75mm deep and 75mm wide.

4. The embankment height shall be raised uniformly at all stages during construction. Each layer shall have a slight slope from the center of the fill towards the sides so that all water shall drain freely from the embankment with no pockets to collect water. The crest of the embankment shall be provided with from 15mm cambering at the center.

5. Unless otherwise specified all embankments and small irrigation dykes shall be manually or mechanically compacted embankments as specified in clause 307, 308 & 309. Embankments may be uncompacted as specified in clause 306.

6. On completion, the embankment shall be protected by grass sod turfing unless shown otherwise on the Drawings or otherwise instructed by the Engineer. The turfing shall be in accordance with clause 510. The Executive Engineer shall record in the Measurement Book that the specified compaction has been achieved and the 100% of the embankment has been covered by established turf sods. Dol Colmi may be planted on the toe of embankment for wave protection.

7. If Cohesion (c) or Angle of Internal Friction (ϕ) are mentioned in the drawing, it shall be ensured through laboratory test after completion of embankment.

8. If the embankment is proposed to be constructed by dredged material, then either

i. The dredged material shall be stockpiled, dried and mixed thoroughly in a desired ratio (if mentioned) then placed on the embankment alignment in layer of 230mm in thickness. Or
ii. The dredged material may be directly placed on the embankment alignment. In this case a dyke to be constructed to confined the dredged material.
iii. In both cases the dredged material shall be covered by a clay cover of minimum 600 mm thickness.
iv. The dredged material shall be free from any sorts of impurities or pollutions. It must fulfill all the criteria, which is termed as “suitable material” for embankment.

9. In all road crossing, Crest of side road shall be matched with the design Crest Level of Embankment with a slope of 1:10.

10. Necessary Ramp to cross the Embankment, with a slope of 1:7 to 1:10 shall be provided for pedestrian and domestic animal as per field requirement.

11. No earth shall not be removed from the crest of the embankment where the existing crest level is higher than the design crest level

12. A smooth transition 1:50 shall be provided at the point where design crest level changes.

13. KM post shall be provided at each kilometer.

302 UNCOMPACTED EMBANKMENT

(1) In determining formation level of an uncompact embankment, 10% of fill height shall be calculated on the basis of pre-work level and it shall be added to the design level of embankment to allow for maximum shrinkage during the first monsoon season.

(2) Earth fill shall be placed in 150 mm (maximum loose thickness), uniformly spread laid in each layer and clods of earth broken to a maximum size of 100mm.

(3) After the first monsoon season the embankment shall be graded as required to the line and grades shown on the Drawings at no additional cost to the Owner.

303 MANUALLY COMPACTED EMBANKMENT

(1) Fill shall be placed and compacted in layers of 150 mm (maximum loose thickness), uniformly spread and compacted over the fill area of each layer. If, for any reason, progress in compacting the fill is interrupted for any unreasonable time the surface area of the fill shall be scarified or ploughed before compaction continues. Each 150 mm thick layer shall be compacted, using controlled manual compaction methods to avoid any air pocket.

2) If the compaction of a fill layer is found unsatisfactory then by the Engineer, the material above that the unsatisfactory layer shall be removed and the unsatisfactory layer shall be re-compacted to satisfy the specification.

304 PROCEDURE FOR MANUAL COMPACTION OF EMBANKMENT

(1) Earth excavated from the borrow pit shall be placed in the embankment in horizontal layers parallel to the finished grade not exceeding a loose thickness of 150 mm. The earth of each basket is to be placed near to the earth placed before it and spread systematically. Throwing of earth in heaps will not be allowed.

(2) The clods of earth shall be broken down to a maximum size of 100 mm by striking the clods with the back of a spade or by other suitable method before the next

basket of earth is thrown close to it. The earth shall be compacted manually using rammers made of Wood, iron or concrete weighing =>7 kg, fitted with shafts of about 1.5 m long Ramming shall reduce the voids and until no further shrinkage of earth is possible by ramming.

(3) Before commencing ramming, the moisture content of the soil shall be increased or decreased as necessary by sprinkling the soil with water or by allowing natural drying of the soil as necessary so that the ramming can achieve the compaction as specified. Both wetting and drying may be aided by furrowing the fill and then re-spreading when the moisture content is suitable.

(4) The preceding operations shall continue layer after layer until the top of the embankment is reached.

305 MECHANICALLY COMPACTED EMBANKMENT

(1) Embankments designated on the Drawings or by the Engineer to be mechanically compacted shall be compacted to the lines and grades shown on the Drawings or established by the Engineer. The Contractor's operations in the excavation of material designated for use in compacted embankments or compacted backfill shall be such as will result in an acceptable gradation of material, as determined by the Engineer, when placed.

(2) Earth shall be placed in the embankment in horizontal layers parallel to the finished grade not exceeding thickness of 230 mm before compaction.

(3) Just prior to and during placement operations, the materials shall have a moisture content of not greater than 5 percent wet or less than 5 percent dry of optimum moisture content required for the purpose or compaction, as determined by Test No. 12 of BS 1337 and approved by the Engineer, and the moisture content shall be uniform throughout each layer. In-so-far as practicable, as determined by the Engineer, the material shall be brought to the proper moisture content at the site of excavation.

(4) If the moisture content is less than optimum for compaction, the moisture shall be supplemented by sprinkling and reworking the material at the site of compaction. If the moisture content is more than optimum for compaction, the material shall be dried by reworking, mixing with dry materials or other approved means. If the moisture content is less than optimum by more than 2 percent or is greater than optimum by 2 percent, the compaction operations shall not proceed, except with specific approval of the Engineer, until the material is wetted or allowed to dry out, as may be required, to obtain optimum moisture content within the tolerances permitted above, and no adjustment in price shall be made on account of any operations of the Contractor in wetting or drying the materials or on account of any delays occasioned thereby.

(5) If the material being excavated from canal or other water-logged areas for use as embankment material is saturated, then it shall be initially stockpiled to drain the excess water before placing it for construction of embankment.

(6) The material to be compacted shall be deposited in horizontal layers not more than 230 mm thick, and the distribution of materials shall be such that the compacted material will be homogeneous and free from lenses, pockets, streaks or other imperfections. The excavating and placing operations shall be such that the materials when compacted will be blended sufficiently to secure the best practicable degree of

compaction, impermeability and stability, and for this reason the preceding compacted layer shall be scarified before placing the new layer.

(7) When the material has been conditioned and placed as specified or directed, it shall be compacted with appropriate motorized vibratory compaction equipment or tampers of adequate weight and size as approved by the Engineer.

(8) The material in compacted embankment on which a road is to be laid shall be compacted until the dry density of compacted material is not less than 90% (or specified in the drawing) of the laboratory maximum dry density as determined by Test No. 13 of BS 1377 (4.5 kg rammer method) or similar approved test for the material being compacted. Materials forming all other embankments on which limited vehicular traffic might be allowed after completion shall be compacted until its dry density reaches at least 85% of the laboratory value as tested above. The Engineer will take samples of the material being compacted and will perform tests required to determine that the compaction is meeting the requirements of these Specifications. The Contractor shall provide all necessary aid to the Engineer in obtaining representative samples for testing at no extra cost.

(9) The insitu dry density of the compacted fill shall be determined by the sand replacement method described in Test No. 15 of BS 1377 or similar approved test at locations ordered by the Engineer.

306 RE-SECTIONING OF EMBANKMENT

(1) Before commencing the re-sectioning, the original slope and crest shall be cleared in accordance with Clause 205 and stripped in accordance with Clause 301.

(2) The Slopes shall be benched to form a series of horizontal steps to the approval of the Engineer's Representative.

(3) The embankment shall then be filled to the lines and grades shown on the Drawings in accordance with Clause 306.

307 SOIL COMPACTION

SOIL TYPE

(1) Soil may be classified as below :

clay:	<0.002 mm
silt :	0.002 to 0.06 mm
sand:	0.06 to 2.00m
Graval :	2.00 mm to 60mm
Cobbles	60 mm to 200 m
Boulder :	larger than 200mm

CLAYEE SOIL

LL = The water content at which soil changes from liquid to plastic state

PL = The water content at which soil changes from plastic to solid state

PI = LL-PL : means the range of water content at soil remain plastic.

PERMEABILITY

(2) Soil permeability is the property of the soil to transmit water and air. Permeability is commonly measured in terms of the rate of water flow through the soil in a given period of time.

(3) It is usually expressed either as a permeability rate in cm/h, mm/h or cm/d, or as a coefficient of permeability " k " in m/s or in cm/s.

BULK DENSITY

(4) It is defined as the mass of the material divided by the total volume. The total volume includes particle volume, inter-particle void volume, and internal pore volume.

DRY DENSITY

(5) Dry density (ρd) is the dry mass of soil per unit volume

CONSOLIDATION

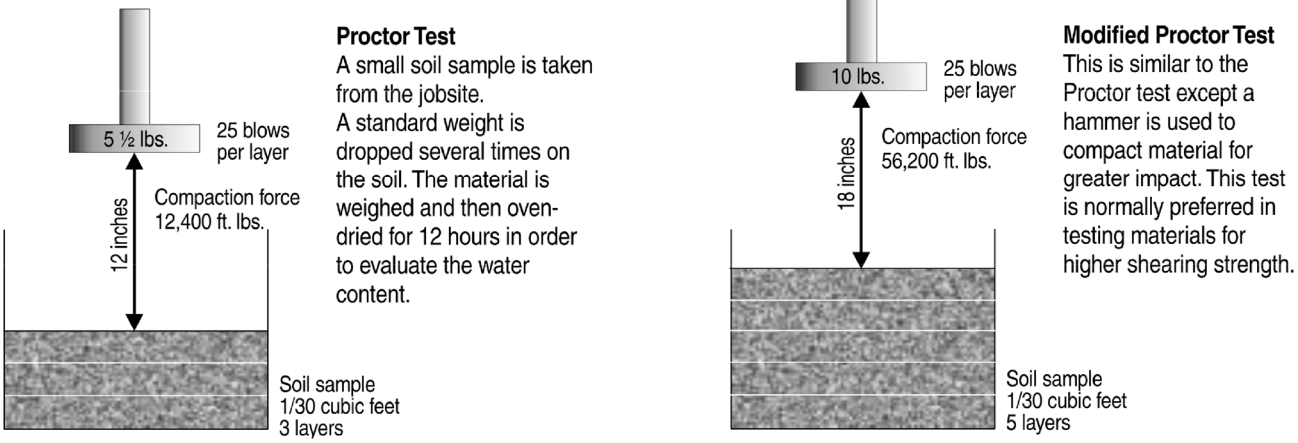
(6) Consolidation is a process by which soil volume is decreases by removing water. Consolidation is a process which involves a decrease in water content of saturated soil without replacement of water by air.

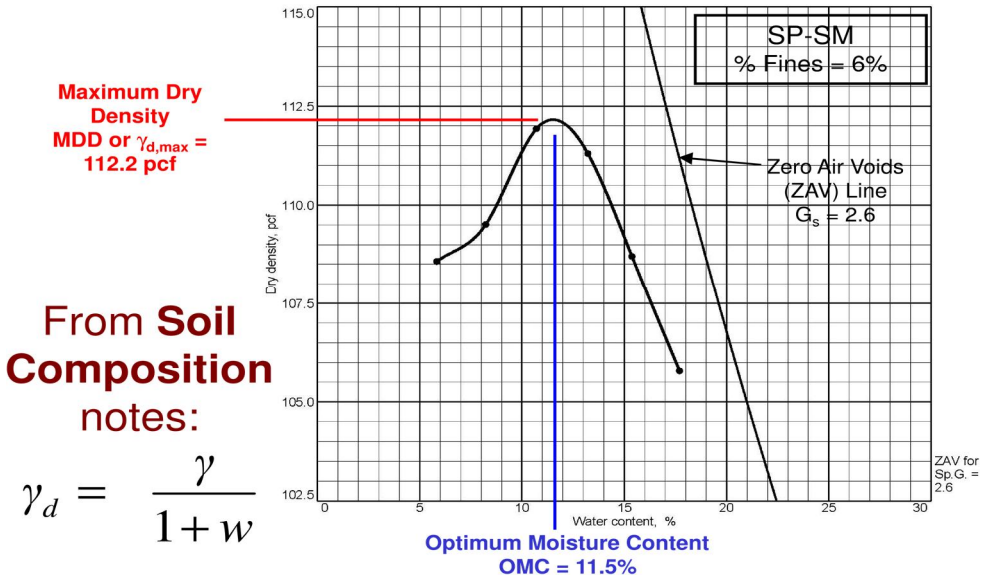
COMPACTION

(7) Compaction is the process by which the bulk density of soil is increased by driving out air. Soil compaction is defined as the method of mechanically increasing the density of soil..

(8) The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density.

(9) The "Modified Proctor" test, ASTM D1557 / AASHTO T180, uses 100 mm diameter mould, a 10 lb. hammer falling through 18 inches, with 25 blows on each of five layers for compaction.





308 FILL WORKS

(1) Fill works shall mean the construction, re-sectioning or repair of embankments, the repair of channel side slopes or beds and backfilling to structures as shown in the Drawings and other minor fill works directed by the Engineer, as per specification and with the specified material and compaction.

(2) The material to be used for fill work shall be suitable earth and shall not contain peat, logs, stumps, vegetation or other undesirable or organic matter and shall

be capable of being compacted to the required standards. All sources of fill material shall be approved by the Engineer. All foundations of fill works shall be inspected and approved by the Engineer before filling commences.

(3) The Contractor Shall:

(a) plan all fill works to allow for delays in preparing, compaction and testing for compaction;

(b) allow for drainage, stockpiling, mixing with dry material or watering to enable the material to be placed in the fill work at the appropriate moisture content for compaction to be effective;

(c) take all appropriate and necessary measures to ensure that the filling is undertaken with self-draining layers.

309 STRUCTURAL BACKFILL

(1) Structural backfill consists of furnishing, placing and compacting fill material around structures and other appurtenance to the lines and grades shown on the Drawings or directed by the Engineer. Prior to placing backfill, all trash, metal, debris, lumber, bricks, soft materials and similar objectionable foreign materials shall be removed from the area to be backfilled.

(2) No backfill shall be placed in standing water, on surfaces that are excessively soft, wet or against concrete structures that have not cured for at least fourteen days or such other period as may be directed by the Engineer.

(3) Structural backfill shall be either compacted by manual or mechanical means as described in the drawing or as per direction of Engineer. Fill shall be placed in horizontal uniform layers of the following thickness:

- Manual compaction – 150 mm of loose material.
- Mechanical compaction – 230 mm of loose material.

(4) Before Compaction, each layer shall be moistened or aerated to provide suitable conditions for compaction. Manual compaction shall be undertaken as described in Clause 307 & 308. Mechanical compaction shall only be undertaken by equipment approved by the Engineer.

(5) Unless specified on the Drawings, each layer shall be compacted in accordance with Clause 307, 308 and 309. Compaction equipment or methods which may cause damage to a structure shall not be used.

(6) Unless shown otherwise on the Drawings, backfilling behind abutments, wing walls and retaining walls shall be with sand of fineness modulus not less than 0.80 or suitable soil approved by the Engineer. Suitable soil for backfill shall conform with Clause 305; clay soil with a peat content shall not be used.

310 TESTING FILL

(1) Layers of filling shall be tested as directed by the Engineer. Each compacted layer shall not be covered until the Engineer is satisfied that the specified degree of compaction has been achieved.

(2) The insitu dry density of the sample points shall be determined in accordance by either Test 15A, BS 1377 or ASTM Designation E-24 and compared to laboratory results to establish the degree of compaction.

311 BORROW PITS

(1) The Contractor shall be responsible for arranging land, purchase of earth and supply of borrow material from pits for earthworks. Prior to the excavation of any material from the borrow pit the area shall be cleared and stripped.

(2) Borrow areas shall be located on the river/sea side of the embankment wherever possible. The minimum distance of the borrow area from the toe of the embankment shall not be less than 1.5 multiplied by the depth of the borrow pit or 3 m whichever is greater or as specified in the drawing.

(3) Depth of Borrow pit shall not exceed 2.00 m. A Berm of minimum 6m should be provided between edge of Borrow pit to River Bank.

(4) Borrow pit shall not excavate continuously along the Embankment. Borrow areas located on the river/sea side of the embankment shall be not more than 30 m in length and shall be separated by gaps of undisturbed ground of not less than 6 m in length measured parallel with the embankment.

(5) No excavation shall be made within 50.00m from the c/s toe of the embankment. If there exists any ditch/pond/depression within 50.00m from the c/s toe, that shall be filled up to the ground level.

312 STRIPPING

(1) Areas to be excavated or filled as well as borrow areas where material for filling is to be excavated, shall be stripped of topsoil containing organic or other unsuitable matter to a depth of at least 150 mm or to such greater depth/as may be shown on the Drawings or as may be determined by the Engineer. The topsoil shall be disposed of in accordance with Clause 316, “Spoil Tips” or stockpiled for the reinstatement of borrow pits.

(2) All topsoil stripped from borrow areas shall be spread evenly over the borrow areas on completion of the work.

313 TRIMMING, SLIPS AND FALLS

The Contractor shall exercise the greatest possible care and take all necessary precautions to prevent slips and falls of material from the sides of the excavation and embankments. Earth work faces shall be trimmed back to form a stable slope and to facilitate construction works to the approval of the Engineer. In the event of slips and

falls occurring the Contractor shall make good all earthworks and associated works and execute any requisite modifications of the Works to the satisfaction of the Engineer.

314 EXCAVATION OF CHANNELS

(1) Excavation shall mean the removal of materials so that channels can be constructed and shall be to the lines, grades and dimensions shown on the Drawings.

(2) Excavated materials shall not be stockpiled at the top edge of cut slopes. Spoils shall be stockpiled at a distance at least 1.5 times the depth of excavation from the edge of the channel or 3m whichever is greater. Gaps shall be formed and maintained in spoil banks at 250m centers to facilitate drainage.

(3) Excavated materials, which meet the specification of fill work, may be stockpiled for backfilling and embankment construction or deposited in spoil tips. Road may be constructed on both bank by Excavated materials or it may be spread over the land as per field situation and as per direction of Engineer.

(4) Whenever a spoil bank passes across any depression or drainage channel, sufficient openings as directed by the Engineer are to be left in it to ensure unobstructed flow of surface run-off in the drainage channel. The spoil bank should be trimmed to a gentle slope across access roads to facilitate easy traffic movement and its top should be graded to a smooth surface to facilitate access.

(5) Cross bundhs may be constructed across the drainage Channels for dewatering purpose to facilitate excavation. The Contractor shall submit his proposals for location and dimensions of cross bundhs to the Engineer for approval before work is permitted to commence.

(6) The Contractor shall arrange to obtain earth for the construction of cross bundhs. The bundhs shall not be removed until the bed has been dewatered, excavated and the measurement of the excavated earth completed.

(7) Bailing out of water shall be continued until excavation or re-excavation to the design bed level and section is completed.

(8) Excavation work shall be done continuously from D/S of the river / channel towards the U/S. Piecemeal approach of excavation or excavation in a discontinuous manner shall be avoided.

(9) A smooth transition 1: 50 shall be provided at the point where design bed width or design bed level changes.

(10) No filling shall be done where the existing bed level of river / channel is lower than the design bed level.

(11) Any or all excess excavation for the convenience of the Contractor or over excavation performed by the Contractor for any purpose or reasons, except as may be directed by the Engineer, shall be at the expense of the Contractor. If the excavation

exceeds the depths specified, back filling shall not be undertaken. If the existing depth is more than design depth, back filling shall not be done.

315 EXCAVATION FOR STRUCTURE

(1) Excavation shall mean the removal of materials so that structures can be constructed to the lines, grades and dimensions shown on the Drawings. The Contractor shall prepare, submit and obtain approval from the Engineer for excavation plans including details of any surface or sub-surface dewatering prior to the start of any excavation.

(2) Excavated materials shall be stockpiled for either backfilling, embankment/cross dam construction or deposited in spoil tips. Excavated material shall not be stockpiled at the top edge of cut slopes. The location of work areas and stockpiles and the use of excavated materials shall be as directed by the Engineer. All excavated material which meets the specification of fill work, unless otherwise ordered by the Engineer, shall be utilized for the fill work.

(3) Except as may be directed by the Engineer, excess excavation for the convenience of the Contractor or over excavation performed by the Contractor for any purpose or reasons, shall be at the expense of the Contractor. If the excavation for foundations exceeds the depths specified, back filling shall be undertaken as fill works at the expense of the Contractor. If back filling is to be undertaken it shall be done by sand and shall have a fineness modulus (FM) between 1.0 and 1.50 or as directed by the Engineer.

(4) When excavating to specified foundation levels, the Contractor shall not excavate the last 150 mm until immediately before commencing the construction work, except that the Engineer shall permit otherwise. Any damage to the work due to the Contractor's operations shall be repaired at the expense of the Contractor.

(5) When the specified levels or limits of excavation are reached, the Engineer will inspect the ground exposed. If the Engineer considers that any part of the ground is by its nature unsuitable, he may direct that the unsuitable material be further excavated to a depth from the lowest excavation level shown on the Drawings or as directed by the Engineer and be replaced by a suitable backfill approved by the Engineer.

(6) If the materials forming the bottom of any excavations, which is acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather condition or due to flooding or have become puddle, soft or loose during the process of the works, the Contractor shall remove such damaged softened, or loosened material and excavate further by hand. Such further excavation shall be held to be excess excavation and the cost of the excess excavation and subsequent replacement with a suitable backfill shall be at the expense of the Contractor.

316 SPOIL TIPS

Spoil and excavated material from stripping and excavation which does not meet the specification for fill work, shall be disposed of at the selected sites to be arranged by the Contractor or within the specified site limits in locations approved by the Engineer or within the specified site limits.

317 TEMPORARY COFFERDAMS

(1) Where necessary, the Contractor shall protect the works from the effects of tidal or flood waters ensuring that the works are constructed in the dry.

(2) The Contractor shall submit his proposed method of protecting the construction works to the Engineer for approval ten days prior to the commencement of construction. If the cofferdam has not been detailed on the Drawings, the Contractor will be responsible its design and subsequent performance; the Engineer's approval of the proposal will not relieve the Contractor of full responsibility for the design, maintenance and safety of the temporary cofferdam until its removal.

(3) The temporary cofferdam shall not be removed without the written permission of the Engineer, following his satisfactory inspection of the works within.

(4) The Contractor shall ensure that the cofferdam and its associated elements are carefully and completely removed without causing any harm to the permanent works.

318 CLOSURE

All the work of Closure must be consolidated into one item and Measurement of Closure shall be lump sum.

DESIGN OF CLOSURE

(1) A complete set of design and drawings duly approved by the competent authority shall be made available to the Contractor which shall act as a guide for the construction of the closure and the work is to be executed in accordance with this specification.

(2) Alternately, the contractor may prepare a design and drawing of his own and submit the same to the Engineer for his approval and the work is to be executed in accordance with the specifications.

(3) In either case, the design and drawings shall not relieve the contractor from his obligations under this contractor to close the flowing channel in full design section to meet the project needs.

SITE INFORMATION

Any survey works and sub-soil investigation conducted by the BWDB will be made available for the tenderer's review. The tenderer may repeat the survey works and sub-soil investigations or collect additional information. The BWDB assumes no responsibility regarding the correctness of these data. It is the responsibility of the tenderer to verify all surfaces and sub-surface conditions prior to submitting a Tender.

CONTRACTOR'S RESPONSIBILITIES

(1) The contractor shall be solely responsible for the work under execution and include in his lump sum rate for the following tasks :

(a) Satisfying with the design of closure in accordance with which the work shall be executed. For the purpose the contractor shall have to collect all the requisite data, prepare plans and drawings necessary for the construction of the closure. A detail work programme has to be drawn for successful completion of the work.

(b) Providing all equipment and accessories including site illumination etc. required for satisfactory execution of the work.

(c) Transportation, furnishing, installation, safe operation and maintaining of all equipment including operators, mechanics, supply of power, fuel, lubricants, spares, repairing and all other materials, labours and temporary works required for the executions of the works throughout and removal of the equipment and temporary works at the end of the construction period under this contract.

(2) The Contractor shall provide continuous supervision of works by persons competent to recognize adverse conditions as they develop and take immediate corrective measures. The supervisors engaged by the Contractor, shall have thorough knowledge of the construction system, including the ability to suggest/make minor emergency repairs.

(3) The contractor shall be solely responsible for correctly assessing quality and the volume of fill materials required for execution of the works. The land acquired by BWDB, if available may be used as borrow area upon receipt of written permission from the Engineer while such permission shall not entitle the Contractor to cause any damage to Government and public property adjacent to borrow area. The contractor shall remain bound and include in his rate materials if required for satisfactory execution of the works.

(4) The contractor shall plan and organize in such mode and manner that the work is completed in all respect within the time stipulated under this contract and for such accomplishment the progress must be proportionate to the time limit. The date and time for closing the flowing channel shall have to be worked out by the contractor based on all surface and sub-surface conditions including the unforeseen parameters and the Engineer must be informed of such date and time at least 7 (seven) days ahead which shall however in no way relieve the contractor from any of his obligations under the contract.

(5) The contractor shall be responsible for maintenance of the work including necessary repairing and mending all kinds of damages during the period from the date of issuance of "Completion Certificate" to the date of releasing the performing Security as per direction of the Engineer-in-charge.

319 DREDGING

(1) Design section of Khal or River is trapezoidal. To have a trapezoidal section, cutter section dredger is needed. For dredging of khal or River Cutter Section Dredger shall be used. Suction dredger or bulkhead dredger which is termed as "Local Dredger" shall not be used for dredging of khal or River.

(2) Dredged material shall not be dumped in the river or khal or floodplain. Dredged material shall be dumped in such a way that it must not come back to river or khal. Dredged material shall be dumped in pond, ditch, low lying area, depression etc. or be dumped in an area confined by dyke.

(3) During Dredging care shall be taken that thallague does not approach the bank. Dredging must not damage existing bank protection work or other structure. A safe distance from the River Bank or existing Protective Work shall be maintained during dredging.

(4) Piecemeal approach of Dredging or Dredging in a discontinuous manner shall be avoided.

(5) Measurement of dredging shall be always on a pre-work and post-work basis. Pit measurements are not acceptable.

DREDGERS

(6) Dredger is simply an underwater or partially underwater excavator. Dredger is used for dredging which is a four-part process: loosening the material by cutter, bringing the material to the surface by suction or mechanical means, transportation of dredged material and disposal of dredged material according to plan.

(7) The main types of dredgers used throughout the world are cutter suction dredgers (CSD), trailing suction hopper dredgers (TSHD) and grab dredgers (GD). which are typically mounted on a barge and consist of a rotating cutters head with an adjacent suction pipe that collects a slurry of cuttings and water which it pumps through a discharge pipeline to its destination. Mainly different sizes of cutter suction dredgers (CSD) are used in our country according to the dredging requirement and the site condition. CSDs are classified according to the discharge pipe inside diameter of dredge pump: 8 inch, 10 inch, 12 inch, 18 inch, 20 inch, 26 inch etc.

ANCILLARY EQUIPMENT

(8) For a dredging project other than the dredger a set of auxiliary equipment are also used. Based on site condition, the type of dredgers used, dredging material disposal distance, the accessibility of the dredging area any of the following equipment can be required.

(9) There is other necessary equipment such as excavators, crane, pipe handling attachment etc. which are also required for the completion of the dredging work necessary for completion of dredging or filling work will be maintained by the contractor.

PIPELINES

(10) Pipelines include suction hose and discharge pipeline which is used to carry the soil to desired destination. Pipelines will be different shapes and sizes as different circumstance is required to meet the situation. There are floating pipeline, shore pipeline and sinking pipeline. In accordance with the mean pressure and discharge volume, different pipe materials, connectors and hoses are used.

WORKBOAT

(11) Workboats are used to mobilize/demobilize the dredger and ancillary equipment. It also used for moving dredger around the site to setting anchors, for maintaining and positioning discharge pipe, to transporting crew and supplies etc. It is equipped with a hydraulic crane and anchor handling winches.

TUGBOAT

(12) It is used for pulling or pushing of dredgers and other vessels, workboat, barge etc.

HOUSEBOAT

(13) Houseboat provides the lodging facility of the operators and crews at the dredging site.

BOOSTER STATION

(14) Booster stations are placed in the long distance discharge pipelines to boost up the transportation of dredged materials through a booster pump.

320 TURFING

(1) The crest and slope of the embankment shall be shaped to slopes and levels, fully compacted then fine dressed with approved top soil in a layer of not less than 50 mm thick before being covered by Durba grass turf or a similar approved turf from a source approved by the Engineer. The turf should be approximately 200 mm × 200mm and 75 mm thick and be placed close together in a staggered pattern with 100% coverage. The turfs shall be set firmly into the top soil dressing and watered immediately after planting, then daily until the grass is well established and new growth is clearly visible.

(2) All sodded areas shall be watered until the grass grows fully. Areas that do not grow or wash out shall be repaired and returned with fresh sods at the Contractor's expense.

Chapter 4

400 DEWATERING SYSTEMS

All the work of Dewatering must be consolidated into one item and Measurement of Dewatering shall be lump sum.

401 TYPE OF DEWATERING SYSTEMS

The Contractor may adopt one or both of the following dewatering systems considering the actual field conditions and requirements for proper executions of work.

(a) Dewatering by Sub-Surface Water Control System- the work is to be executed in accordance with prescribed Specification.

(b) Dewatering by Surface Water Control System- the work is to be executed in accordance with prescribed Specification.

402 CONTRACTOR'S RESPONSIBILITIES

(1) The Contractor shall be solely responsible, and include in his rate, for the following tasks:

(a) the design of the dewatering system including the collection of the requisite data, preparation of plans and drawings necessary for dewatering system(s).

(b) Providing all equipment and accessories required for dewatering by the Surface Water Control System and Sub-Surface Water Control System for satisfactory execution of the work.

(c) transportation, furnishing, installation, safe operation and maintaining of the system including operators, mechanics, supply of power, fuel, lubricants, spares, repairing etc. throughout and removal of the equipment at the end of the construction period under this Contractor.

(2) The Contractor shall provide continuous supervision of the system by persons competent to recognize adverse conditions as they develop and take immediate corrective measures. The supervisor engaged by the Contractor shall have thorough knowledge of the system, including the ability to suggest/make minor emergency repairs.

(3) The control of water throughout the time of this Contract shall be sole responsibility of the Contractor. The ground water table shall be maintained at minimum of 1.00 m below the lowest designed excavation level.

(4) The control methods adopted by the Contractor shall be subject to the approval of the Engineer, including equipment, plan, methods, installation, operation, monitoring, maintenance procedures and precautions against the failure of any part of the system. The precautions shall include sufficient standby pumping plant and essential spare parts. The standby pumping plant shall comprise of at least one pump having minimum capacity of 10% of the total withdrawal requirement.

403 SITE INFORMATION

Any sub-soil investigation conducted by the BWDB will be made available for the Contractor's review. The BWDB assumes no responsibility regarding the correctness of these data. It is the responsibility of the Tenderer to verify all surface and sub-surface conditions prior to submitting a Tender.

404 DEWATERING BY SUB-SURFACE WATER CONTROL SYSTEM

GENERAL

(1) Dewatering by Sub-Surface Water Control System is defined as controlling water accumulated from any source requiring the use of well point or tube well system.

(2) Works to be performed under this clause include furnishing, installing, maintaining, operation and removing the sub-surface water control system, including observation wells, so that the required excavation can be safely and properly performed and the structure built and backfilled to the elevation as shown on the Drawings.

PRECAUTIONARY MEASURES

(1) Excavation shall not be made below a level of 1.00 m above the ground water level as per the observation wells. If the excavation level is less than 1.00 m from ground water table and the ground water is likely to endanger either the open excavation or structure, backfill may be ordered by the Engineer as a precaution against failure at the cost of the contractor.

(2) If for any reason, ground water control is lost and ground water appears in any portion of the excavation, the Contractor shall take immediate action to control and confine the flow. Any portion of the final grade which, in the opinion of the Engineer, has been damaged by the action of the ground of the ground water, shall be excavated as directed by the Engineer and backfilled in accordance with the specifications at no extra cost to the Contract.

(3) If it becomes necessary for any reason to stop the sub-surface de-watering operations before the construction of sub-structure is complete, the Engineer may order the site to be flooded up to the surrounding ground water level as de-watering is discontinued. Under no circumstances shall the site be flooded by allowing the ground water to rise through the soil. If it becomes necessary to flood the site as described above, all equipment that can be damaged shall be removed to safety.

(4) The cost of all such backfilling, flooding and subsequent draining and re-excavation shall be included in the lump sum price for dewatering and no extra payment will be allowed.

OPERATION

The sub-surface dewatering system shall be operated uninterruptedly 24 hours per day, seven days per week during the period that dewatering is required. The Contractor shall take advance precautions against failure of any part of the system.

MONITORING WELLS

Observation wells of 40 mm diameter GI pipes with 1.8 m strainer and full filters shall be installed by the Contractor to suitable monitor the ground water levels maintained by the Contractor's dewatering system. The depth of wells shall be a minimum of 3.0 m below the lowest level of the foundation excavation. The Contractor shall provide a means for locking the access to the observation wells, and shall maintain a log book with daily reading of sub-soil water levels recorded every three hours, available at all times for inspection. The log book shall be periodically checked and authentication by Engineer's Representative.

REMOVAL OF SYSTEM

The dewatering system shall be removed when the construction has progressed to **a** stage that site dewatering is no longer required, but only after receiving the written permission of the Engineer. Certain portions of the Contractor's dewatering system may be left in the ground when construction procedures so require and when written permission of the Engineer is obtained. Any such portion of the dewatering system shall be plugged, capped and/or otherwise rendered harmless to the work and the public.

405 DEWATERING BY SURFACE WATER CONTROL SYSTEM

GENERAL

(1) Evacuation of surface water is defined as controlling surface water levels within the ring dyke by use of pump, sump pump, gravel drain or other mechanical devices, but without requiring the use of a well point or tube well system. Such water may accumulate from percolation, rain or pumping flood water into the ring dyke, or any other source or combination of sources. The water levels inside the ring dyke shall not exceed the levels as directed by the Engineer.

(2) Work to be performed under this clause include furnishing, installing, maintaining, operating and removal of the surface water control system for dewatering the accumulated water from the area within the ring dyke so that the desired construction can be safely and properly performed. The discharge line/drainage system for the disposal of the evacuated water shall be constructed by the Contractor at his own cost as per approved drawing including the arrangement of the land and permission when necessary.

OPERATION OF DEWATERING SYSTEM

The Contractor shall make all arrangement for pumps, fuel, lubricants, maintenance and operation of the equipment and the whole Surface Dewatering System and shall take precautions in advance, against failure of any part of the system.

REMOVAL OF SYSTEM

The Surface Dewatering System shall be removed, upon written permission of the Engineer, when the Construction has progressed to a stage that site dewatering is no longer required.

Chapter 5

500 PROTECTIVE WORKS

501 MATERIALS

Earthworks

Earthwork shall be undertaken in accordance with the requirements of Section 300 and to the lines and levels shown on the Drawings unless directed otherwise by the Engineer.

In carrying out earthworks, the Contractor shall take all necessary precautions to avoid damage to or deterioration of the earthwork materials and the existing embankment.

Concrete

Concrete shall be as specified in Section 800.

Miscellaneous Materials

The miscellaneous materials for revetments shall be as specified in Section 1800.

502 BOULDERS OR HARD ROCK

(1) Before Tender, contractor shall ensure the location of quarry for collection of Boulders or Hard Rock according to specifications.

(2) The Boulders or Hard Rock shall comply with the grading requirements as specified for concerned work. Boulders or Hard Rock shall conform to the sizes/weights and grading shown on the Drawings. The material shall not be polluted, and shall be free from objectionable quantities of dirt, sand, dust and elongated or flaky stones. The dimension of single Boulders or rock shall not differ notably in size. The ratio between the smallest and largest dimension of single stone shall generally be not less than 0.4.

(3) The boulders or rock shall be free from cracks and veins which could lead to breakage during loading, unloading and dumping. The bulk specific gravity of the boulder shall have a minimum value of 2600 kg/m3 as per BS 812; part 2, chapter 6.

(4) The weighted average loss of materials in the sodium sulphate soundness test shall not be more than 10% by weight in accordance with ASTM C88.

(5) The percentage of wear as determined by the Los Angeles Test shall not be more than 40 as per ASTM C535.

(6) The aggregate impact value on average shall not exceed the 3% limit included in BS 812; Part 3, Chapter 6.

(7) Water absorption of stone/boulder shall not exceed 6% (BS 812).

(8) Minimum compressive strength is 100 N/mm2 (ASTM C 170-50).

GRADING TESTS AT POINT OF DELIVERY

(9) Testing at the agreed point of delivery (stockpile yard) shall take place at the contractor's or supplier's expenses.

(10) The gradation of materials stock piled at the yard shall be tested at least one time for each 500 ton of delivery.

(11) Samples for determination of weight gradation shall contain at least 100 individual stones/ rocks. The samples shall be taken by random selection from each specified gradation to obtain representative samples, and shall confirm to the grading as specified.

(12) Only stone/rock with a factor not exceeding 2.5 between the longest and shortest dimension of the rock shall be allowed in the delivery.

(13) In case of non-compliance with the specified gradation range more tests may need to be performed.

(14) In case the additional tests show non-compliance the whole or part of the rock delivery may be rejected.

503 CC BLOCK

(1) Before Tender, contractor shall identify and ensure the location of casting of CC Block. Contractor has to arrange the land from his own cost for casting of CC Block.

(2) Precast concrete blocks shall be made to the dimensions shown on the Drawings and to the specified tolerances. The blocks shall comply with the percentages of the different block as shown on the Drawings. The Contractor shall prepare a size wise schedule of all blocks required for the Engineer's approval before execution of the work.

(3) Except otherwise shown on the Drawings, cc blocks (precast concrete blocks) shall be made from concrete of specified strength in accordance with Section 800 and cast in moulds formed from steel sheet. The moulds shall be sufficiently tight fitting to prevent grout losses and sufficiently rigid to withstand the effects of placing and vibratory the concrete without distorting and capable of releasing the hardened concrete blocks without causing damages to the blocks.

(4) Pre-cast concrete blocks shall be made as per dimensions shown on the drawings.

(5) The materials and workmanship shall comply with the standard specification in all respects.

(6) Pre-cast concrete blocks (cc blocks) shall be made from concrete with the compressive strength as shown in the drawing, such as 9 N/mm2, 10.5 N/mm2, 15 N/mm2, 16 N/mm2 etc.

(7) Blocks for use in launching aprons shall be stockpiled in different sizes and in the percentages shown on the Drawings to the satisfaction of the Engineer. Prior to the commencement of placing the blocks, the Contractor's proposal to ensure

that the different block sizes are well distributed shall have been approved by the Engineer. If required, the effectiveness of the Contractor's proposal shall be demonstrated to the Engineer.

(8) Each block shall be marked with a serial number and the date of casting. Marking shall be engraved on the block whilst the concrete is still "green". Marking by paint is not acceptable.

(9) A register (officially issued by the Engineer) shall be maintained containing the number, date of casting, date and location of placing of each block and shall make the register available at all times for inspection by the Engineer. Similar register (officially issued by the Engineer) shall also be maintained for dumping.

(10) Blocks shall not be stockpiled until they have been cured in accordance with Section 800 thereof. They shall not be placed in the Works until at least twenty one days after casting have elapsed or the specified strength has been attained.

(11) Blocks which are damaged during transport, stockpiling or handling shall be rejected and removed from the site.

QUALITY CONTROL OF CC BLOCK

(12) During casting of CC blocks, specification related to concreting, described in Section 800 shall be followed.

(13) During the production of CC blocks quality tests shall be performed in accordance with the DIN 1045 or BS.

(14) Compressive Strength of CC Block shall be determined by taking cylinder for each 100cum of concrete poured. 6 (six) specimen shall be prepared in each set. Compressive Strength may also be tested by taking cube, if required, with permission from Engineer.

(15) Size of cylinder shall be of 150mm in diameter and 300mm in height. Size of cubes shall be 20x20x20cm.

(16) In case more than one batching plant is used, then one set of six test specimens is to be produced for each plant on every working day.

(17) Three samples of each set shall be tested after 7 days and other three sets shall be tested after 28 days of its production.

(18) The compressive strength shall at least correspond to the minimum values stipulated in design.

(19) Compressive strength may also be determined by cutting core from CC Block at any time. According to ACI 318 and BNBC, the concrete represented by the cores is considered structurally adequate if the average strength of three cores is at least 85 % of the specified strength and no single core strength is less than 75 % of the specified strength.

PRODUCTION OF CC BLOCK

(20) Formwork and moulds shall ensure the designed shapes and sizes of block. Formwork must be of steel.

(21) Formwork and moulds must be water tight during placing of concrete.

(22) The Formwork shall be sufficiently tight fitting to prevent grout losses and sufficiently rigid to withstand the effects of pouring and vibrating during placing the concrete without distorting and capable of releasing the hardened concrete blocks without causing damages to the blocks.

(23) The ingredients of concrete such as cement, fine aggregates, coarse aggregates and water shall be measured correctly for each batch of mixing. In case of volumetric batching the bulking of aggregates must be accounted.

(24) Hand mixing of concrete is prohibited. Batching plants shall be used for mixing concrete.

(25) Mixing of concrete shall be done thoroughly to ensure that concrete of uniform color and consistency is obtained.

(26) Concrete shall be transported from the place of mixing to the place of final deposition as quickly as possible. The methods adopted should ensure that concrete is placed in position within Initial Setting Time of cement i,e 45 minutes.

(27) Re-handling shall not occur at any time.

(28) Un-used concrete of one day shall not be used on the next day.

(29) Platform as per specification shall be constructed for casting of CC block.

(30) Concrete shall be placed directly in its final position avoiding segregation.

(31) Concrete should be placed gently at its position and not thrown from a height.

(32) Before placing concrete the formwork and moulds shall be cleaned and well wetted.

(33) Compaction of concrete shall be properly done to secure maximum density and strength.

(34) Compaction of concrete shall be done immediately after placing of concrete.

WATER IN THE PRODUCTION OF CC BLOCK

(35) Water used in concreting shall be fit for drinking purpose.

(36) The water used for concrete mixing, curing, or other designated applications shall be fresh water, clean and free from oil, salt acid, alkali, sugar, vegetable or any other substance injurious to the finished product.

(37) The water shall meet the requirements of the Standards, in particular DIN 4030 or BS 3148.

(38) The water to cement ratio shall be within 0.45 to 0.55 by weight. This ration shall strictly be maintained.

CURING OF CC BLOCK

(39) Concrete shall be protected from the effects of sunshine, dry wind, running water or mechanical damage for a continuous period, until the concrete has reached at least three quarters of its 28 day strength, but not less than 10 days.

(40) Curing shall begin as soon as the concrete is sufficiently hard and shall be continued for 21 days.

(41) Curing methods may be by spraying water to the concrete, or by covering the concrete surface with a layer of gunny bags, canvas, hessian, straw or similar absorbent materials which is to be kept constantly wet.

(42) In short, concrete surface shall be always wet, without any break, for 21 days.

504 GEOBAG

(1) Geobag shall be made of Geotextile. Geotextile shall be manufactured from 100 % polypropylene or as per drawing and fiber shall be needle punched.

(2) Brand name and grade shall be clearly and uniformly marked on the upper face of all geotextiles and Geobag. The marking shall take the form of an indelible repeat roll imprint at the edge of each geotextile roll recurring at least every 1.5 m.

(3) Filler material of Geobag is sand, 95% retain on #200 sieve or as per drawing.

(4) Geobag must withstand loads resulting from filling, handling, transporting, dumping and hydrodynamic forces.

(5) It is very important that the sand does not leak out over time.

(6) Each batch of geobag delivered at site shall be packed in standard numbers and marked with labels that identify the (i) brand and grade, (ii) production lot number and date of production of geotextile, (iii) number of bags, (iv) size of bags, and (v) name and signature of the quality control person certifying the compliance of all bags per bale

(7) Each bag shall be double stitched along all edges except for the opening at the top of each bag which shall be closed after filling. The minimum tensile strength of the seam shall be not less than 90% of the tensile strength of the geotextile.

(8) After filling, the opening of geobag shall be closed by double stitched with corner stitch.

(9) The number of stitch per inch should not be less than 5. The stitch shall be double thread chain type.

(10) The two lines of stitches shall be within 5 mm distance with a margin of 2 cm from the edge of the geotextile to the centerlines between the two seams.

(11) The thread used for the seam should be of same material as the geotextile (e.g. polypropylene or polyester).

(12) At the bottom end of each seam (at the folded site) the stitch shall be locked either by stitching one time back and forth for a length of minimum 2.5 cm from the end of the bag, or by joining the ends of the two threads e.g. by gluing, welding, knotting or other appropriate methods.

(13) The bags shall be stored under cover, well sheltered from direct sunlight and to prevent the ingress of dust or mud. They shall be protected from damage by insects or rodents.

(14) Average Area Coverage of Geobag after sand filling :

Weight of Geobag	Approximate Area covered by geobag after sand filling (sqm)
80 kg	0.32 sqm
125 kg	0.50 sqm
175kg	0.70 sqm
250kg	1.00 sqm

505 GEOTEXTILES

PROPERTIES OF GEOTEXTILE

Properties	**Test Standard**	**Test values**
Opening size O_{90}	EN ISO 12956	$\geq$0.06 and $\leq$0.08 mm
Mass per unit area	BS EN 965	$\geq$ 400 g/m^2
CBR Puncture Resistance	EN ISO 12236	$\geq$ 4000 N
Tensile Strength (machine direction-MD or cross machine direction-CMD)	EN ISO 10319	$\geq$ 20.0 KN/m
Elongation at maximum force-MD	EN ISO 10319	$\geq$ 60% and $\leq$ 100%
Elongation at maximum force-CMD	EN ISO 10319	$\geq$ 40% and $\leq$ 100%

Properties	Test Standard	Test values
Permeability (velocity index for a head loss of 50 mm – V_{H50}	EN ISO 11058	$\geq 2*10^{-3}$ m/s
Minimum thickness	EN ISO 9863	$\geq$ 3.00 mm
Abrasion	Following RPG of BAW, Germany, O_{90} according EN ISO 12956 and thickness according BS EN 9641	After test: tensile strength $\geq$ 75% of specified tensile strength, thickness $\geq$ 75% of original value, $O_{90} \leq 0.09^{*2}$
UV Resistance	ASTM D4355	$\geq$ 70% of original tensile strength before exposure

TRANSPORT, STORAGE AND HANDLING OF GEOTEXTILE

(1) All geotextiles shall be transported, handled and stored in full accordance with the manufacturer's instructions. They shall be wrapped in black polyethylene sheeting to prevent UV exposure until immediately before use in the Works. If the wrapping is damaged during handling it shall be repaired immediately by the Contractor using additional black polyethylene sheeting. Unused portions shall be re-wrapped promptly.

(2) Geotextile fabrics arriving on site in containers shall be unpacked and stored under covers, well sheltered from rain and direct sunlight, until required for use in the Works. Sufficient ventilation under the shelter shall be provided so as to minimize the effects of high temperature thermo-oxidation.

(3) Torn or punctured geotextile fabric shall not be permitted in the permanent Works.

(4) Geotextiles are to be covered with suitable materials within one week of being laid. When laying the covering material, it shall not be dropped in the dry from a height greater than 2m.

(5) Stock piles of materials are not to be set on top of laid Geotextile unless the geotextile has been designed for such loads.

(6) No construction equipment is to work on the geotextile without at least 300 mm of suitable material overlying the geotextile.

TESTING OF GEOTEXTILES

(7) Properties of Geotextile as shown in above table shall be carried out by an approved testing laboratory on samples taken from each quantity of 10,000 m² of geotextile fabric supplied.

(8) The sample size for the fabric shall be 2 sqm and shall be marked to indicate its upper side, longitudinal and transverse directions, type of geotextile and the date that the sample was taken.

(9) Seam samples shall be at least one meter in length and the ends of the threads are to be firmly tied off by the Contractor or supplier at the time the samples are taken. Each test shall be carried out on at least five samples.

(10) The Contractor shall bear the expenses of all routine tests. Notwithstanding the submission of reports to the effect that the geotextile conforms to the Specification, the Engineer shall at all times be entitled to have additional samples of geotextile tested if he is of the opinion that the geotextile does not conform to the Specification. The Engineer shall only select samples from ends of geotextile rolls or geotextile which has been cur already.

506 WIRE MESH MATTRESSES OR WIRE NETTING MATTRESS

(1) Crates or Wire mesh mattresses are box like chambers made of hexagonal wire netting. Wire mesh are made of galvanized or PVC-coated steel wire of 12 SWG wire or as provided in the approved design drawing. The mesh is normally100mm hexagonal size or as shown on the Drawings. Normally, they are filled with stones or bricks or brickbats.

(2) Wire mesh mattresses are to be pre-assembled and, if installed above the water level, placed on the designated slopes or the floodplain. They have to be stretched out on the surface and any unnecessary creases must be stamped out.

(3) The diaphragms must be perpendicular to the direction in which the filling will move, either down to the slope or in the direction of the flow. Prior to filling, the individual cages must be connected to each other along with all the corners using the proper lacing wire.

(4) When the mattress is placed on a geotextile filter, care must be taken to ensure that projecting ends of the wire are bent upward to avoid puncturing or tearing the filter cloth.

(5) In case the mattresses have to form a curve, individual mattresses can be divided diagonally to form two triangular sections. The open side of one section is to be butt-jointed to the intact side of the next section.

(6) Partial or full grouting with asphalt mastic can increase the stability and durability of gabion mattresses.

(7) Where mattresses are to be installed below the water level, individual mattresses are to be preassembled and joined to units, which are to be filled densely with the specified material. After closing the lid covers tightly, the complete unit is to be lifted by special appropriate means and to be laid on the prepared slope or bed. Proper and tight placing of the units must be ensured, one closely to the other. This work requires employment of heavy crane equipment.

(8) The mattress shall be secured by anchors made from the specified materials, driver to the depth and set at the centers shown on the Drawings or as directed by the Engineer.

(9) The location of the anchors shall be marked on the prepared underlying surface with dry powdered lime or similar approved marking substance in accordance with the Drawings or as directed by the Engineer. On inspection and approval of the

locations by the Engineer, the anchors shall be driven to the specified depth before placing the wire netting and brick/boulders.

(10) The wire netting mattress base sheet shall be spread and fixed in position to the previously driven anchors. Successive wire netting sheets shall be lapped 150 mm. The wire netting shall be tied top and bottom by 2 ply 12 SWG galvanized wire at 600 mm intervals in both directions and firmly tied to the anchors unless shown otherwise on the Drawings.

(11) The filler material must have a nominal diameter of about 1.5 times the mean mesh dimension and individual units should be greater than the nominal mesh size. Accordingly, the minimum stone size acceptable for such mattress fill should not be less than D = 10 cm, i.e., just larger than the wire mesh dimensions (100mm). Boulder of specified size shall be place to fill the mattress so as to have a minimum percentage of voids.

(12) Brick fill of mattresses shall be carried out using only full-size and half-size bricks. Any fill material shall be properly and densely dumped in the mattress cages in order to fill the units to maximum extent with the minimum of voids. Particular attention is to be paid to neat filling at the mattress corners.

(13) The stones shall be good sound material without cracks/fissures to avoid breaking during handling and placing or dumping. Materials standards and tests shall confirm as said set in the standard test procedures. Only stone/rock with a factor not exceeding 2.5 between the longest and shortest dimension of the rock shall be used.

BRICK MATTRESSING

(1) The dimensions of brick shall be 240×120×70 mm, with ± 5 mm tolerance for any of the dimensions. Minimum crushing strength shall be 15 N/mm^2. The increase in weight shall be less than 16% after wetting in water for one hour.

(2) Bricks to be used for mattresses filling in cover layers shall be first class bricks, sound, hard, well burned, uniform in size and color, homogeneous in texture, well-shaped with sharp edges, with even surfaces and without cracks, spongy areas, rain spots or flaw of any kind.

(3) The hexagonal wire netting shall be manufactured form 12 SWG galvanized wire with a maximum mesh size of 100mm. The width of the wire netting roll shall be 1800mm (6ft) or as directed by the Engineer.

(4) Brick Mattresses may be constructed by one layer or two layer of bricks. Bricks shall be placed on the wire netting base as shown on the Drawings

(5) In case of two layers, the first layer shall be laid up the slope and the second layer shall be laid across the slope; both layers shall be laid in a staggered formation. On completion of the two brick layers, a second layer of wire netting with 150 mm laps shall be laid on top.

WIREMESH CAGES

(1) Wire mesh mattresses are large and thin box-type construction elements made of zinc plus PVC-coated hexagonal double twisted wire mesh (wire diameter 2 mm/3 mm including coating layers). The mesh is stretched on steel bars with a diameter of at least 12 mm, which forms the edges of the mattress cages.

(2) Mattress dimensions are 4×2 m, with partitions at every 1 m; The nominal mesh size varies from 44×60 mm to 100×120 mm and recommended mesh size is 60×80 mm
or as shown on the Drawings.

(3) The mattress thickness depends on the type of fill material such as

- d = 20 cm (stone fill)
- d = 35 cm (full-sized brick-fill)
- d = 30 cm (stone fill, at exposed situations)
- or as shown on the Drawings

(4) The wire mesh must comply with the following factory specifications:

- the wire used for the manufacture of mattress and the lacing wire shall have a tensile strength of 38-50 kg/mm^2 according to BS 1052/80 "Mild Steel Wire";
- Zinc coating at 240 g/m^2 meet the requirements of BS 443/32 and DIN 1548, and
- PVC-coating conforms to ASTM and has a thickness of 0.5 mm.

507 BRICK MASONRY BLOCKS

(1) Bricks shall be as specified in Section 700. Water for mixing mortar shall conform to the requirements as specified under concrete Section 800. Sand for cement mortar shall be non-saline, hard, dense and free form deleterious materials. Sand shall be screened through a No. 16 sieve and have a minimum fineness modules of 1.5.

(2) Masonry blocks shall be cast in a casting yard using a 1 part cement to 4 parts of sand unless shown otherwise on the Drawings and delivered to the site after proper curing and placed to proper line and grade as shown on the drawings. All blocks shall be cured for not less than fourteen days by a method approved by the Engineer.

508 FILTER MATERIALS

In protective work, inverted filter materials shall be used as filter or otherwise specified on the Drawings. Sequence of Filter is as below :

1. Finer filter shall be at the bottom. Thickness of filter shall be 100mm or specified in the drawing.

2. A geotextile filter complying with Clauses 505 shall be placed over fine filter. Thickness of geotextile filter shall be 3mm or specified in the drawing.

3. Course filter shall be placed over geotextile filter; Thickness of Course filter shall be 150mm or specified in the drawing..

FINE FILTER MATERIAL

(1) Sand shall be used as fine filter as specified in Section 800 or otherwise specified in the Drawings.

COARSE FILTER MATERIAL

(2) Coarse Aggregate shall be used as Coarse filter material as specified in Section 800. Coarse Aggregate shall be made from either :

(a) first Class or picked jhama bricks as specified in Section 700; or

(b) Gravel (single) or broken stone of hard durable rock. The stone delivered to the Works shall be rejected if not perfectly clean and if it contains soft, clayey, shale or decomposed stone. The stone may be broken in a stone crusher of approved type or manually. Any dust or fine material below 5 mm in size made in the stone crusher is to be removed by screening and the stone shall be thoroughly washed by an approved method.

(3) Filter materials shall be laid in two layers of equal thickness or as shown in the drawing. The filter material in the bottom layer shall be well graded between 5 to 20 mm and the filter material of the top layer shall be well graded between 20 to 50 mm or in accordance with the grading shown on the Drawings.

509 FOUNDATION PREPARATION

The foundation for the filter materials shall be thoroughly compacted and graded to the elevations shown on the Drawings prior to the placement. The filter material shall be placed in a uniform layer of the thickness shown on the drawing or directed by the Engineer.

510 BRICK CHANNEL PROTECTION

(1) All bricks furnished for pitching shall be first class bricks as specified in Section 700.

(2) The bricks shall be placed to the lines and grades, and laid as, shown on the Drawings or directed by directed by the Engineer. All brick pitching shall be underlain by filter material as specified on the Drawings.

511 CONCRETE CHANNEL PROTECTION

(1) Concrete channel protection shall consist of paving the channels slope with either cement concrete or reinforced cement concrete as specified in the Drawing.

(2) Prior to the construction of the concrete channel protection, the channel bank shall prepare in accordance with section 300 to the satisfaction of the Engineer.

(3) Class M16 or M10 concrete as shown in the drawing shall be used for channel protection. Concrete work shall be undertaken in accordance with Section 800.

(4) Any expansion joints and weep holes shall be constructed as specified on the drawings to the satisfaction of Engineer.

512 CONSTRUCTION OF BANK REVETMENT WORK

PRECAUTION

(1) Construction material or Protection material shall not heaped on the edge of bank slope. Stack or heap of Construction material or Protection material carets a surcharge load on the slope. It shall be heaped or stacked at a safe distance from the edge of bank slope.

(2) Dredged material (e,g for collection of sand) shall not heap on the edge of bank slope. It creates surcharge load on the slope and water within the Dredged material causes seepage problem on slope.

(3) Casting and curing of CC Block shall be done at a safe distance from the edge of bank slope. Because water used for washing of Construction material and curing causes seepage problem on slope when it infiltrates into ground. Precaution shall be taken for proper drainage waste water.

(4) The spoil earth which comes out during slope preparation (for pitching material) shall not heap at the toe of pitching material. Toe of pitching material shall not be built with this spoil earth. This spoil material shall be removed from the site.

CONSTRUCTION SEQUENCE

(5) The revetment works shall commence form the most upstream part of the eroded bank.

(6) The alignment of the starting point of the revetment slope may be adjusted, subject to the approval of the Engineer, to minimize the amount of fill without compromising the stability of the existing bank slope.

(7) The river bed (may be the Falling Apron) at each section of the revetment shall first be built up to design level, and then the sloping revetment constructed from the toe to upwards.

(8) Dumping shall start from extreme end on R/S and shall proceed towards the bank.

(9) Dumping shall be completed within 30th April or as shown in the drawing.

(10) A berm shall be constructed at or near LWL or as shown in the drawing. Pitching work above LWL shall be made supported from this Berm.

(11) Pitching work above LWL shall be done after completion of work on Berm.

(12) KM post shall be constructed at each kilometer.

(13) Permanent Concrete post shall be constructed at “Zero (0)” point of each section mentioned in the design. Survey for monitoring, repair or rehabilitation shall be done from the same “Zero (0)” point.

(14) Necessary Stair shall be constructed according to Drawing. Location of stair, if not mentioned in the Drawing, shall be identified as per field requirement.

PREPARATION OF TOE OF REVETMENT

(15) The toe shall be built up by excavation on original earth to the lines and levels shown on the drawing.

(16) Excavation shall be undertaken in accordance with Section 300.

(17) Regular bathometric survey shall be done to ensure that either the excavation is being undertaken to the design line or levels or gunny bags are being closely packed to the correct lines and levels.

REVETMENT MATERIAL

(18) The revetment material shall either be boulders, hard rock, cc blocks, sand filled geobag, brick mattressing or boulder mattressing, brick blocks etc.

UNDERWATER DUMPING

(19) Below LWL, material shall be dumped by controlled dumping in a planned manner with GPS as shown in the Drawings.

(20) Revetment material shall be dumped to construct the Falling Apron, in the proportions as shown on the Drawings form conveniently located stockpiles of individual size.

(21) Placing of underwater apron materials demand a considerably higher skill, proper equipment and standard of control.

(22) Sufficient or necessary number of pontoons or flat-top barges shall be arranged at site for completion of works as per schedule. The pontoons or flat-top barges shall have a guided fence at the bottom, so that it ensures positioning of dumping material at proper location.

(23) Total material required to be dumped in a particular stretch shall be stacked on flood plain/bank before start of dumping in the reach.

(24) CC blocks/hard rock/boulders/sand filled geobag i,e apron material from stack-yard will be transported to the dumping barges/pontoons by engine boats or self-propelled barges.

(25) No dumping shall be allowed without properly positioned and anchored dumping pontoon/flat-top barge.

(26) Any strip of underwater protection from the river-side edge of the falling apron to the edge of shallow water (Average Low Water Level) must be completed in a day's work.

(27) The quantity of material to be dumped per unit length of bank shall be stacked along the dumping edge of the pontoon/barge and dumped at proper position through total station placed on the bank.

(28) Dumping aid shall not have any sharp corners or edges or any other features that could damage the Geobags or reduce the properties of the Geobags making them unsuitable as protective launching element.

(29) Immediately after mobilization of equipment, preparation for anchoring of pontoons should start. Anchor points on flood plain should be free from flooding and risk against wave erosion. Sufficiently strong anchors, piles, bollards or winches shall be used and safely installed.

(30) Anchor points in the river may consist of anchor pontoons equipped with winches temporarily positioned at site to hold and move the dumping pontoons during dumping of bags. Alternatively, dumping pontoons can be directly anchored into the

riverbed. Standard anchors can be used, such as stockless anchors having a holding power of about 3 to 5 times the own weight. In selecting type of anchors, flow velocity, bed material etc. shall be taken into consideration.

(31) No construction work on under-water apron shall start if the flow velocity is 1.5 m/sec or higher. This can be relaxed only when emergency protection or repair of protection work is needed.

(32) Survey boat equipped with sonar scanner, multi beam Eco-sounder and divers for direct underwater inspection shall be used throughout the construction period.

ABOVE LWL RIVER BANK SLOPE

(33) The eroded embankment/river bank above water level shall be cleared and stripped then trimmed back to stable sections.

(34) Placing of pitching block on filled earth, preferably be avoided. It is preferable to place the pitching block on original soil for sustainability of Protection work.

(35) Where necessary, the bank slopes below low water level, shall be built up by placing or dumping earth filled gunny bags in layers, working form the bank into the rivers. The river bank slopes above water shall be built-up with compacted earth and earth fill gunny bags /synthetic bag/geobag if required. In that case, earth shall be compacted in 150 mm thick layers.

(36) After completion of the toe preparation, where necessary, filling above water level shall commence form the bottom of the slope, being brought up in compacted 150 mm thick layers. A three gunny bag wide dam shall from the outer extremity of each layer, with the fill compacted up to it.

(37) Care shall be taken to form the gunny bag extremity into a neat and dense slope to the line and levels shown on the Drawings.

(38) The inverted filter layers and revetment material placement shall start from the toe and progress up the slope of the bank.

(39) The fine filter layers shall be placed and lightly tamped into place, followed by Geotextile and the coarse filter layer which shall be sufficiently compacted to support the overlaying material.

(40) The inverted filter shall not advance more than 1 m up the slope before being covered by the specified overlaying material to assist placement and prevent damage to the filter layer.

(41) Above LWL the overlaying material shall be laid on the filter in rows parallel to the direction of the current. The blocks in each row shall be staggered half a block width form those in the row below. Adjacent blocks shall be laid as close as possible with a maximum allowable gap as given below :

Block Size	Maximum Allowable Gap (mm)
600 mm and less	10
Larger than 600 mm	15

The bricks and blocks shall be laid in manner so as not to damage or displace the underlying filter. Any damage caused to the filter during placing of the blocks shall be repaired by the Contractor at his own cost and to the satisfaction of the Engineer.

(42) The outer face of the revetment above LWL shall have a smooth and even appearance.

(43) During the placement of the bricks or revetment material, the underlying filter shall not be disturbed by removing or denting a portion thereof by any manner harmful to the filter. Any damage to the filter during overlaying shall be repaired by the Contractor at his own cost.

KHAL ARMOURING

(44) Khals mouth must be armored by C.C block at least 30m (or as per design) towards country side. Bed of the outfall khlas must be excavated to dump launching material into the excavated zone so that the khals mouth must not be closed by protection work and navigation work are not hampered.

MONITORING

(45) As built drawing containing cross sections at 50 m interval shall be prepared immediately after completion of dumping.

(46) The river behaviour with respect to scour, erosion and performance of revetment work during and after completion shall be monitored carefully on regular basis to take timely mitigation and strengthening measures by adaptive approach. If any detrimental morphological changes is observed, then all concern office including BWDB design office must be informed with adequate data so that necessary action can be taken.

(47) Regular monitoring of protective work must be done through bathymetric survey of an area specified in design.

(48) From June to October bathymetric survey should be done on 15 days interval & shall be kept as record.

(49) Dredging adjacent or in front of protective work shall be strictly prohibitive.

EQUIPMENT NEEDED FOR RIVER BANK PROTECTION WORK

- Flat top barges with guided fence.
- Pontoons
- Tug boats (400 HP)
- Drum mooring winches with ropes and anchors
- Crane (40-ton capacity)
- Topographic and bathymetric survey teams with equipment
- Diver team
- Sewing machines (if geobag is used as apron material)
- Generators
- Laboratory for sand and concrete strength testing
- Motorized country boat

- Concrete mixers
- Excavator
- Compaction Equipment

513 REPAIRS TO BANK REVETMENTS

SELECTION OF RECONSTRUCTION LENGTHS

(1) Prior to the commencement of the Works, the Engineer shall confirm in writing the actual lengths of revetment that are to be reconstructed.

SEQUENCE OF CONSTRUCTION

(2) The Contractor shall clearly indicate on his construction programme his intended sequence of construction, taking full account of the need to protect the works during construction. Consideration should be given to progressing the works as follows:

(a) Removal and stockpiling of existing revetment materials;

(b) Investigating and making good adjacent revetment;

(c) Preparing, backfilling, compaction and trimming the earth embankment;

(e) Construction of launching apron;

(f) Construction of the slope revetment, commencing from the toe and working up the slope;

REMOVAL OF THE EXISTING REVETMENT MATERIAL

(3) The existing revetment material shall be removed from the agreed reconstruction lengths and the earth embankment cleared of all debris. The c.c. blocks and any boulders shall be stockpiled and sorted in locations approved by the Engineer.

CONSTRUCTION OF BANK REVETMENT

(4) The construction of the bank revetment shall be undertaken as described in Clause 512.

514 PORCUPINES

The bank protective works by porcupine shall in general be in accordance with the specification as approved in the drawings unless otherwise specified. It shall be used in case of emergency situations or for precautionary work.

(1) Porcupines shall be box like bamboo framing with leg extensions from all corners ballasted by filling the box with brick bats (not smaller than ½ brick) or boulders (not less than 150 mm).

(2) Borak bamboo of dia 75 mm to 100 mm having effective length of 1.8 m shall be fixed by 200 mm long nails and tied with strings.

(3) The size of the porcupine shall be 0.6m×0.6m×0.6m cube chamber or as specified in the drawing.

515 SAND-CEMENT GUNNY BAG /GEOBAG

(1) Shall be used in emergency situations or for precautionary work.

(2) Water Cement ration is 0.50.

(3) Minimum curing is 7 days.

(4) Dumping or placing shall be done after curing.

(5) Approximate thickness of one layer of Sand-Cement filled Gunny Bag :

Size	Approximate thickness
75kg	0.14m.
50kg	0.10m

516 GEOTUBE

(1) Geotube system is used for bund construction, reclamation dykes, stacked in tiers up to a height of about 7 m over soft estuarial deposits. Geotube also used for bank protection.

(2) Material of Geotube shall be Geotextile. Specification of Geotextile shall be as stated above. Geotubes are sand filled elements made from high strength woven geotextiles. The geotextiles used are specially designed for Geotube with the same strength in both directions.

(3) Geotube shall be filled hydraulically with sand. 95% sand shall retain on # 200 sieve or as per design. These tubes can be filled with local soils with good permeability, such as sand and silt. Thus, the construction cost that this technique entails can be much lower than that required by other dike construction methods.

(4) Height of Geotube is approximately 70% of diameter after sand fill or as per design. On the shore, height of Geotube is approximately 60 % of theoretical diameter and height of Geotube is approximately 70 % of theoretical diameter on ssubmerged situation.

(5) Normally length of Geotube is used as 30 m. But the length can be up to 100 meters.

TABLE FOR DIMENSIONS OF GEOTUBE

Diameter	Circumference	Height	Fill Volume	Width	
				max	base
m	m	m	cum/m	m	m
1.6	5.0	1.0	1.7	2.0	1.7
2.5	7.9	1.5	4.1	3.2	2.7
3.25	10.2	2.2	6.9	4.2	3.5
4.00	12.6	2.4	10.4	5.1	4.3
5.00	15.7	2.7	16.3	6.4	6.0

FILLING PROCEDURE OF GEOTUBE

(6) Shall be filled on position. The tube shall achieve its desired shape when filled up to about 80 % ; Higher filling grade diminish the friction resistance between the tubes.

(7) Can be filled on land (e.g. as dikes for land reclamation, bunds, toe protection or groyns).

(8) Can be filled in water (e.g. offshore breakwaters, sills of perched beaches, dikes for artificial islands or interruption of gullies caused by tidal currents.

GENERATION OF TENSION ON GEOTUBE

(9) Height of geotube must be controlled during soil filling, and specific pump pressure and tube size must be maintained. The relationships among tube size, pumping pressure, unit weight of the slurry, and tension stress in geosynthetic tubes shall be maintained.

(10) During filling care shall be taken at the location of generation of tension i,e circumference, axis and at filling port connections. Generation of tension depend on size of tube and degree of filling.

MACHINERY AND EQUIPMENT NEEDED

- Sand supply barge
- Work barge
  - – Crane
  - – Mixing tank
  - – Water pumps
  - – Excavators
- Booster pump

Chapter 6

600 ROADWORKS

601 CONSTRUCTION OF HBB ROAD

(1) The earthworks shall be undertaken in accordance with Section 300. The road shall either be laid on a compacted embankment or an embankment that has been allowed to consolidate for at least two seasons.

(2) The embankment top shall be cleared, scarified and depressions filled. The resulting surface shall be compacted and graded to the cross falls shown on the Drawings.

(3) The road paving shall be laid between the specified brick edging. The brick edging shall be constructed in accordance with the Drawings.

(4) Sand (FM>=0.8) shall be laid for construction of road sub-grade in layers of maximum 150 mm thick and compaction to attain minimum CBR-8% by using mallet/vibro compactor as approved by the Engineer.

(5) A single layer of flat brick soling of first class bricks shall be placed on the sub-base with the long edge of each brick in a transverse direction.

(6) The joints between edging, flat soling and HBB bricks shall be filled with sand and watered into place.

602 RECONSTRUCTION OF HBB ROAD

(10) The bricks from the existing crest road shall be removed and sorted, with bricks suitable for reuse and rejected bricks stockpiled separately.

(11) The road shall then be constructed in accordance with Clause 601.

603 BITUMINOUS MATERIALS

(1) The bitumen shall be homogeneous, free from water and shall not foam when heating to 180º C. It shall be packed in brand new non-leakable steel drums minimum 0.63 mm thick and securely sealed. Gross weight of each drum shall not exceed 180 kgs. The quality of bitumen shall meet the following requirement:

Penetration	=	within 80 to 100
Specific gravity	=	within 1.00 to 1.05 (at 25°C)
Softening point	=	within 40°C to 54°C
Loss on heating	=	not to exceed 0.75 %
Flash point	=	not less than 230°C
Solubility	=	not less than 99.5 %

PENETRATION TEST

Penetration Grading of Bitumen is based on the penetration test. The depth of penetration is measured in units of 0.1 mm and reported in penetration units (e.g., if the needle penetrates 8 mm, the asphalt penetration number is 80).

- Load = 100 grams
- Temperature = 25° C (77° F)
- Time = 5 seconds

All tests shall be carried out in accordance with the standard test procedures adopted by RHD.

(2) The bitumen shall not be stored for a period of more than three months to avoid (i) segregation and sedimentation and (ii) damage to the containers.

(3) The following rules should be followed when storing the drums of bitumen:

(a) The drums storage should be well drained, preferable above the ground level on large timbers or iron rails. The storage area should be large enough to ensure ease of handling and the drums should be carefully handled to avoid damage.

(b) The drum should be protected from direct sun light to avoid being overheated.

(c) Prior to use the bitumen emulsion in each drum should be thoroughly agitated and stirred.

604 BITUMINOUS SURFACING ON A NEW HBB ROAD

(1) This clause provides for the surfacing of a new HBB road. The work consists of the careful cleaning of the existing road surface, the application of a tack coat and construction of 30-50 mm thick premixed bituminous carpeting.

STONE CHIPS

(2) The stone chips shall be sampled in accordance with standard British or American test procedures and tested for grading, unit weight and abrasion.

(3) The chips shall be completely non-plastic and free from all organic and foreign materials. The broken faces shall not be less than 75% of stone surface. The stone chips shall be graded as under:

Two layers of stone chips shall be spreaded over the road surface in mode and manner as specified in the Schedule of Rates. The 1st layer of stone ships shall be of 40 mm to 25 mm size. 80% of stone in second layer shall comprise 25mm to 20 mm size and the balance 20% of 20mm to 10mm size unless otherwise specified.

BRICK CHIPS

(4) Two layers of 1st class or picked Jhama brick chips shall be spreaded on the road surface in mode and manner as specified in the schedule of Works. The brick chips shall be of 25mm downgraded.

(5) The unit weight of stone chips shall not be less than 1600 kg/cu.m. The maximum wear shall not exceed 30%.

CONSTRUCTION METHODS

(6) The road sub-base surface shall be prepared to receive tack coat by careful cleaning the surface from dust, dirt and loose materials. The weather-bound surface shall be cleaned to expose the pattern of coarse aggregate. Special care shall be taken to clean the edges of the road to be primed in order to ensure uniform application of the bituminous material directly on the existing base of pavement material.

(7) A tack coat of fluxed bitumen shall be constructed, at a temperature between 170**ºC** to 190**ºC,** shall be uniformly applied to the prepared surface @ 0.75 kg per sqm. (Item Code 56-300)

(8) A premixed bituminous seal coat of 0.015 m³ of pea-gravels mixed with 80 kg. of bitumen per m³ of pea-gravels shall be laid on 1.00 sqm of road surface properly cumbered and shall be blinded with dry sand (FM>= 0.8) @ 0.01 cum per sqm and rolled with 8 to 10 m-ton road rolled. (Item Code 56-310)

(9) A pre-mixed bituminous seal consisting of 0.015 cum of coarse sand (FM= 2.00 to 2.80) mixed with 96 kg of bitumen per cum of sand shall be laid over 1.00 sqm of road properly cambered surface and shall be blinded with dry sand @ 0.01 cum (FM $\geq$ 0.80) per sqm and rolled with a 8 to 10 m-ton road roller. (Item Code 56-320)

(10) A premixed bituminous seal coat of 0.012 m³ of pea-gravels and 0.006 m³ of coarse sand (FM = 2.0 to 2.8) mixed with @ 80 kg of bitumen per m³ of pea-gravels coarse and @ 96 kg of bitumen per m³ of coarse sand shall be laid over 1.00 sqm of properly cambered road surface and shall be blinded with dry sand @ 0.010 m³ (FM = > =0.8) per sqm, heating bitumen between 170**ºC** to 190**ºC** and rolled with 8 to 10 m-ton road roller. (Item Code 56-330)

(11) All other specification as regards premixing, heating, placing, rolling etc. shall conform with the specification of Works in the standard Schedule of Rates of BWDB and appropriate British or American specification as adopted by RHD of Bangladesh.

605 CONSTRUCTION OF BITUMINOUS SURFACED ROAD

(1) The earth foundation shall be prepared in accordance with Section 300 to the lines and grades shown on the Drawings.

(2) Box cutting up to 1.00 m depth shall be done as per drawing by removing the spoils to a safe distance, including levelling and dressing, maintaining required cambering. (Item Code 56-100)

(3) The road sub-grade with sand with a FM>= 0.5 in maximum 150mm thick layer shall be constructed including dressing, levelling, ramming, watering, cambering and compacting to attain minimum CBR-5% by vibro compactor and compacted to 95% of maximum dry density at optimum Moisture content. free from dust, earth and organic matter. The sand shall be thoroughly watered and compacted to the lines and grades shown on the Drawings. (Item Code 56-105)

(4) The improved road sub-grade of sand (FM>=0.8) in maximum 150mm thick layer shall be constructed including dressing, levelling, ramming, watering, cambering and compacting to attain minimum CBR-8% by vibro compactor and compacted to 95% of maximum dry density at optimum Moisture content. The sand shall be thoroughly watered and compacted to the lines and grades shown on the Drawings. (Item Code 56-110)

(5) The road sub-base shall be constructed with graded materials of crushed well burnt cum picked jhama or first class brick chips (50mm downgraded) mixed with sand (FM>=1.0) in proportion 2:1 (chips:sand), and spreading uniformly in maximum 150mm thick layers (Loose) to proper camber, grade and super elevation where necessary including dressing, levelling, ramming, watering and compacting to attain minimum CBR-25% by 8.0 to 10.0 m.ton power driven road roller (minimum 20 to 25 passes over every point and reduction of loose height by 30% to 35%). Aggregate Crushing Value (ACV) <38% shall be attain. (Item Code 56-150)

(6) Depending on the type of road **Base Type-1** or **Base Type-2** shall be used as per design. Water Bound Macadam are not used now.

The road **Base Type-1** shall be constructed with graded materials of crushed boulder/gravel aggregate (40mm downgraded) mixed with sand (FM>=1.0) in proportion 2:1 (stone chips : sand), and spreading uniformly in maximum 150mm thick layers (Loose) to proper camber, grade and super elevation where necessary including dressing, levelling, ramming, watering and compacting to attain minimum CBR-80% by 8.0 to 10.0 m.ton power driven road roller (minimum 20 to 25 passes over every point and reduction of loose height by 30% to 35%) and compacted to 98% of maximum dry density at optimum Moisture content. Aggregate Crushing Value (ACV) <30% and Los Angles Abrasion Value (LAA) <35% shall be attain. (Item Code 56-200)

Or

The road **Base Type-2** shall be constructed with graded materials of crushed well burnt cum picked jhama or first class brick chips (40mm downgraded) mixed with sand (FM>=1.0) in proportion 2:1 (stone chips : sand), and spreading uniformly in maximum 150mm thick layers (Loose) to proper camber, grade and super elevation where necessary including

dressing, levelling, ramming, watering and compacting to attain minimum CBR-50% by 8.0 to 10.0 m.ton power driven road roller (minimum 20 to 25 passes over every point and reduction of loose height by 30% to 35%) and compacted to 98% of maximum dry density at optimum Moisture content. Aggregate Crushing Value (ACV) <35% and Los Angles Abrasion Value (LAA) <40% shall be attain. (Item Code 56-210)

(7) Premixed bituminous carpeting of 30mm thick shall be constructed with specified well graded stone chips (20mm to 4.0 mm) @ 0.038 cum. of stone chips mixed with 80 kg. of bitumen (heated between 170 deg. centigrade & 190 deg. centigrade) per cum. of stone chips, while still hot the resulting mixture is to be spreaded uniformly over 1.0 sqm. prepared surface in proper camber, grade and super elevation and rolling hard to full compaction with 8 to 12 M. tons power driven road roller and spreading 0.012 cum sand (FM>=0.80) per sqm or as per design. (Item Code 56-260)

(8) Pre-mixed bituminous seal coat shall be constructed with 0.012 cum of pea gravels and 0.006 sqm cum. of course sand (FM=2.0 to 2.8) mixed with @ 80kg of bitumen per cum of pea gravels and @ 96kg of bitumen per cum of coarse sand and laid over 1.0 sqm. of road surface including spreading with proper camber and blinding with dry sand (FM>=0.80) @ 0.01 cum per sqm, heating bitumen 170**ºC** to 190**ºC** temperature, rolling with 8 to 10 M. tons power driven road roller or as per design. (Item Code 56-330)

(9) All other specification as regards premixing, heating, placing, rolling etc. shall conform with the specification of Works in the standard Schedule of Rates of BWDB and appropriate British or American specification as adopted by RHD of Bangladesh.

606 REPAIR AND SURFACING OF EXISTING HBB AND SURFACED ROADS

(1) The existing road surface shall be cleaned and pot holes repaired with pre-mixed bituminous material in accordance with clause 603 (7) up to a general level of the sub-base surface.

(2) The wearing surfacing shall be constructed in accordance with Clause 603.

Chapter 7

700 BRICKWORK

701 BRICKS

(1) Bricks for concrete coarse aggregate and khoa packing shall be broken first class bricks or so-called "picked Jhama" bricks. Picked Jhama bricks shall be over burnt first class bricks, uniformly textured, with good shape, slightly black in colour and without cracks and spongy areas. Otherwise picked Jhama bricks shall meet the same requirements as "first class" bricks.

CLASSIFICATION

1st Class Bricks They should be of uniform size and colour (typical red or buff) and thoroughly well burnt. They must emit clear metallic sound when struck with a hammer or another brick. They should be homogenous, well in texture, well shaped with sharp edges and even surfaces and free from flows, rainspot and cracks. A fractured surface shall show a uniform compact structure, free from holes, lumps or grills.

2nd Class Bricks Same as first class bricks but edges are not sharp.

Picked Jhama Bricks Slightly over burnt uniformly textured, without cracks and spongy areas.

(2) First class bricks and picked Jhama bricks shall comply with the following requirements :

DIMENSION

Individual bricks shall be 240 mm x 120 mm x 70 mm size. The variation in dimension shall not be more than 5 mm in length, 2.5 mm in breadth and 1.5 mm in height.

WATER ABSORPTION

On being immersed in water for 1 (one) hours, the absorption shall not exceed 15% of dry weight for 1st class bricks and 25% for 2nd class bricks.

EFFLORESCENCE

Bricks shall be free from harmful salts (Sodium and Potassium). If this type of bricks is used in construction, the salt present in the brick got dissolved while mixing with water and cause structural damage.

This defect can be identified by visual test. If lot of white patches are visible on the brick surface (known as efflorescence), then the bricks are containing more amount of sodium and potassium salt and these bricks shall be rejected.

The presence of alkalis in brick, form a gray or white layer on brick surface by absorbing moisture. Efflorescence test is performed to find out the presence of alkalis in brick. In this test a brick is immersed in fresh water for 24 hours and then it's taken out from water and allowed to dry in shade.

If the whitish layer is not visible on surface it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface then the presence of alkalis is in acceptable range. If that is about 50% of surface then it is moderate. If the alkalis's presence is over 50% then the brick is severely affected by alkalies

MINIMUM CRUSHING STRENGTH

The minimum crushing strength shall be as follows:

1st class or Jhama bricks	:	14.00 N/mm^2 and above.
2nd class bricks	:	11.00 N/mm^2 to 14.00 N/mm^2.

At least five brick specimens are tested one by one and average result shall be taken as brick's compressive/crushing strength.

UNIT WEIGHT

Unit Weight of bricks shall be as follows:

1st class bricks	:	Not less than 1100 kg/m^3
Picked Jhama bricks	:	Not less than 1200 kg/m^3

702 MATERIALS

Unless otherwise specified or directed all brickwork shall be with first class bricks (in accordance with Clause 701) set in cement mortar of required proportions. The sand use in this work shall be in accordance with Section 500 & 800 and shall have a minimum fineness modules of => 1.5. Water for mixing the mortar shall conform to the requirements of Section 800.

703 SOAKING OF BRICKS

Before use in work, wall bricks shall be soaked in clear water for a minimum period of 6 hours. Soaking shall be discontinued two hours before use so that at the time of laying they are skin dry. Such soaked bricks small be stacked on a clean place where they shall not be spoilt by dirt, earth or any other objectionable materials.

704 MORTARS

(1) Unless otherwise specified in the Drawings, cement mortar for brick masonry shall consist by volume in proportion as specified in the Schedule of Rates. In each mortar just enough water shall be added and the components mixed and thoroughly incorporated together to give workability appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

(2) Mortar shall be mixed in an approved method unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand-mixing is

permitted, the operation shall be carried out on a clean watertight platform, and cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour and then the mortar shall be mixed for at least two minutes after addition of water.

(3) Only a sufficient quantity of sand and cement shall be mixed with water as can be used within 30 minutes after the addition of water. The adding of additional water to, and re-tempering, cement mortar that stiffened because of evaporation of water, shall be permitted only within thirty minutes from the time of addition of water at the time of initial mixing.

(4) Mixing troughs and pans shall be washed clean at the end of each day's work.

705 BRICK MASONRY CONSTRUCTION

(1) The method and equipment used for transporting and placing the bricks and mortar shall be such that it will not damage the brick or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

(2) All brickwork shall be placed only after the foundation surfaces have been prepared satisfactorily in accordance with the specifications and the Engineer's instructions;

(3) The bricks shall not be placed during heavy or prolonged rain such that it washes the mortar from the bricks. Mortar already which becomes diluted by rain shall be removed and replaced before continuing the work at the expense of the Contractor;

(4) All bricks to be used in brickwork with mortar joints shall be completely soaked in water for a minimum period of 6 hours and taken out from water two hours before use. All bricks shall be free from water adhering to their surface when they are placed in the brickwork;

(5) Before laying bricks in foundation, a layer of not less than 10 mm of mortar shall be spread to make the surface on which the brick work will be laid even. Immediately thereafter, the first course of bricks shall be laid;

(6) Bricks shall be laid in English bond unless otherwise directed by the Engineer and shall be set with both bed and vertical joints filled with mortar and shall be bedded in by firmly tapping with the handle of the trowel. The face with the frog mark shall be placed upward to ensure that the frog mark is filled with mortar. Bricks shall be skillfully laid with the level courses, uniform joints, square corners, plumb vertical and true surfaces, except when otherwise shown on the Drawings or directed by the Engineer;

(7) The bricks used on face shall be selected whole or uniform size and with true rectangular face. Only full bricks shall be used in the brickwork unless absolutely necessary for breaking joints or maintaining bond;

(8) Bricks shall be laid on full bed of mortar and shall be slightly pressed so that mortar gets into all the surface pores of bricks to ensure proper adhesion. Bricks shall be laid where possible from on face only and each brick shall be set with both horizontal and vertical joints filled with mortar and the bricks shall be bedded in by firmly tapping with the handle of the trowel. Mortar joints shall be checked and any hollow or defective joints shall be racked and filled with mortar immediately.

(9) Each course shall break the joints with the course below. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. In thick walls or foundations, not only the face joints but the joints inside also shall break course.

(10) The thickness of mortar in any joint shall not be less than 6 mm and not more than 10 mm and the height of four courses as laid shall not exceed more than 25 mm the height of four dry bricks stacked one upon the other.

(11) All brick work shall be truly plumb and shall always be carried up regularly along their entire length throughout the structure. When the entire work cannot be carried out in even courses, the break shall be made at regular steps each of a length of at least 1-1/2 times its height. Unless otherwise directed no overhead work shall be allowed. Toothing may be done where future extension is contemplated but shall be used as an alternative to raking back.

(12) Where specified, fabric reinforcement shall be embedded completely in mortar. During construction of well steining members, bars shall be placed accurately in accordance with the Drawings.

(13) The surface of each course shall be thoroughly cleaned form all dirt before another course is laid on top of it. If the mortar in any course has begun to set, the joints shall be racked out to a depth of 25 mm before any subsequent course is laid. When the top course has been exposed for more than two weeks, it shall be removed and the surface below thoroughly cleaned before any more courses are added;

(14) When fresh masonry is to be placed against the existing surface of structures, these surfaces shall be cleaned of all loose materials, roughened and wetted as directed by the Engineer so as to effect a good bond with the new work.

706 WEEP HOLES

Weep holes in abutment, wing wall and return wall shall be provided as shown on the Drawings. The Contractor shall clear or replace at his own expenses to the satisfaction of the Engineer weep holes that become blocked for any reason during the contract period.

707 SCAFFOLDING

The scaffolding shall be sound and strong to withstand all loads likely to come upon it and subject to the Engineer’s approval. Pole going into the masonry is at a place which can be filled with a header brick. The holes which provide resting space for horizontal members shall not be left in masonry under one meter in width or

immediately near the skew backs of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good.

708 PROTECTION AND CURING

(1) Brickwork shall be protected during construction and for 3 days after laying against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed work shall be covered or wetted in such manner that it will prevent rapid drying of the brickwork.

(2) All brickwork requiring mortar shall be cured as it is constructed for not less than seven days after completion of the last course by being kept continuously wet with water or by covering with water saturated material or other curing methods approved by the Engineer.

(3) At the completion of the Works all visible surfaces shall be free of damage or debris and shall look clean. Care shall be taken that bricks are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

709 FINISHING OF SURFACES

GENERAL

(1) The surfaces shall be finished by "Jointing" or "Pointing". The surfaces which shall remain exposed shall be pointed, and those which shall be buried under ground shall be jointed. The mortar for finishing shall be prepared as per Clause 704.

JOINTING

(2) In jointing, the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work. The faces of brick-work shall be cleaned to remove any splashed of mortar during the course of raising the brick work.

POINTING

(3) For pointing, the joints shall be squarely raked out to a depth of 15 mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted. The mortar shall be filled and pressed into the raked out joints, before giving the required finished. The pointing shall then be finished to proper type given on the Drawings.

(4) If type of pointing is not mentioned on the Drawing or Schedule of Works, flushing pointing shall be used. For ruled pointing after the mortar has been filled and pressed into the joints and finished off level with the edges of the bricks, it shall while still green be ruled along the centre with a half round tool of such width as may be specified by the Engineer. The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned of all mortar.

710 REPAIRING OF BRICKWORK

After the completion of any brickwork, if any brick is out of alignment or level, or does not conform to the lines and grades shown on the Drawings, or shows a defective surface, it shall be removed and replaced by the Contractor at his expense unless the Engineer grants written permission to patch or replace the defective area.

Chapter 8

800 CONCRETE WORK

801 GENERAL

(1) All concreting shall be carried out in accordance with the current British Standard BS 8110 and as specified by the Engineer.

(2) All sampling and testing of constituent materials shall be carried out in accordance with the provisions of the appropriate British or American Standard and all sampling and testing of fresh and hardened concrete shall be carried out in accordance with the provisions of BS 1881 "Method of Testing Concrete" or similar.

802 CEMENT

(1) In the most general sense, Portland Cement is produced by heating sources of lime, iron, silica, and alumina to clinkering temperature (2,500°F to 2,800°F) in a rotating kiln, then grinding the clinker to a fine powder. The heating that occurs in the kiln transforms the raw materials into new chemical compounds. Therefore, the chemical composition of the cement is defined by the mass percentages and composition of the raw sources of lime, iron, silica, and alumina as well as the temperature and duration of heating. It is this variation in raw materials source and the plant-specific characteristics, as well as the finishing processes (i.e. grinding and possible blending with gypsum, limestone, or supplementary cementing materials), that define the cement produced.

TYPES OF CEMENT

(2) To ensure a level of consistency between cement-producing plants, certain chemical and physical limits are placed on cements. These chemical limits are defined by a variety of standards and specifications. For instance, Portland cements and blended hydraulic cements for concrete in USA, conform to the American Society for Testing and Materials (ASTM) C150 (Standard Specification for Portland Cement), C595 (Standard Specification for Blended Hydraulic Cement) or C1157 (Performance Specification for Hydraulic Cements).

(3) AASHTO uses M 85 for Portland cement and M 240 for blended cements. In the US, three separate standards are applied depending on the category of cement.

(4) For Portland cement types, ASTM C150 describes:

Cement Type	Description
Type I	Normal
Type II	Moderate Sulfate Resistance
Type II (MH)	Moderate Heat of Hydration (and Moderate Sulfate Resistance)
Type III	High Early Strength
Type IV	Low Heat Hydration
Type V	High Sulfate Resistance

For blended hydraulic cements – specified by ASTM C595 – the following nomenclature is used:

Cement Type	Description
Type IL	Portland-Limestone Cement
Type IS	Portland-Slag Cement
Type IP	Portland-Pozzonlan Cement
Type IT	Ternary Blended Cement

In addition, some blended cements have special performance properties verified by additional testing. These are designated by letters in parentheses following the cement type. For example Type IP(MS) is a Portland-pozzolan cement with moderate sulfate resistance properties. Other special properties are designated by (HS), for high sulfate resistance; (A), for air-entraining cements; (MH) for moderate heat of hydration; and (LH) for low heat of hydration.

(5) Chemical tests verify the content and composition of cement, while physical testing demonstrates physical criteria. In C150/M 85 and C595/M 240, both chemical and physical properties are limited. Chemical testing includes oxide analyses (SiO_2, CaO, Al_2O_3, Fe_2O_3, etc.) to allow the cement phase composition to be calculated.

(6) Typical physical requirements for cements are: air content, fineness, expansion, strength, heat of hydration, and setting time. Most of these physical tests are carried out using mortar or paste created from the cement.

SPECIFICATIONS OF CEMENT

(7) Ordinary Portland Cement (OPC) shall be used for the construction work of BWDB. Cement shall be Ordinary Portland Cement (OPC) conforming to the requirements of BDS-EN-197-1-CEM1 52.5 N, ASTM C150 Type 1 or BS 12, or equivalent standard. Special cement shall conform to the requirements laid down by the Engineer.

(8) The cement used in the Works shall be obtained from the manufacturers, who were approved in writing by the Engineer.

(9) Each consignment of cement delivered to the Site must be accompanied by a certificate showing the place of manufacture and the results of standard tests carried out on the bulk supply from which the cement was extracted.

(10) The Engineer may make any tests which he considers advisable or necessary to ascertain if the cement has deteriorated in any manner during transit or storage. Any cement which, in the opinion of the Engineer, is of doubtful quality shall not be used in the Works until it has been re-tested and test result sheets, showing that it complies in all respects with the relevant standard, have been delivered to and accepted by the Engineer.

(11) Cement containing lumps which cannot be broken to original fineness by finger pressure will be rejected irrespective of age and shall be removed from the Site.

(12) Unit weight : The unit weight of cement shall be 14.16 KN/m^3.
Size of Bag : 50 kg, 1.25 cft

FM of Cement : "0"

(13) The following are the quality tests on cement at construction site:

1. Color test.
2. Adulteration test.
3. Float tests.
4. Setting test.
5. Presence of lumps.
6. Temperature test.
7. Strength test.
8. Date of packing.

STRENGTH OF CEMENT

(14) The Engineer shall ask to carry out the sampling, inspection and testing of all cement as he may consider necessary. Samples shall be taken as instructed from the site
store, or form elsewhere on the works or from any places where cement is used for incorporation in the works. Cement may be rejected, at the discretion of the Engineer, if it fails to meet any of the requirements of the specifications. All testing shall be in accordance with ASTM designation C150 or equivalent. The compressive strength and tensile strength of standard cubes and briquettes respectively shall be not less than as follows :

TABLE 8.1 : MINIMUM STRENGTH OF CEMENT

Days	Compressive strength, (N/mm²)	Tensile strength (N/mm²)
3	13	1.00
7	20	2.00
28	28	2.50

SETTING TIME OF CEMENT

Initial setting time : Shall not be more than 45 minutes
Final setting time : Shall not be more than 8 hours.

FINENESS OF CEMENT

(15) Fineness of cement is property of cement that indicate particle size of cement and specific surface area and indirectly effect heat of hydration. The size of the particles of the cement is its *fineness*. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

(16) Fineness of cement are calculate as below :

- Take 100 g of the cement and place it on a standard 90 micron IS sieve with the pan below to collect the sieved cement.
- Sieve the sample continuously for 15 minutes.
- Weigh the residue left on the sieve.

$$Fineness = \frac{Weight\ of\ Residue}{Total\ Weight\ of\ Sample}\ X\ 100$$

The fineness shall not exceed 10 % for OPC and 5% for RHC

(17) Importance Fineness of cement are as below :

- Higher the fineness percentage, poorer the quality of the cement.
- Fineness of cement has a great effect on the rate of hydration and hence the rate of obtaining the strength of concrete.
- Fineness of cement increases the rate of evolution of heat.
- Finer cement offers a great surface area for hydration and hence faster the development of strength.
- Increase in fineness of cement also increases the drying shrinkage of concrete and hence creates cracks in structures.
- Excessive fineness requirement increases cost of grinding.
- Excessive fine cement requires more water for hydration, resulting reduced strength and durability.
- Fineness of cement affects properties like gypsum requirement, workability of fresh concrete & long term behavior of structure.
- Coarse cement particles settle down in concrete which causes bleeding.

SOUNDNESS OF CEMENT

(18) The expansion of cement after setting causes disruption of the hardened mass and create severe difficulties concerning strength and durability of the structure. Soundness test of cement is done to ensure that cement doesn't show any expansion after hardening and to find out the uncombined lime in cement (excess lime). In simple words, this test is conducted to check "unsoundness of cement".

(19) In the soundness test a specimen of hardened cement paste is boiled for a fixed time so that any tendency to expand is speeded up and can be detected. Soundness means the ability to resist volume expansion. The cement when tested for soundness shall not have an expansion of more than 10 mm.

(20) Causes of Unsoundness of cement :

- Unsoundness is caused due to the presence of excess of lime in cement.
- Inadequate burning at kiln during manufacturing of cement.
- Improper grinding and mixing of raw materials during the production of cement.
- Unsoundness is also caused due to the high proportion of magnesium content or sulphate content.

(21) How to prevent unsoundness in cement :

Gypsum is added in cement while production to control the rate of hydration in cement. The quantity of gypsum added will vary from 3 to 5 percent depending upon C_3A content. If the addition of gypsum is more than that could be combined with C_3A, an excess of gypsum will remain in the cement in free state. This excess of gypsum leads to an expansion in the hardened state.

803 STORAGE OF CEMENT

(1) Cement shall be delivered to the work site in sound and properly sealed jute/paper bags, each plainly marked with manufacture's name or registered mark. The cement shall be protected from the weather by tarpaulins or other approved covering during transit. The weight of individual bag containing cement shall be 50 kg and weight of all bags shall be uniform. The weight of cement shall be legibly marked on each bag. Bags in broken or damaged condition shall be rejected.

(2) Each consignment of cement delivered to the site must be accompanied by a certificate showing the place of manufacture and the results of standard tests carried out on the bulk supply from which the cement was extracted.

(3) The Contractor shall provide waterproof and well ventilated godowns at the specified or approved location at the site, having a floor of wood or concrete raised at least 450 mm above the ground. The sheds shall be large enough to allow a minimum 300mm gap between the stacked cement and the godown walls, to store sufficient cement stored to ensure continuity of work and to permit each consignment to be stacked separately therein to permit easy access for inspection. All storage facilities shall be subject to approval by the Engineer.

(4) Immediately upon arrival at the site, cement shall be stored in the godowns with adequate provision to prevent absorption of moisture. The Contractor shall use the consignments in the order in which they are received. Cement delivered to the site in drums or bags provided or by the supplier or manufacturer shall be stored in the drums or bags until used in the Works. Any cement in drums or bags which have been opened shall be used immediately after opening. The cement shall not be stored in a godown for more than four months or a lesser period as directed by the Engineer. After this period has expired, any unused cement shall be removed from the site.

804 AGGREGATES : GENERAL

(1) Aggregates shall be hard, strong, durable, dense and free form injurious amount of adherent coatings, clay, lumps, dust, soft or flaky particles, shell, mica, alkali, organic matter and other deleterious substances. The various sizes of particles of which an aggregate is composed shall be uniformly distributed throughout the mass.

(2) Testing of aggregates shall be in accordance with BS 812 or ASTM C-136.

(3) Approval of a source of aggregate by the Engineer shall not be construed as constituting the approval of all materials to be taken from that source and the Contractor shall be responsible for the specified quantity and quality of all such materials used in the works. Aggregates shall not be obtained from sources which have not been approved by the Engineer.

(4) The Contractor shall provide means of storing the aggregates at each point where concrete is made such that :

i. aggregates shall be stored on a hard and dry patch of ground covered with a 50 mm thick layer of lean concrete;

ii. each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times;

iii. contamination of the aggregates by the ground or other foreign materials shall be effectively prevented at all times;

iv. each heap of aggregate shall be capable of draining freely;

v. the aggregates shall be handled so as to avoid segregation.

(5) The Contractor shall make available to the Engineer such samples of the aggregate as he may require. Such samples shall be collected at the point of discharge of aggregate to the batching plant/mixing machines. If any such sample does not conform with the specification, the aggregate shall promptly be removed from the site and the Contractor shall carry out such modifications to the storage arrangements as may be necessary to secure compliance with the specification.

805 FINE AGGREGATES

(6) Normally sand is used as fine aggregates. It also used as a filter material. Sand shall be non-plastic, non-saline, free from all silt, clay, roots and other organic materials. Five aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a fineness modulus between 1.5 and 2.5. The sand shall have sharp angular grains of silica and grains shall be hard, dense and durable. It shall be free from injurious amount of clay lumps, lightweight materials or other deleterious of clay lumps, lightweight materials or other deleterious substances. The amount of silt, clay and fines should not exceed 5%. Fine aggregates shall be tested for organic impurities in accordance with ASTM Designation C40.

(7) The fine aggregate shall be tested according to ASTM Designation C136, conform to the following requirements, unless otherwise specified, and at fitness modulus between 1.5 and 2.5.

TABLE 8.2 : GRADING OF FINE AGGREGATES FOR CONCRETE

Sieve No (U.S. standard square mesh)	**Sieve size (mm)**	**Percentage by weight passing**
4	4.76	95 – 100
16	1.18	45 – 80
50	0.30	10 – 30
100	0.15	2 – 10
Pan	-	3 - 7

FINENESS MODULUS

(8) Fineness modulus (FM) is an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves, and dividing the sum by 100.

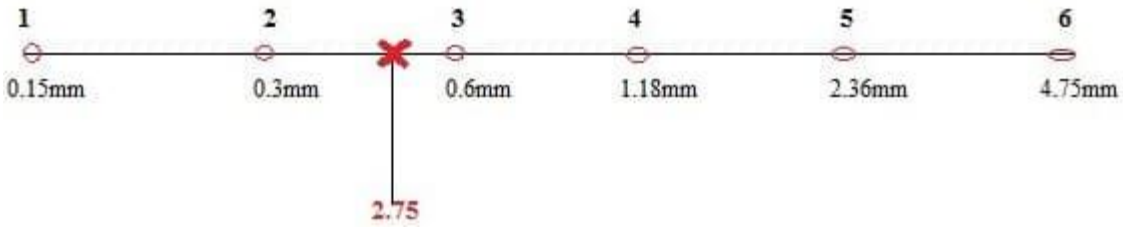
Let us say the dry weight of sample = 1000gm

After sieve analysis the values appeared are tabulated below:

Sl No.	Sieve No.	Sieve size	Weight retained (g)	Cumulative weight retained(g)	Cumulative percentage weight Retained (%)
6	#4	4.75mm	0	0	0
5	#8	2.36mm	100	100	10
4	#16	1.18mm	250	350	35
3	#30	0.6mm	350	700	70
2	#50	0.3mm	200	900	90
1	#100	0.15mm	100	1000	100
		Total			**275**

Therefore, Fineness Modulus = (cumulative % retained) / 100 = (275/100) = **2.75**

Fineness modulus of fine aggregate is 2.75. It means the average value of aggregate is in between the 2nd sieve and 3rd sieve. It means the average aggregate size is in between 0.3mm to 0.6mm as shown in below figure.



GRADING AND FM

The grading of the various sized sand shall be as shown in the following table:

TABLE 8.3 : GRADING LIMITS OF SAND (% PASSING)

Sieve Size	% Passing F.M. (1.50-2.80)	% Passing F.M. (1.00-1.50)	% Passing F.M. (0.80-1.00)	% Passing F.M. (0.50-0.80)
4.80 mm	95-100	100	100	100
2.40 mm	90-100	100	100	100
1.20 mm	70-95	97-100	100	100
600 micron	40-80	85-95	95-100	100
300 micron	10-50	50-70	70-80	80-90
150 micron	00-20	20-35	35-40	40-60

806 COARSE AGGREGATES

(1) Coarse aggregates shall consist of either
picked jhama chips or first class brick chips
or shingles/ natural stones
or crushed stone chips

(2) The pieces of aggregates shall be angular in shape and have granular or crystalline or smooth, but not glossy non-powdery, surfaces.

(3) The amount of clay, fine silt, fine dust occurring in a free state or as a loose adherent shall not exceed 1 percent. The sum of the percentages of all deleterious substances in any size shall not exceed 3 percent, by weight. After a minimum period of 6 hours immersion in water, the previously dried sample shall not have gained in weight more that 5 percent for use in reinforced concrete not more than 10 percent for use in plain concrete. The specific gravity shall not be less than 2.60.

(4) Coarse aggregates shall be tested according to ASTM Designation C130 or equivalent. Gradations for 50mm, 40mm, 25mm and 20mm size aggregates, unless otherwise specified shall conform to the following requirements.

TABLE 8.4: GRADING OF COARSE AGGREGATE FOR CONCRETE

Sieve Designation U.S. Standard Square Mesh	Percent Passing by Weight			
	50 mm	40 mm	25 mm	20 mm
63.50 mm (2.5″)	100	-	-	-
50.80 mm (2.0″)	95-100	100	-	-
38.10 mm (1.5″)	-	95-100	100	-
25.40 mm (1.0″)	35-70	-	95-100	-
19.05 mm (3/4″)	-	35-70	-	100
12.70 mm (1/2″)	10-30	-	25-60	90-100
9.52 mm (3/8″)	-	10-30	-	40-70
NO. 4 (3/16″)	0-5	0-5	0-10	0-15
NO. 8 (1/8″)	-	-	0-5	0-5

BRICK CHIPS OR KHOA

(5) Brick chips shall be made from picked jhama brick or first class brick as as specified in Section 700. Brick chips shall be completely soaked in water for a minimum period of 6 hours and taken out from water two hours before use. All brick chips shall be free from water adhering to their surface when they are used for concreting; Brick chips shall be in saturated surface dry condition when used for concreting.

STONE CHIPS OR SHINGLES

(6) Shingles/ natural stones or crushed stone chips made from boulder/ gravel/ rock as specified in Section 500 shall be used as Coarse Aggregates**.**

807 FIELD OF USE OF COARSE AGGREGATE

Coarse aggregate for cc blocks shall be consist of stone chips in accordance with Clause 806. The pieces of aggregate shall be angular or rounded in shape and have a granular, non-powdery surface. The coarse aggregates shall be well graded in

accordance with Clause 806 and to the satisfaction of the Engineer. The other field of use of Coarse aggregate are as below:

TABLE 8.5: FIELD OF USE OF COARSE AGGREGATE

Field of use	Coarse Aggregates
All RCC works	stone chips
CC Blocks	stone chips
CC Work	Brick Chips or Khoa, Shingles/ natural stones or crushed stone chips
Filter	Brick Chips or Khoa, Shingles/ natural stones or crushed stone chips

808 WATER

Water that shall be used in the concrete shall be usually such as to be fit for drinking purposes and will be taken from an approved source. It shall be free from objectionable quantities of silt, organic matters, alkali, salt and other impurities. Water from an unapproved source shall not be used for making concrete.

809 ADMIXTURES

(1) Admixture shall mean materials added to the concrete materials during mixing for the purpose of altering the properties of the concrete mix.

(2) The Contractor shall obtain the Engineer's written permission before using admixtures. The methods of use and the quantities of admixture used shall be subject to the Engineer's approval, which approval or otherwise shall in no way limit the Contractor's obligations under the Contract to produce concrete with the specified strength and workability.

810 CONCRETE CLASSES

The following classes of concrete shall be used as shown on the Drawings or as directed by the Engineer. Each mix shall be designed to ensure optimum workability, prevent segregation and produce a dense, durable concrete by adjusting the fine and coarse aggregate proportions following procedures set out in this Chapter.

TABLE 8.6: SPECIFICATION FOR CLASSES OF CONCRETE

Concrete Class	Leanest Mix	*28 day Cylinder Strength (N/mm²)	
M25	1:1.5:3	25.0	RCC plies, RCC machine made pipes and major RCC or massive structures i.e pump houses, Barrage, Regulator, Bridge, Buildings etc.

Concrete Class	Leanest Mix	*28 day Cylinder Strength (N/mm²)	
M22	1:1.5:3	22.0	RCC structures.
M20	1:2:3.5	20.0	Small structural elements
M18	1:2:4	18.0	CC Blocks
M16	1:2:4	16.0	Mass concrete in structures
M15	1:2:4	15.0	CC Blocks
M10	1:3:5.5	10.5	CC Blocks
M9	1:3:6	9.0	CC Blocks
M6	1:4:8	6.0	
F1	1:3:6	Not specified	CC Works
F2	1:4:8	Not specified	blinding Concrete

* Average value of 85% strength of the cylinders tested.

811 WATER CEMENT RATIO

(1) The ratio between the weight of water to the weight of cement in the concrete mix is called Water Cement (W/C) ratio. On an average 25% of water by weight of cement is required for the completion of chemical reactions in the process of hydration of cement. But for workability extra water is added which gets evaporated in later stage and leaves behind voids. More water cement ratio causes porousness in concrete. So admixtures are added to increase workability of concrete without changing the water cement ratio.

(2) Total water for each batch of concrete shall be the minimum amount necessary to produce a plastic mixture of the strength specified with adequate density, uniformity and workability. Total water content for each batch shall be calculated to include moisture content of the fine and coarse aggregates. The workability for various types of construction shall be within the limits tabulated below or as approved by the Engineer.

TABLE 8.7 : WORKABILITY OF CONCRETE (Wilby 1991)

Degree of Workability	Slump (mm)	Compaction Factor		Applications
		Small Apparatus	Large Apparatus	
Very Low	0-25	0.78	0.80	Vibrated concrete in roads or other large sections.
Low	25-50	0.85	0.87	Mass concrete foundations without vibration. Simple reinforced sections with vibration.

Degree of Workability	Slump (mm)	Compaction Factor		Applications
		Small Apparatus	Large Apparatus	
Medium	50-100	0.92	0.935	Normal reinforced work without vibration and heavily reinforced sections with vibration.
High	100-180	0.95	0.96	Sections with congested reinforcement. Not normally suitable for vibration.

The compaction factor test has been used more widely in Europe than in the United States, although the overall use of the test seems to be declining.

(3) Water affects the strength of concrete to a large extent. It is responsible for the hydration process which in turn is responsible for the strength gaining properties. If the amount of water is low, the hydration process will not be as good as required, and concrete will not be able to gain strength accordingly. But what if a large amount of water is add more than the required, then it will cause segregation i.e. the particles will not be able to make bonds tightly. Strength improves with lower water cement ratios.

(4) Normally, the water cement ratio varies between 0.4 to 0.6 . Water Cement Ratio shall not exceed 0.45, unless otherwise mentioned in the Drawing or approved by the Engineer.

If ratio of W/C is considered as 0.45, then

Quantity of water = 0.45 x 50 = 22.50 Liters (1 bag cement = 50 Kg)

So, the required quantity of water is 22.50 Liters per bag of cement.

812 SLUMP

(1) The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The inexpensive test, which measures consistency, is used on job sites to determine rapidly whether a concrete batch should be accepted or rejected. The test method is widely standardized throughout the world, including in ASTM C143 in the United States and EN 12350-2 in Europe.

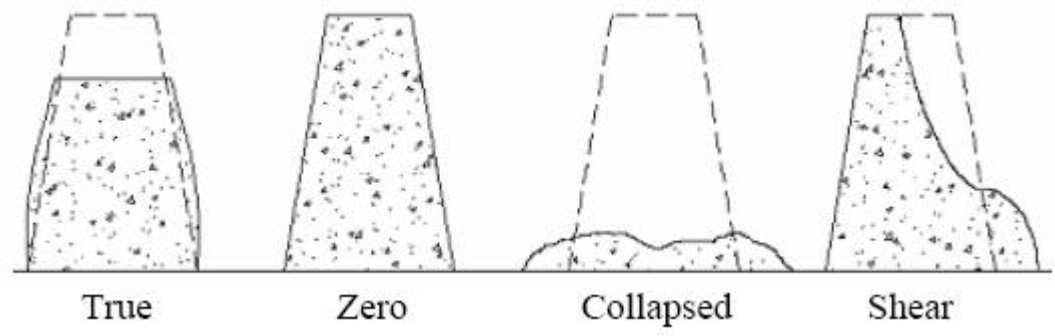
(2) The slump test is a very simple test. The slump cone is a right circular cone that is **12 inches** high. The base of the cone is **8 inches** in diameter and the top of the cone is **4 inches** in diameter.

(3) Procedure for Concrete Slump Cone Test

- Clean the internal surface of the mould and apply oil.
- Place the mould on a smooth horizontal non- porous base plate.
- Fill the mould with the prepared concrete mix in 4 approximately equal layers.

- Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.
- Remove the excess concrete and level the surface with a trowel.
- Clean away the mortar or water leaked out between the mould and the base plate.
- Raise the mould from the concrete immediately and slowly in vertical direction.
- Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.
- The slump (Vertical settlement) measured shall be recorded in terms of millimeters of subsidence of the specimen during the test.

(4) When the slump test is carried out, following are the shape of the concrete slump that can be observed:



- **True Slump** – True slump is the only slump that can be measured in the test. The measurement is taken between the top of the cone and the top of the concrete after the cone has been removed.
- **Zero Slump** – Zero slump is the indication of very low water-cement ratio, which results in dry mixes. This type of concrete is generally used for Machine Made CC Block and Road Construction.
- **Collapsed Slump** – This is an indication that the water-cement ratio is too high, i.e. concrete mix is too wet or it is a high workability mix, for which a slump test is not appropriate.
- **Shear Slump** – The shear slump indicates that the result is incomplete, and concrete to be retested.

(5) The only type of slump permissible under ASTM C143 is frequently referred to as the "true" slump, where the concrete remains intact and retains a symmetric shape. A zero slump and a collapsed slump are both outside the range of workability that can be measured with the slump test. Specifically, ASTM C143 advises caution in interpreting test results less than 12.5mm and greater than 225mm. If part of the concrete shears from the mass, the test must be repeated with a different sample of concrete. A concrete that exhibits a shear slump in a second test is not sufficiently cohesive and should be rejected.

(6) The slump test is not considered applicable for concretes with a maximum coarse aggregate size greater than 40mm. For concrete with aggregate greater than 40mm in size, such larger particles can be removed by wet sieving.

TABLE 8.8: SLUMP OF CONCRETE

Slump	Placing conditions	workability
0 – 25 mm	road making	Very dry mixes
10 – 40 mm	foundations with light reinforcement	Low workability mixes
50 – 90 mm	normal reinforced concrete placed with vibration	Medium workability mixes
slump > 100 mm	reinforcing has tight spacing, and/or the concrete has to flow a great distance	High workability concrete

813 WORKABILITY

(1) The ease of placing, consolidating, and finishing freshly mixed concrete and the degree to which it resists segregation is called workability. Concrete should be workable but the ingredients should not separate during transport and handling.

(2) The degree of workability required for proper placement of concrete is controlled by the placement method, type of consolidation, and type of concrete. Different types of placements require different levels of workability.

(3) Factors that influence the workability of concrete are: (1) the method and duration of transportation; (2) quantity and characteristics of cementitious materials; water content; (3) concrete consistency (slump); (4) grading, shape, and surface texture of fine and coarse aggregates; (5) entrained air; (6) water content;. (7) concrete and ambient air temperatures; and (8) admixtures. A uniform distribution of aggregate particles and the presence of entrained air significantly help control segregation and improve workability

(4) Properties related to workability include consistency, segregation, mobility, pumpability, bleeding, and the consistency is too dry and harsh, the concrete will be difficult to place and compact and larger aggregate particles may separate from the mix. However, it should not be assumed that a wetter, more fluid mix is necessarily more workable. If the mix is too wet, segregation and honeycombing can occur. The consistency should be the driest practicable for placement using the available consolidation equipment.

814 SEGREGATION

(1) Segregation is the "**Separation of constituent materials in concrete.**" In concrete technology, segregation is of three types:-

i. Separation of Coarse aggregate from the concrete mixture,
ii. Separation of Cement pastes from the concrete during its plastic stage.

iii. Separation of water from the concrete mix (Bleeding in concrete)

(2) Concrete is a mixture of Cement, fine and coarse aggregates. A good concrete is one in which all the constituents are properly categorized to form a homogeneous mixture. The primary cause of Segregation in concrete is the differences in specific gravities of the constituents, Specific gravity of Cement is in between 3.1-3.6g/cc, and for aggregate it lies between 2.6-2.7g/cc due to this differences, the aggregate separates from the matrix and causes segregation in concrete.

(3) Some other factors causing segregation in concrete :

i. Transporting concrete mixes for long distances.
ii. Poorly proportioned mix, where sufficient matrix is not there to bind the aggregates.
iii. Dropping concrete from more than 1.00m.
iv. Vibrating concrete for a long time.

(4) How to minimize segregation in concrete:

i. Segregation can be controlled by maintaining proper proportioning the mix.
ii. By peculiar handling, placing, transporting, compacting and finishing of concrete.
iii. Adding air entraining agents, admixtures and pozzolanic materials in the mix segregation controlled to some extent.

815 BLEEDING AND SETTLEMENT

(1) Bleeding is the development of a layer of water at the top or surface of freshly placed concrete. It is caused by sedimentation (settlement) of solid particles (cement and aggregate) and the simultaneous upward migration of water. Bleeding is normal and it should not diminish the quality of properly placed, finished, and cured concrete. Some bleeding is helpful to control plastic shrinkage cracking.

(2) Bleeding ordinarily occurs in the wet mix of concrete. The Prime factor for bleeding in concrete is the high dosage of Water cement ratio. Higher water-cement ratio weakens concrete and leads to excessive bleeding. The bleeding in concrete is not harmful if the rate of evaporation of water is equal to the rate of bleeding. Normal bleeding is quite good, and it enhances the workability of concrete. When the concrete is fully plastic, bleeding may not cause much harm. However, concrete is still in the plastic stage later it is subsidized and compacted.

(3) Excessive bleeding increases the water-cement ratio near the top surface; a weak top layer with poor durability may result, particularly if finishing operations take place while bleed water is present. A water pocket or void can develop under a prematurely finished surface.

(4) After evaporation of all bleed water, the hardened surface will be slightly lower than the freshly placed surface. This decrease in height from time of placement to initial set is called settlement shrinkage.

(5) The bleeding rate and bleeding capacity (total settlement per unit of original concrete height) increases with initial water content, concrete height, and pressure. Use of properly graded aggregate, certain chemical admixtures, air entrainment, supplementary cementitious materials, and finer cements, reduces bleeding. Concrete used to fill voids, provide support, or provide water tightness with a good bond should have low bleeding properties to avoid formation of water pockets.

816 CONSOLIDATION

(1) Vibration sets into motion the particles in freshly mixed concrete, reducing friction between them, and giving the mixture the mobile qualities of a thick fluid. The vibratory action permits use of a stiffer mixture containing a larger proportion of coarse and a smaller proportion of fine aggregate. The larger the maximum size aggregate in concrete with a well-graded aggregate, the less volume there is to fill with paste and the less aggregate surface area there is to coat with paste; thus less water and cement are needed. Concrete with an optimally graded aggregate will be easier to consolidate and place. Consolidation of coarser as well as stiffer mixtures results in improved quality and economy. On the other hand, poor consolidation can result in porous, weak concrete with poor durability.

(2) Mechanical vibration has many advantages. Vibrators make it possible to economically place mixtures that are impractical to consolidate by hand under many conditions such as concrete of a stiff consistency (low slump). This concrete was mechanically vibrated in forms containing closely spaced reinforcement.

817 DESIGN OF CONCRETE MIX

(1) Prior to the commencement of concreting operations, the Contractor shall design a mix for the concrete, and prepare and test concrete samples of this mix under laboratory conditions. Preliminary mixes shall be repeated and adjusted as necessary to produce a concrete mix meeting the requirements of Clause 810. The details of the mix and test results shall be submitted to the Engineer for his approval.

(2) Following the Engineer's approval of the mix design, the Contractor shall prepare a trial mix in the presence of the Engineer. The trial mix shall be batched, mixed and handled using the same methods and plant the Contractor proposes to use. The mix shall comprise not less than half a cubic miter of concrete. The Proportions of cement, aggregates and water shall be carefully determined by weight in accordance with the Contractor's approved mix design and sieve analysis shall be made of the fine and coarse aggregates.

(3) Twelve concrete cylinder samples shall be made from the trial mix in the presence of the Engineer. The concrete cylinders shall be made, cured, stored and tested in accordance with BS 1881. Six cylinders shall be tested at 7 days and six cylinders shall be tested at 28 days. If the strength of any of the cylinders tested at 28 days is below the characteristic strength, the Contractor shall redesign the mix, make further preliminary mixes for the Engineer's approval then undertake additional trial mixes and test the resultant samples until a satisfactory mix is obtained and approved by the Engineer.

(4) No change shall be made in the approved design mix without the Engineer's approval.

818 PROPORTIONING OF MIX

(1) The approved mix shall be proportioned by weight or, except cement, by volume, if volume batching is approved by the Engineer. Allowance shall be made for the moisture content of the aggregates.

(2) Fine and coarse aggregate and water may only be measured by volume in boxes or containers approved by the Engineer. Cement shall be added to concrete mixers by whole number of bags only.

819 MIXING OF CONCRETE

(1) All concrete shall be mixed in modern mechanically operated mixers capable of combining aggregate, cement and water into a uniform mixture and discharging without segregation. Mixers shall be to the approval of the Engineer.

(2) Mixing time shall be at least one minute after the last ingredient has been added to the mixer or so much more time as may be recommended by the manufacturer of the mixer.

(3) Mixing of concrete are preferable by Batching Plant. At least Mixture Machine with hopper shall be used for mixing of concrete. Hand mixing of concrete are not be allowed.

820 QUALITY CONTROL OF CONCRETE

(1) The Contractor shall be responsible for providing samples of concrete and its constituent materials either for testing by him or for testing at the Engineer's laboratory or laboratory designated by the Engineer. For this purpose, "concrete test cylinders" shall be made in accordance with BS 1881, shall be deemed to be 'samples'. All sampling of constituent materials shall be carried out in accordance with the provisions of the appropriate British Standard, and all sampling of fresh and of hardened concrete shall be carried out in accordance with the provisions of BS 1881 unless such provision is at variance with the specification.

(2) The tests which the Contractor is required to undertake himself on behalf of the Engineer are those to be carried out on fresh concrete at the place of final deposit, or elsewhere on the Site as directed by the Engineer.

ADJUSTMENT OF WATER/CEMENT RATIO

(3) The Contractor shall test aggregates for moisture content and so determine the water/cement ratio of the fresh concrete. Determinations of water/cement ratio shall be carried out as required by the Engineer and the results and calculations submitted to him.

SLUMP TESTS

(4) The Contractor shall undertake slump tests on each batch of the freshly made concrete or less frequently if directed by the Engineer. The slump of concrete to be used in the Works shall not exceed the slump of the trial mix by more than 10% and shall in any case not be more than maximum specified.

CONCRETE CYLINDERS

(5) The sampling of concrete for concrete cylinders shall, where possible, be undertaken at the place of deposition of the concrete. Each sampling shall sufficient concrete to make six cylinders and allow a slump test.

(6) After stripping, each cylinder shall be indelibly marked with the date in each active day unless directed otherwise by the Engineer.

821 FAILURE TO PASS TESTS

(1) If cylinders taken at site during the progress of the works fail to reach the specified strength no further concreting shall take place until the cause of the failure has been established and corrective measures taken to the satisfaction of the Engineer.

(2) The Engineer may require that core samples be taken and tested in accordance with ASTM Designation C-42 or a similar standard or other test be performed on sections of the works made from the suspect concrete; the cost of all such testing being borne by the Contractor. If such testing fails to demonstrate the integrity of the sections of the works, then all sections made with the suspect concrete shall be removed from the site.

822 TRANSPORTING, PLACING AND COMPACTING CONCRETE

(1) Concreting shall not be commenced without the written approval of the Engineer or his Representative. This approval shall be in the form a standard check list approved by the Engineer prior to the commencement of the work. The check list shall be filled in and approved by the Engineer's representative during his inspection and acceptance of materials, plant and equipment, concreting arrangements, the positioning, fixing and condition of reinforcement and any other items to be embedded and the cleanliness, alignment and suitability of the containing surfaces or formwork.

(2) Concrete shall be conveyed from the mixer/batching plant as rapidly as possible by methods which will prevent segregation or drying out and ensure that the concrete is of the required workability at the point and time of placing. The re-mixing of concrete will not be permitted.

(3) The concrete shall be placed in the position and sequences indicated on the Drawings and Specification or as directed by the Engineer. The concrete shall be

placed in clean, oiled formwork and compacted before initial set has occurred, and in any event, not later than thirty minutes from the time of mixing. The concrete shall be placed in layers not greater than 450 mm thick and each layer thoroughly compacted by power driven internal type vibrators supplemented by hand spading and tamping.

(4) The concrete shall be deposited as far as possible in its final position without rehandling or segregation and in such a manner so as to avoid displacement of the reinforcement and other embedded items or formwork. Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation and suitable spouts or baffles shall be provided where necessary. Concrete shall not be dropped through a height greater than 1200 mm except with the approval of the Engineer who may order the use of bankers and the turning over of the deposited concrete by hand before being placed.

(5) The vibrators shall at all times be adequate in numbers, amplitude and power to compact the concrete properly and quickly throughout the whole of the volume being compacted to the satisfaction of the Engineer. Spare vibrators shall be readily on hand in case of breakdown. The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall on account be continued after water or excess grout has appeared on the surface.

(6) The concreting shall be carried out in such a way that the exposed faces of concrete shall be plain, smooth, sound and solid, free from honeycombing and excrescences. After compaction the exposed concrete surface shall be struck off smooth with hand held steel floats. No plastering of imperfect concrete faces will be allowed. Any concrete that is defective in any way shall, if so ordered by the Engineer, be cut out and replaced to such depth or be made good in such manner as the Engineer may direct.

(7) Where concrete is required to be placed against undisturbed ground, the entire space between the finished concrete surface and the ground, including any over break, is to be completely filled with concrete of the specified class. The concrete shall be well rammed and compacted to ensure that all cavities are filled and the concrete is everywhere in contact with the ground. Where permitted by the Engineer, any extensive patches of over break may first be filled with concrete Class M9 as directed by the Engineer.

(8) Where concrete is required to be placed against a metal surface to which it is required to adhere, care shall be taken to work the concrete well into the re-entrant angles and to ensure contact by hammering the metal part on its free side provided that this is done without damaging the metal or its protective coating, if any.

(9) The placing of concrete under water will be permitted only in exceptional circumstances and with the prior approval of the Engineer. Where concreting under water is allowed, 25 per cent additional cement must be added. Concrete shall be deposited continuously in each section by the use of tremie pipes or other approved means and no horizontal construction joints will be permitted to be made under water.

Approved and adequate protection against possible damage or movement due to scour must be provided.

(10) The Contractor shall organize the casting of mass concrete to minimize thermal cracking. The Contractor's proposal and his casting sequence shall be submitted to the Engineer and concreting shall not commence until the Engineer's written approval is received.

(11) Construction joints shall be formed in the work where indicated on the Drawings or as previously approved by the Engineer. Where necessary, the Contractor shall allow for working beyond ordinary working hours in order that each section of concrete may be completed in a continuous pour with the concreting carried up to each construction joint. Concreting to a formed construction joint shall be undertaken in accordance with Section 1100.

823 CONCRETING IN ADVERSE CONDITIONS

(1) Concreting during periods of constant heavy rain shall not be permitted unless aggregate stockpiles, batching and mixing plants, transporting equipment and the precast yard are adequately covered. During showery weather, the Contractor shall ensure that work can be concluded at short notice. Adequate covering shall be provided to protect newly placed concrete form the rain.

(2) In hot weather, the aggregate stockpiles shall be shielded or sprayed with water and the mixing water shall be adequately cooled or insulated to ensure that the temperature of the concrete when placed shall not exceed 30ºC.

824 CURING CONCRETE AND PROTECTION

(1) Concrete shall be protected from the effects of sunshine, dry wind, rain, running water or mechanical damage for a continuous period, until the concrete has reached at least three quarters of its 28 day strength, but for not less than 10 days. The Contractor shall submit his proposals to achieve this protection for the Engineers approval.

(2) During casting, the chemical reaction takes place between water and cement is called "Hydration". Because of hydration process, the heat generated is called heat of hydration. Therefore, due to hydration, temperature increases inside the concrete and water evaporate from the concrete and concrete becomes dry and cracks are formed due to drying. This released heat is always proven as harmful in volume stability. Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. The object of curing is to control the temperature inside the concrete, to continue hydration process and to prevent dryness of concrete. It is necessary that sufficient quantity of water should be available in concrete till it attains its full strength.

(3) Curing plays an important role on strength development and durability of concrete. Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth

and near the surface, for extended periods of time. Properly cured concrete has an adequate amount of moisture for continued hydration and development of strength, volume stability, resistance to freezing and thawing, and abrasion and scaling resistance. This would mean maintaining a relative humidity in the concrete of greater than 80 percent and a temperature greater than 10°C (50 °F).

(4) The protection and curing of concrete which has achieved its final set shall be by one or more of the following methods:

a) by water spray in continuous operation or a layer of water;

b) by covering with Hessian or similar absorbent material, or sand, kept constantly wet;

c) after thorough wetting, by covering with a layer of water proof fabric kept in contact with the concrete surface.

(5) Use of saline water for curing purposes shall not be permitted.

(6) Curing shall be continued at least for 21 days, unless otherwise mention in the drawing or by the Engineer.

825 CONCRETE SURFACE FINISHING

(1) Finishing of concrete surfaces shall be performed by skilled workmen to the satisfaction of the Engineer. Exposed flat concrete surfaces shall be screened to produce an even and uniform surface then they shall be given a trowel finish unless otherwise specified on the Drawings. All exposed and unprotected edges shall be given 20 mm × 20 mm chamfers. Concrete stairs and bridge decks shall have a broom finish.

(2) The Concrete surface finish on upward facing horizontal or sloping faces shall be, except for blinding concrete or otherwise stated on the Drawing, a “fair” surface. A “fair” surface shall be obtained by spreading and troweling with a wood float.

(3) Spreading shall be carried out, following compaction of the concrete, by the slicing and tamping action of a screed board running on the top edges of the formwork or spreading guides to give a dense concrete skin true to line a level.

(4) Wood float troweling shall be carried out after the concrete has stiffened and the film moisture has disappeared. Working should be kept to the minimum compatible with a good finish and the surface shall be true to the required profile to fine tolerance. Whenever necessary the Contractor shall provide and erect overhead covers to prevent the finished surface from being marred by raindrops or dripping water.

(5) The surface of blinding concrete shall be that obtained by spreading as described above.

(6) Where a “fine” surface is indicated upon the drawings this shall be obtained in a similar manner to “fair” surface save that a steel float shall be used in lieu of the wood float.

(7) Formed surface for painting, exposed to view and waterway surfaces shall be smooth and free from projections, and shall be rubbed smooth immediately after the forms are removed. Formed surface shall be classified as follows:

(a) Unexposed concrete surfaces upon or against which backfill or concrete is to be placed require no treatment except the removal and repair of defective concrete.

(b) Exposed and hydraulic surfaces of water ways shall have a very smooth, smooth, sound surface by control of form work, concrete placement and repair of abrupt surface irregularities by grinding or rubbing of high spots and filling of voids.

826 FINISH AND FINISHING

(1) Surface irregularities shall be classified as "abrupt" or "gradual" offsets caused by displaced or misplaced form sheathing or lining of form sections, or loose knots in forms or otherwise defective formwork, will be considered as "abrupt" irregularities. All other irregularities will be considered as gradual irregularities. Where a surface is partly above the final ground level, the finish for the exposed surface shall extend for 0.15 m below the ground level.

(2) The formed surfaces which will be permanently buried under earth will require no treatment for abrupt or gradual irregularities. However, repair of defective concrete and filling of holes left by the removal of fasteners form the ends of tie rods shall be undertaken.

(3) All abrupt and gradual irregularities at all exposed surfaces shall be removed by sack rubbing or sand blasting or grinding or by all these methods or any other method approved by the Engineer which not harmful to the concrete. The permissible surface irregularities shall not exceed 6 mm for abrupt irregularities and 13 mm for gradual irregularities. The permissible irregularities may be reduced at places of the surface, where in the opinion of the Engineer, the formed finish does not provide the desire effect and no extra payment shall be permissible for such work. (see also Appendix A – Table of Tolerances).

(4) Holes, honeycombs, or other defects left by forms shall be promptly repaired in accordance with Section 900.

(5) All surfaces such as blinding concrete, opening for second stage concrete etc. on which concrete is to be placed subsequently, shall not be finished for abrupt or gradual irregularities.

827 EMBEDDED ITEMS

All embedded items shall be firmly and securely fastened in the place as indicated on the Drawings or as required by the Engineer.

828 SECOND STAGE CONCRETE

(1) Unless shown on the Drawings or otherwise instructed by the Engineer, second stage concrete shall be class M20 concrete.

(2) Blackouts for second stage concrete and the specifications and locations of the embedded parts shall be in accordance with the Drawings.

(3) The surface against which the second stage concrete are to be placed shall be thoroughly cleaned to make the surface free from all loose particles, organic substances, oil, grease, rust, plastic materials, wood and defective concrete.

(4) The projecting parts of the embedded items or the parts which will remain embedded shall be thoroughly cleaned of oil, grease and rust. The parts such as gate frames, guides, bolts, G I posts, rails, including all other embedded parts, shall remain true to dimensions, plumb and levels as shown in the Drawings and directed by the Engineer.

829 PRECAST CONCRETE

(1) Unless shown on the Drawings or otherwise instructed by the Engineer, precast concrete shall be Class M18 concrete.

(2) Concrete members specified to be fabricated as precast concrete units shall be fabricated with concrete of the specified class placed into a grout tight mould. If so required the mould shall be laid on a vibrating table and vibration applied while the concrete is placed.

(3) Permanently exposed surfaces shall have a finish obtained by casting the unit in properly designed moulds of closely-jointed wrought boards or steel or other suitable material.

(4) With the approval of the Engineer the Contractor may be permitted to precast members which were specified to be constructed in-situ in such cases the Contractor shall carry to the work as described above but payment shall be made in the manner appropriate to the method of construction originally specified. Generally, members which are structurally dependent on a rigid fixing with the adjoining structures will not be permitted to be constructed by precasting.

830 HANDLING AND STACKING OF PRECAST UNITS

The Contractor shall give the Engineer full details of his proposed methods of handling and stacking precast concrete beams and units. The Engineer will examine these details and will either approve the methods or order modifications designed to ensure that no excessive stresses are set up in the beams or units. The finally approved methods are to be adhered to at all times and the Contractor shall be deemed to have included in his rates for all measures required to handle and stack beams and units safety and without undue stressing.

831 RECORDS OF CONCRETING

(1) The Contractor shall provide concrete placement sign-out forms for each concrete placement and Engineer shall check and approve the concrete placement and also shall check and approve the concrete forms for conformance with those Specifications, line and grade, reinforcing steel, embedded items cleanliness, cement

aggregate, water, batching equipment and vibrators before starting each concrete placement. One copy of the concrete placement sign-out form shall be retained by the Contractor and one copy shall be submitted to the Engineer with request for payment.

(2) An accurate and up-to-date record showing dates, times, weather and temperature conditions for each concreting shall be kept by the Contractor and shall be available for inspection by the Engineer. The Contractor shall also record the results of all tests of concrete and shall identity these results with the parts of the work of which the sampled materials are representative.

832 CORE TEST

(1) According to ACI 318, the concrete represented by the cores is considered structurally adequate if the average strength of three cores is at least 85 % of the specified strength and no single core strength is less than 75 % of the specified strength.

(2) The commentary of ACI 318 Section R5.6.5 also states “Core tests having an average of 85% of the specified strengths are realistic. To expect core tests to be equal to f’c is not realistic, since differences in the size of specimens, conditions of obtaining samples, and procedures for curing, do not permit equal values to be obtained.”

(3) According to International Building Code IBC Section 1905.6.5.2, three cores will be taken for each strength test. And Section 1905.6.5.4 states, “the average of three cores is equal to at least 85% of f’c”.

Chapter 9

900 FORMWORK

(1) Formwork is used for the shaping of concrete structures in the hardening phase of concrete. Formwork is the term used for the process of creating a temporary mould into which concrete is poured and formed. Traditional formwork is fabricated using timber, but it can also be constructed from steel, glass fibre, reinforced plastics and other materials.

(2) Steel Formwork shall be used for C.C. blocks and all RCC work such as beam, column, slab, pier, wall, pile, footing or foundation etc.

901 CONCRETE FORMWORK

(1) The Contractor shall submit for the approval of the Engineer details of the methods and materials proposed for formwork to each section of the work. Details of all proposed wrought formwork and formwork to produce special finished are to be submitted, for approval in writing, to the Engineer before any materials are bought on to the Site. If the Engineer so requires, samples of formwork shall be constructed and concrete placed so that the proposed methods and finish effect can be demonstrated.

(2) Formwork shall be constructed from sound materials of sufficient strength, properly braced, strutted and shored as to ensure rigidity throughout the placing and compaction of the concrete without visible deflection. Formwork shall be so constructed that it can be removed without shock or vibration to the concrete.

(3) All joints shall be close fitting to prevent leakage of grout and at construction joints the formwork shall be tightly secured against previously cast or hardened concrete to prevent stepping or ridges to exposed surfaces.

(4) Where the Contractor proposes to made the formwork from standard sized manufactured formwork panels, the size of such panel shall be approved by the Engineer before they are used in the construction of the work. The finished appearance of the entire elevation of the structure and the adjoining structures shall be considered when planning the patterns of joint lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.

(5) Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete shown on the Drawings. Due allowance shall be made for any deflection which will occur during the placing of concrete within the formwork. Panels shall have true edges to permit accurate alignment and provide a neat line with adjacent panels and at all construction joints. All panels shall be fixed with their joints either vertical or horizontal, unless otherwise specified or approved.

(6) Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15º with the horizontal and shall be anchored to enable the concrete to be properly compacted and prevent floatation; care shall be taken to prevent air being entrapped. Openings for inspection of the inside of the formwork and for the removal

of water used for washing down shall be provided and so formed as to be easily closed before placing concrete.

902 FORMWORK FOR EXPOSED CONCRETE SURFACE

(1) Unless otherwise stated on the Drawings, wrought formwork shall be used for all permanently visible concrete surfaces. Wrought formwork shall be such as to produce a smooth and even surface free from perceptible irregularities. Tongued and grooved planed boards, plywood or steel forms shall have their joints flush with the surface. The formwork shall be formed form approved standard sized panels. The panels shall be arranged in a uniform approved pattern, free from defects likely to be detected in the resulting concrete surface.

(2) Formwork for concrete, permanently exposed to public inspection shall be faced with plain 28/26 gauge steel sheet fitted over 38 mm thick wooden plank panels suitable braced or steel framing faced with minimum 12/14 BWG mild steel sheet. Formwork for C.C. blocks shall be fabricated from M.S sheet of sufficient thickness to prevent any distortion.

(3) The finished surface shall be within the tolerances specified and full cover to reinforcement steel shall be maintained.

903 FORMWORK FOR NON-EXPOSED CONCRETE SURFACES

(1) Unless otherwise stated on the Drawings, rough formwork may be used for all surfaces which are not permanently exposed. Rough formwork may be constructed of plain butt-jointed sawn timber but the Contractor shall ensure that all joints between boards shall be grout-tight.

(2) The finished surface shall be within the tolerances specified and full cover to reinforcement steel shall be maintained.

904 PREPARATION OF FORMWORK

(1) Before concrete is placed, the surfaces of formwork shall free from adhering foreign matter, projection nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter.

(2) Before placing concrete all reinforcement bars, anchoring, steel, beams, cables, fixing truss, bolts, pipes or conduits or any other fixtures which are to be built in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without the approval of the Engineer.

(3) All exterior and interior angles on the finished concrete of 90º or less shall be given 20 mm by 20 mm chamfers unless otherwise shown in Drawings or ordered by the Engineer. When chamfers are to be formed, the fillets shall accurately cut to size to provide a smooth and continuous chamfer.

(4) No ties or bolts or other device shall be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such supports embedded in reinforced concrete shall be capable of removal so that no part remaining embedded in the concrete shall be nearer than 50 mm from the surface. Holes left after removal of such supports shall be neatly filled with well rammed dry-pack mortar in accordance with Section 900.

(5) After cleaning, the formwork in contact with the concrete shall be treated with suitable non-staining mould oil or approved from of oil to prevent adherence of the concrete. Care shall be taken to prevent the oil from coming in contract with reinforcement or mixing with the concrete. At construction joints, surface retarding agents shall be used only where ordered by the Engineer.

(6) All formwork shall be inspected and approved by the Engineer before concrete is placed in it though this shall not relieve the Contractor form the requirements as to soundness, finish and tolerances of the concrete specified elsewhere.

905 REMOVAL OF FORMWORK

(1) Formwork shall be removed in such a manner as will not damage the concrete. No formwork shall be removed until the concrete has gained sufficient strength to support itself. Centres and props may be removed when the member being supported has gained sufficient strength to carry itself and the load to be supported on it with a reasonable factor of safety.

(2) The following table is a guide to the minimum periods which must elapse between the completion of the concreting operations and the removal of formwork. No formwork shall be removed without the permission of the Engineer and such permission shall not relieve the Contractor of his responsibilities for the safety of the Structure.

Table 9.1 Minimum period of curing before removal of formwork

Type and Position of Formwork	Approximate Period (days)
Side of beams, walls and columns (unloaded)	3
Slab soffits (props supporting)	14
Removal of props to slabs	21
Beam soffits (props supporting)	21
Removal of props to beams	28

(3) Notwithstanding the foregoing the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

906 JACKS, WEDGES, CHAMFER STRIPS

Formwork for the support of a bridge superstructure shall contain suitable jacks, wedges or chamber strips to set the forms to the required grade and to take up any settlement in the framework either before or during the placing of concrete.

907 OPENINGS

Temporary and permanent opening in concrete shall be framed neatly with provisions for keys or reinforcing steel as shown on the drawing or directed by the Engineer.

908 9DEFECTS IN FORMED SURFACES

(1) Workmanship in formwork and concreting shall be such that concrete shall normally require no repair to surfaces being perfectly compacted and smooth.

(2) If any blemishes are revealed after removal of formwork, the Engineer's decision concerning remedial measures to be undertaken shall be obtained immediately. These measures may include, but shall not be limited to, the following:

a) fins, pinholes, bubble, surface discoloration and mirror defects may be rubbed down with sacking immediately the formwork is removed;

b) abrupt and gradual irregularities may be rubbed down with carborundum stone and water after the concrete has been fully cured;

c) deep honey combed concrete shall be repaired within 24 hours of stripping the formwork by cutting back to sound concrete. The concrete shall be cut back at least 50 mm behind face reinforcement. Cut edges shall be regular and not feathered. Recasting shall be with the same concrete as the original casting; the Contractor's formwork and method of placing shall be approved by the Engineer;

d) under some circumstances, abrupt and gradual irregularities of shallow honey combed concrete may be repaired by cutting back and reforming with an approved epoxy resin or mortar in accordance with the Manufacturer's instructions.

909 HOLES TO BE FILLED

(1) Holes formed in concrete surfaces by formwork supports or the like shall be filled with dry pack mortar made from one part by weight of ordinary Portland cement and three parts of specified fine aggregate approved by the Engineer. The mortar shall be mixed with only sufficient water to make the materials stick together when being molded in the hands.

(2) The Contractor shall thoroughly clean any hole that is to be filled and break out any loose, broken or cracked concrete or aggregate, removing any dry cement in the hole. The surrounding concrete shall be soaked until the whole surface that will come into contact with the dry pack mortar has been covered and darkened by absorption of the free water by the cement. The Surface shall then be dried so as to leave a small amount of free water on the surfaces.

(3) The dry pack material shall then be placed and packed in layers having a compacted thickness not greater than 10 mm in thickness. The compaction shall be carried out by use of a hardwood stick and a hammer and shall extend over the full area of the layer, particular care being taken to compact the dry pack against the sides of the hole;

(4) After compaction the surface of each layer shall be scratched before further loose material is added. The hole shall be slightly over filled and the surface shall be finished by laying a hardwood block against the dry pack fill and striking the block several times.

Chapter 10

1000 REINFORCEMENT

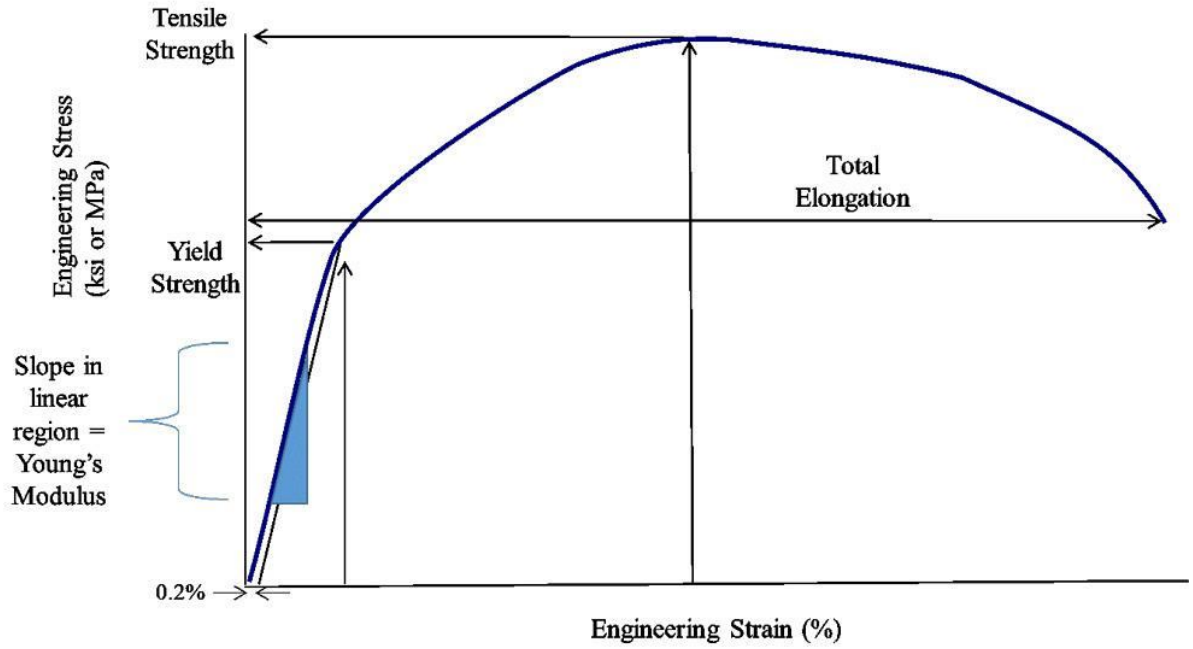
1001 GENERAL

(1) The steel reinforcement shall be prepared and fixed in accordance with the Drawings furnished by the Engineer.

(2) The Contractor shall provide the Engineer, the bar bending schedules detailing the reinforcement required for the Works. Such schedules are to be approved by the Engineer prior to the commencement of work. Approval shall not relive the Contractor from his responsibilities under the Contractor for providing the materials called for on the Drawings. All further working drawings and lists of reinforcement necessary to carry out the Works shall be provided by the Contractor at his own cost.

(3) All reinforcement delivered to the site shall be stacked prior to use off the round and kept free from dirt, oil, grease and avoidable rust.

(4) Stress-Strain Curve of Steel are as follows :



1002 STEEL REINFORCEMENT

1. ASTM specification shall be followed for Steel Reinforcement. ASTM A615 is an international material standard for reinforcement bar made from billet steel for strengthening application.

2. Steel Reinforcement bars shall be mild steel, made from billet structural grade and shall conform to following specifications.

(1) Code or standard	:	Standard of equivalent code: ASTM A575, A615-Grade-40 & 60, A-576.
(2) Chemical Composition (%)	:	P (Phosphorous) – 0.05 % max. S (Sulphur) – 0.05 % max.
(3) Physical Properties	:	Strength : According to Table 10.1 Elongation : 20% minimum. (min. gauge length – 5 dia).
(4) Standard Dimension & Weight	:	According to Table 10.2
(5) Dimensional tolerance	:	Below 28mm bar +/- 0.5mm Above 28mm bar +/- 0.5mm
(6) Weight tolerance	:	The difference between calculated Weight and actual shall be within +/-3.5%.

SPECIFICATION OF STRENGTH

3. For Steel Reinforcement to be acceptable, Minimum value of both Yield Stress and Tensile Strength shall be achieved. Strength of Steel Reinforcement of different Grade are as follows :

TABLE 10.1: SPECIFICATION OF STRENGTH

Grade of steel	Minimum Yield Stress (N/mm^2 or MPa)	Minimum Tensile Strength (N/mm^2 or MPa)
40	276 (40 ksi)	483 (70 ksi)
60	412 (60 ksi)	620 (90 ksi)
75	517 (75 ksi)	690 (100 ksi)

STANDARD DIMENSION & WEIGHT

4. Reinforcing Steel may be either plain or deformed or ribbed twisted. All reinforcement bars shall be Mild Steel made from Billet Structural Grade and shall conform to following specifications.

TABLE 10.2: STANDARD DIMENSION & WEIGHT

Bar Diameter		Cross Sectional Area		Perimeter		Unit Weight	
in	mm	in²	mm²	in	mm	1b/ft	Kg/m
1/4	6.356	0.05	28.27	0.79	18.85	0.167	0.249 0.22
5/16	7.94 8	0.07	50.26	0.98	25.13	0.261	0.370 0.395
3/8	9.525 10	0.11	78.54	1.18	31.42	0.376	0.56 0.62
1/2	12.70 12	0.20	113.10	1.57	37.70	0.688	0.99 0.89
5/8	15.875 16	0.31	201.06	1.96	50.27	1.043	1.56 1.58
3/4	19.05 20	0.44	283.53	2.36	59.69	1.502	2.24 2.46
7/8	22.23 22	0.60	380.13	2.75	69.12	2.044	3.05 2.98
1	25.40 25	0.79	490.87	3.14	78.54	2.670	3.98 3.85
1-1/8	28.65 28	1.00	615.75	3.54	87.96	3.400	5.06 4.83
1-1/4	31.75 32	1.27	804.25	3.99	100.53	4.303	6.22 6.31

REQUIREMENTS OF DEFORMED BAR

5. Deformations shall be spaced along the bar at substantially uniform distances. The deformation on opposite sides of the bar shall be similar in size and shape.

6. The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45º (degree) where the line of deformation forms and included angle with the axis of the bar of form 45º to 70º (degree), inclusive, the deformations shall alternately reversed in direction form those on the opposite side. Where the line of deformation is over 70º (degree) a reversed in direction is not required.

7. The average centre to centre or distance between deformation on each side of the bar shall not exceed seventeenths of the nominal diameter of the bar.

8. The overall length of deformation shall be such that the gap between the extreme ends of the deformations on opposite sides of the bar shall not exceed 12.5% of the nominal perimeter of the bar where the extreme ends terminate in a longitudinal ribs are involved the gap where more than two longitudinal ribs are involved the total width of all longitudinal ribs shall not exceed 25% of the nominal perimeter of the bar; furthermore the summation of gaps shall not exceed 25% of the nominal diameter of the bar. The nominal diameter.

9. The minimum height of deformations shall be not less than the following percentages of the nominal diameter of the bar.

Diameter of the M.S Rod	Minimum height of Deformation in Percent of nominal Diameter of bar
10 mm dia	4.0
12 mm dia	4.0
16 mm dia	4.5
20 mm dia	5.0

10. The Spacing, Height and Gap of deformations shall conform to the requirements prescribed below:

Bar size	Max. average Spacing in mm	Min. average Height in mm	Max. gap in chord 12.5% nominal perimeter
10 mm dia	6.7	0.38	3.5
12 mm dia	8.9	0.51	4.9
16 mm dia	11.1	0.71	6.1
20 mm dia	13.3	0.96	7.3
22 mm dia	15.5	1.11	8.5
25 mm dia	17.8	1.27	9.7
28 mm dia	20.1	1.42	10.9

RIBBED TWISTED BARS

<table>
<tr><td>i.</td><td>Quality Mark</td><td colspan="4">High Strength Ribbed Twisted Bar</td></tr>
<tr><td>ii.</td><td>Code or Standard</td><td colspan="4">Ribbed Twisted Bars shall conform to British Standard : BS 1144 & BS 4461 (1969); or Indian Standard : IS 1986-1979 or equivalent.</td></tr>
<tr><td rowspan="3">iii.</td><td rowspan="3">Chemical composition</td><td colspan="4">Ribbed twisted Bar shall made from soft Mild Steel with maximum Limit (percent) of:</td></tr>
<tr><td colspan="2">Carbon</td><td>Sulphur</td><td>Phosphorous</td></tr>
<tr><td colspan="2">0.25%</td><td>0.055%</td><td>0.055%</td></tr>
<tr><td rowspan="5">iv.</td><td rowspan="5">Physical Properties</td><td colspan="2">Yield Stress</td><td colspan="2">400 N/mm²</td></tr>
<tr><td colspan="2">Tensile Stress</td><td colspan="2">621 N/mm²</td></tr>
<tr><td colspan="2">Elongation (Gauge length 5d)</td><td colspan="2">14.50%</td></tr>
<tr><td colspan="2">Bend Test</td><td colspan="2">Around a mandrel of 3d through 45 degree and reverse bend through 23 degree.</td></tr>
<tr><td colspan="2">Rebend Test</td><td colspan="2">Around a mandrel of 5d, through 45 degree and reverse bend through 23 degree.</td></tr>
<tr><td rowspan="4">v.</td><td rowspan="4">Rib
Requirement</td><td colspan="2">Pivot length of any Rib</td><td colspan="2">8 to 12 bar dia (after twisting)</td></tr>
<tr><td colspan="2">Width of all longitudinal</td><td colspan="2">25% (max.) of nominal perimeter</td></tr>
<tr><td colspan="2">Longitudinal Rib</td><td colspan="2">A uniform continuous rib parallel to the axis of the bar before twisting.</td></tr>
<tr><td colspan="2">Traverse Rib (or Lug)</td><td colspan="2">Weight in kg/m</td></tr>
<tr><td rowspan="4">vi.</td><td rowspan="4">Standard Dimension
And Weight</td><td colspan="2">Dia in mm</td><td colspan="2">Weight in kg/m</td></tr>
<tr><td colspan="2">6</td><td colspan="2">0.222</td></tr>
<tr><td colspan="2">8</td><td colspan="2">0.395</td></tr>
<tr><td colspan="2">10</td><td colspan="2">0.617</td></tr>
</table>

		12	0.888
		16	1.578
		20	2.466
		22	2.980
		25	3.854
		28	4.830
		32	6.313
vii.	Dimensional and Weight tolerances.	As plain and Deformed bar mentioned previously	

PLAIN M.S BAR (MADE FROM SCRAP)

11. Plain M.S bar made from scrap may be used in minor structures if specified. Minimum Yield Strength (f_y) for such bars shall be 248 N/mm². All other criteria shall be similar to those of M.S bars from billets.

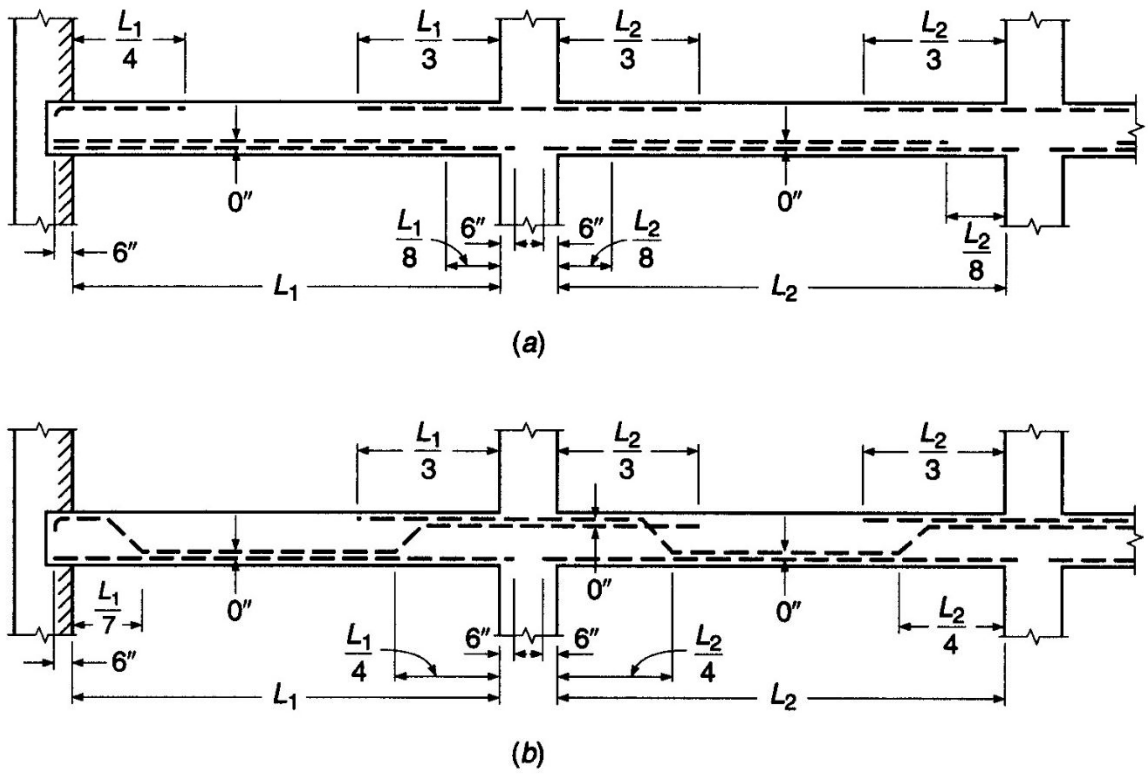
1003 CUTTING AND BENDING

(1) All cutting and bending shall be in accordance with standard approved practice. Straightening of bends and re-bending of incorrectly bent bars shall not be permitted. Bars shall be bent cold by use of an approved bending machine.

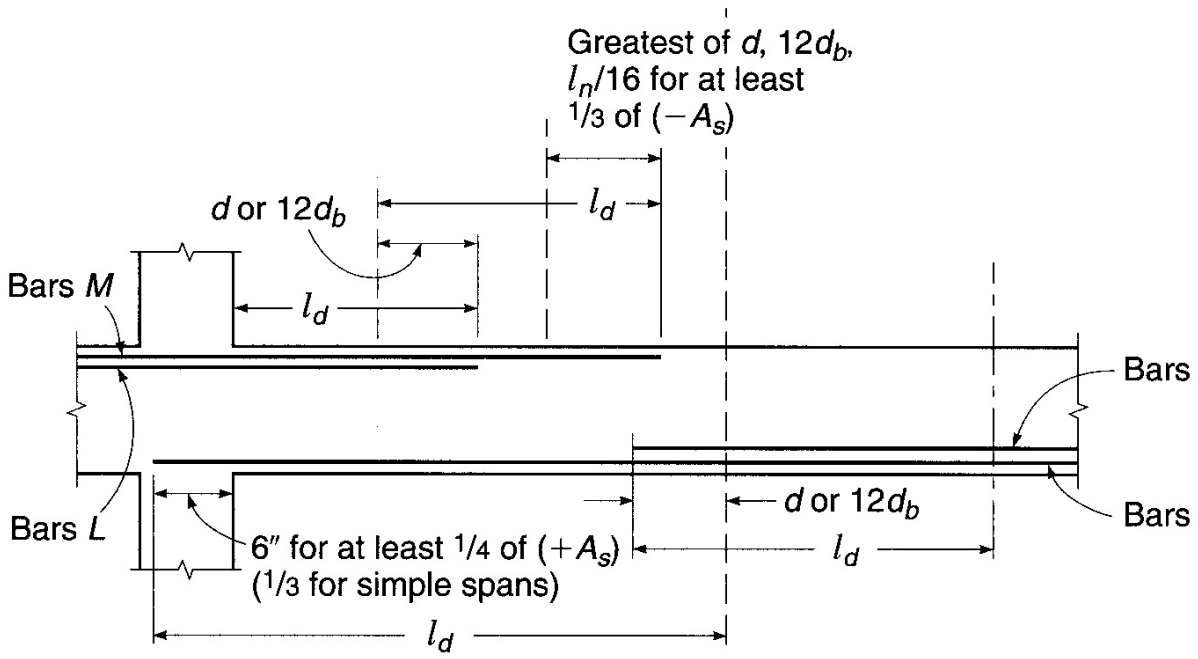
(2) Bending radii shall be made as specified on the drawings with a bend made round having a diameter of at least three times the diameter of the bar. The radius of bend shall be made on the inside of the bar. If the radii are not shown on the Drawings, ACI standards shall be followed. Extension at the free end of bar is as follows :

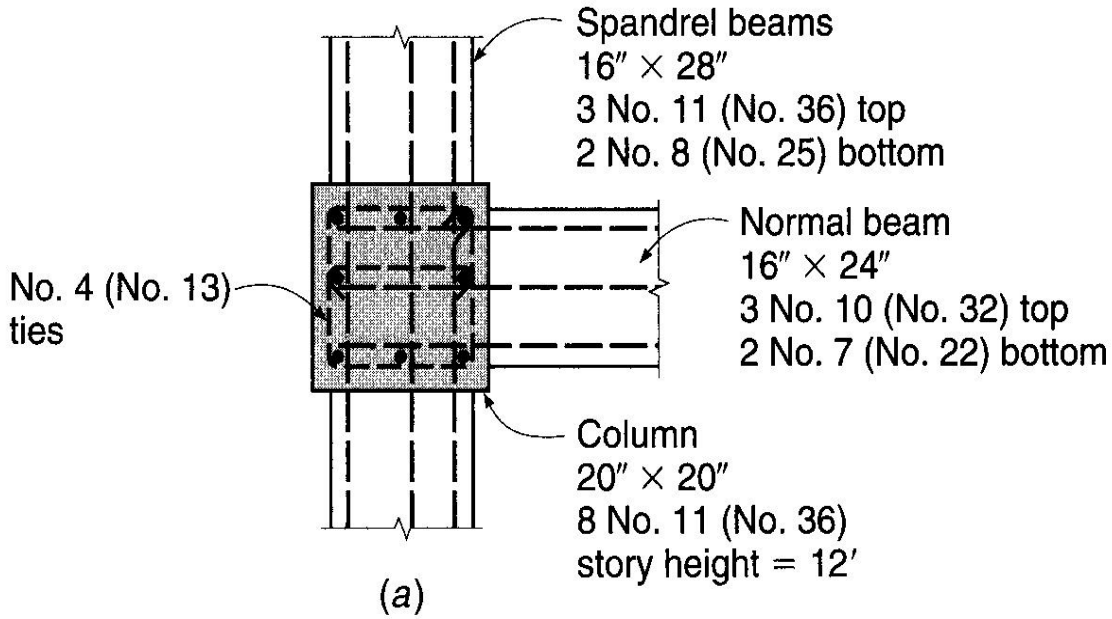
1. A semicircular turn plus an extension of at least 4D (four bar diameter), but not less than 62mm at the free end of bar.
2. A 90º turn plus an extension of at least 12D (twelve bar diameter) at the free end of bar.
3. For stirrup and tie anchorage, either a 90º or 135º turn plus an extension of at least 6D (six bar diameter), but not less than 62mm at the free end of bar.

(3) Where splices or overlapping in reinforcement are required the bars shall, unless otherwise shown on the drawings, have and overlap of not less than thirty times the diameter where a U-Hook is employed on each of the overlapping bars and forty-five times the diameter for bars without hooks.

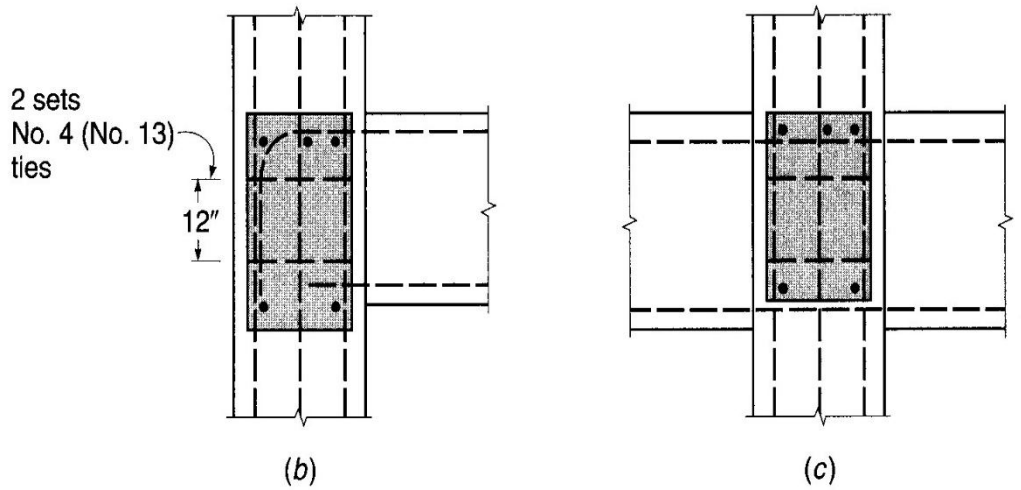


Cutoff or bend points for bars in approximately equal spans with uniformly distributed loads

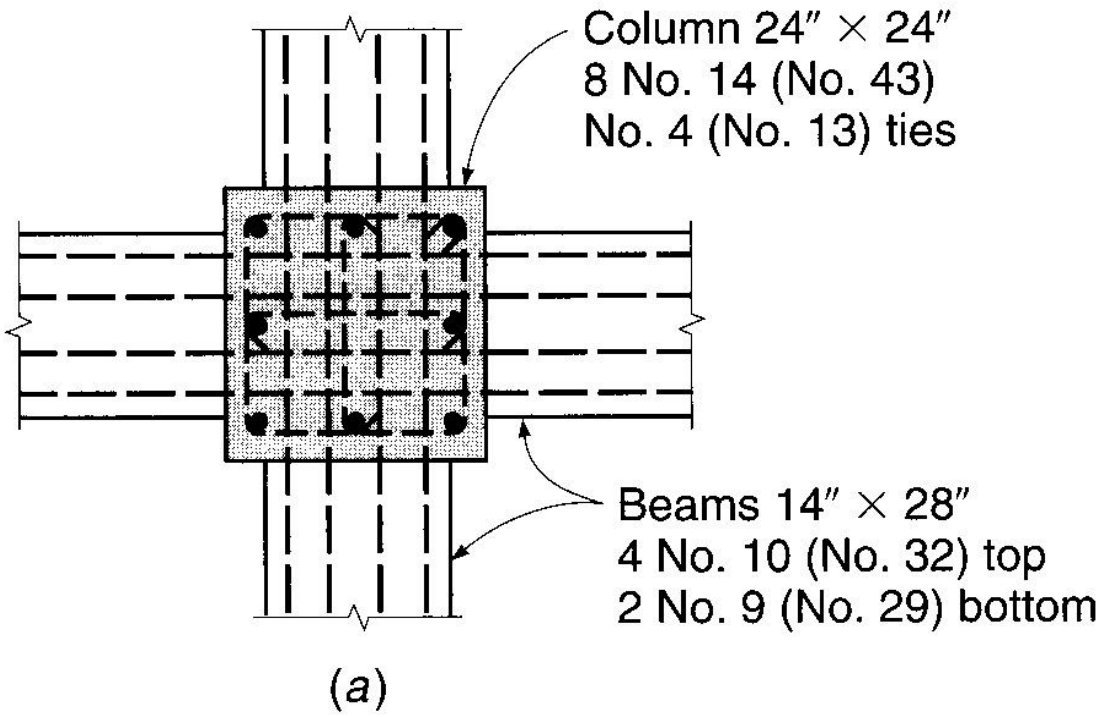




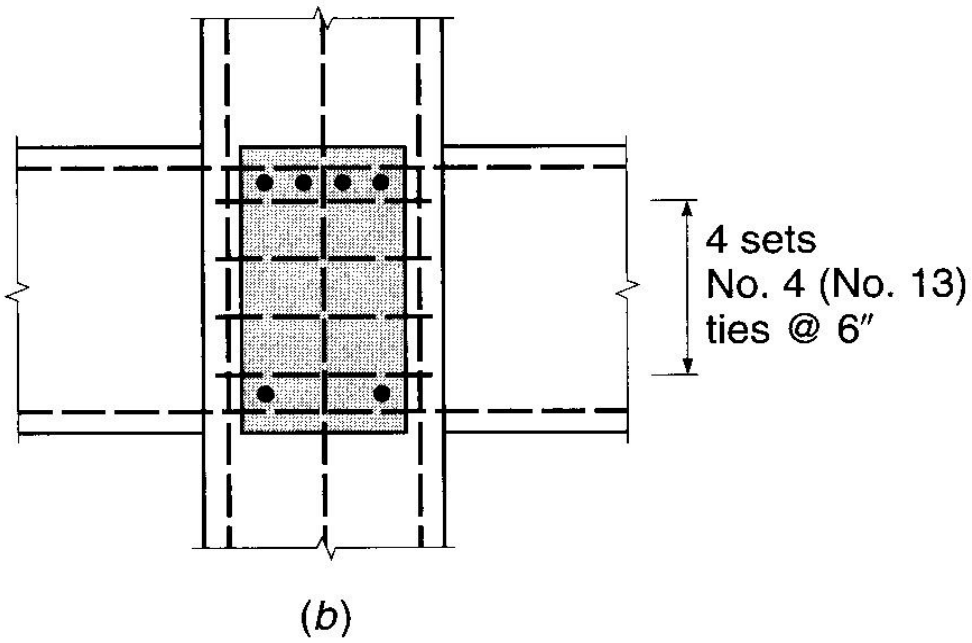
Exterior beam-column joint (a) Plan view



Exterior beam-column joint for
(a) cross section through spandrel beam;
(b) cross section through normal beam



Interior beam-column joint (a) plan view



Interior beam-column joint (b) section through beam

1004 PLACING AND FIXING REINFORCING STEEL

(1) All reinforcement shall be securely and accurately fixed in position shown on the drawings using approved spacer blocks and chairs. Tolerance allowance for placing reinforcement shall not exceed 12mm. No splices of reinforcement shall be made other than as shown on the Drawings or approved by the Engineer.

(2) All intersections of bars shall be secured with No. 22 to 18 gauge galvanized iron wire, the ends being turned into the body of the concrete. The reinforcement shall be held securely in place to the lines and grades shown on the Drawings by approved concrete supports, spaces or ties with particular care being taken during placing of the concrete.

(3) The specified concrete cover to reinforcement shall be maintained with the aid of approved supports and spacer pieces. Top reinforcement in slabs shall maintained in position by means of chairs made out of mild steel, the diameter and quantity being sufficient to ensure security of the reinforcement shall be used to support access ways, working platforms, or the placing equipment or for the conduction of an electric current. Reinforcement supports and spacers shall be sufficient to maintain reinforcement in place throughout the concerting operation and shall not be exposed on the concrete face or discolor the finished concrete.

(4) Before any steel reinforcement is embedded in the concrete any loose mill scale, loose rust and any oil, grease or other deleterious matter shall be removed. Partially set concrete which may adhere to the exposed bars during concreting operations shall be removed.

1005 WELDING OF REINFORCEMENT

(1) Reinforcement which is specified to be welded shall be welded by any process the Contractor can demonstrate by bend and tensile tests which will ensure that the strength of the parent metal is not reduced and that the weld possesses strength no less than that of the parent metal. The welding procedure established by the successful test weld shall be maintained and no departure from this procedure shall be permitted. Following the establishment of satisfactory welding procedures, each welder to be employed on the work shall carry out welding performance qualification tests on reinforcing bars of the same metal and size as those on the works.

(2) Welds in positions other than those shown on the Drawings shall not be permitted.

1006 CONCRETE COVER TO REINFORCEMENT

(1) Unless specified on the Drawings, the clear concrete cover to reinforcement shall be as tabulated below:

Table 10.3: CLEAR CONCRETE COVER TO REINFORCEMENT

Description of Concrete Element	Clear Cover (mm)	
	Normal Exposure	Saline Water
Wall and floor slab :		
- Contract with earth	60	75
- exposed to weather and water	50	60
Piles : Cast-in-Situ	75	100
Pre-cast	40	50
Beam, Girder, Column	40	50
Building Roof and Floor Slab	25	30
Bridge Pier	50	60
Bridge Deck Slab	40	40
Railing	25	25

(2) Cover shall be maintained by the use of the minimum practical number of concrete block, approved spacers and reinforcement chairs. Concrete spacer blocks shall be made from cement, sand and small aggregate to match the mix proportions of the surrounding concrete as far as practical to ensure comparable strength, durability and appearance.

Chapter 11

1100 JOINTS IN CONCRETE

(1) Cracks in concrete can't be prevented completely, but they can be prohibited or minimized by properly designed joints. Concrete cracks are caused because:

- The Concrete is weak in tension, if its natural tendency to shrink is restrained, in such a way that tensile stresses exceed the tensile strength it can develop, it will result in cracking.
- At early stages, cracking is caused by temperature changes or by slight contractions that take place as the concrete sets and hardens. As the concrete dries, it shrinks further developing additional cracks or widening preexisting cracks.

(2) Joints provide relief from the tensile stresses. Joints are easy to maintain and are less detrimental than uncontrolled or uneven cracks.

(3) Concrete expands & shrinks with variations in moisture and temp. The overall affinity is to shrink and this can cause cracking at an early age. Uneven cracks are unpleasant and difficult to maintain but usually do not affect the integrity of concrete. The Joints are pre-planned cracks. Joints in concrete slabs can be created by forming, sawing, tooling, & placement of joint formers.

1101 CONSTRUCTION JOINTS

(1) A construction joint is defined by the ACI as 'the surface where two successive placements of concrete meet, across which it may be desirable to achieve bond and through which reinforcement may be continuous. Generally, because continuity of structural action will be required across the joint, bond will be desirable and the reinforcement will be continuous.

(2) Construction joint are typically placed at the end of a day's work or when concrete placement is stopped for longer time than the initial setting time of concrete. The locations of construction joints should be predetermined. This is desirable to achieve bond and continue reinforcement through joint. If possible, they should be positioned away from regions of high shear or high moment.

(3) Concrete surfaces upon or against which concrete is to be placed and to which new concrete is to be placed, that have become rigid that the new concrete cannot be incorporated integrally with that previously placed. Formed vertical or inclined construction joints as well as unformed joints which are due to interruption of concrete placement will only be permitted where shown on the Drawings or directed by the Engineer. All exposed faces of construction joints shall be made absolutely straight, level or plumb and normal to finished surface.

(4) Surfaces of construction joints shall be prepared as early as possible after casting. The preparation shall consist of the removal of all laitance, loose or defective concrete coatings, sand and other deleterious materials. Preparation shall be carried out preferable when the concrete has set not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregate without its being disturbed. Where this treatment is impracticable and work is resumed on a surface which has set, the whole surface shall be thoroughly roughened or scrabbled with suitable tools so that no smooth skin of concrete that may be left from the previous work is visible.

(5) The prepared joint face shall be thoroughly cleaned by compressed air and water jets or other approved means and brushed and watered immediately before depositing concrete. If so, ordered the roughened surface shall be covered with cement mortar prior to placing the new concrete. Immediately before new concrete is placed, all construction joints shall be wetted and standing water removed.

1102 DESIGN JOINTS

GENERAL

(4) Design joints shall be formed in the positions and manner shown on the Drawings and shall be shuttered square to the work to provide a smooth surface to the concrete. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. The face of the joint first formed shall be smooth, dense and free from irregularities and honeycombing. The plane of the joint shall extend completely through the structure unless shown otherwise on the Drawings.

(5) Caulking grooves shall be provided as shown on the Drawings or in accordance with the joint sealant manufacturer's recommendations. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried it shall be primed and caulked with approved Sealant compound applied in accordance with the manufacturer's instructions.

(6) Filters, as specified on the drawings, shall be placed between the joints and adjacent earth surface.

(7) Construction joints in floors shall be located within the middle third of spans of slabs, beams and girders. Joints in girders shall be offset a minimum distance of two times the width of intersecting beams.

CONTRACTION JOINTS

(8) Contraction joints are defined as joints placed in structures or slabs to provide for volumetric shrinkage of monolithic unit or movement between monolithic. The joints shall be constructed so that there will be no bond between the concrete surface forming the joints.

EXPANSION JOINTS

(9) Expansion joints are intended to accommodate relative movement between adjoining parts of a structure. The size of expansion joints shall upto 40 mm depth and 20-25 mm wide.

(10) A compressible filler shall be placed between the joint faces to provide freedom for the two adjacent concrete masses to expand. Care shall be taken to ensure that the material fills the joint completely and that no concrete or hard material is left in the joint after the second face of the joint has been cast.

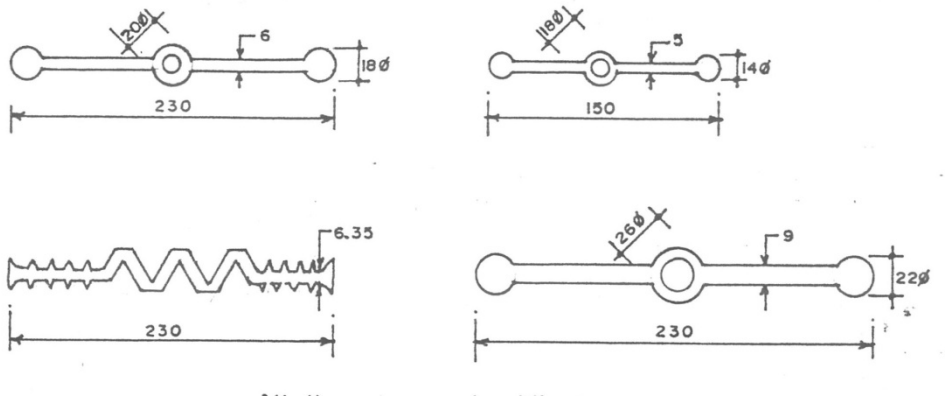
1103 WATER STOPS

(1) Where shown on the Drawings, Construction (as required and approved by the Engineer), Contraction and Expansion Joints shall be made watertight by the

provision of a continuous water stop strip of polyvinyl - chloride (PVC), fixed across the joint.

(2) PVC is used to waterproof Contraction and Expansion Joints by embedding it in both sides of the joint to create a physical barrier. A variety of widths, thicknesses, and sizes are available to suit almost any joint. The advantage of PVC waterstops is that they can be installed in virtually any conditions, including rainy and wet conditions. They also tend to last for a long time. The challenge comes in the actual install process. It takes time to correctly position the PVC to embed it in the joint, and during the concrete pour, it can easily become damaged.

(3) Unless otherwise specified or ordered, a three bulb dumbbell section P.V.C waterstop shall be used in contraction joints and a three bulb section PVC water stop shall be used in expansion joints.



All dimensions are in mm

(4) Waterstops shall be of high grade PVC containing no filler or reclaimed or scrap material. PVC shall comply with the requirements of BS 2571 for PVC type A, class 1 and Item Code No. 76-630 of Schedule of Rates of BWDB. The quality of water stops shall comply with the following major requirements.

Specific gravity	1.30 (max)
Hardness	80 (min)
Tensile strength	13.80 N/mm² (min)
Elongation	225% (min)

(5) The waterstops shall be obtained from a manufacturer's approved by the Engineer, and shall be fixed and jointed according to the manufacturer's instructions. All strips shall be stored in a place as cool as practicable and shall in no case be exposed to the direct sun light.

(6) Waterstops shall be installed with approximately half of the width of the material embedded in the concrete on either side of the joint. It shall be firmly supported by split stop-end shuttering and in no case shall be water stop be pierced to assist in fixing. Special care shall be taken to ensure that the concrete is well worked against the embedded parts of the strips and is free from honeycombing. Precautions are to be taken to protect any projecting portions of the strips from damage during the progress of the works and from sunlight and heat.

(7) If, after placing concrete, water stops are moved out of position or shape, the surrounding concrete shall be removed, the water stop reset, and the concrete replaced at the Contractor's own expense. Two 9 mm reinforcing bars shall be provided to

support the water stops and shall be securely held in position by the use of spacers, supporting wires, or other approved devices.
(8) Flexible waterstops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged waterstops shall be replaced and during concreting care shall be taken to place the concrete so that waterstops do not bend or distort.

(9) Splicing of polyvinyl chloride waterstop shall be performed in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splice. The heat shall be sufficient to melt but not char the plastic. Splices shall develop at least 90 percent of the tensile strength of unspliced materials and shall withstand bending 180 degree around a 50 mm diameter pin without cracking or separating.

(10) The Contractor shall submit to the Engineer for his approval, as soon as practicable after acceptance of his tender and not less than a month before the commencement of concreting, details of his proposals for the installation of water stops. These shall show where joints in the waterstops are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint or shape of any moulded section.

(11) As far as possible, jointing of PVC waterstops on site shall be confined to the making butt joints in straight runs of waterstops. Where it is agreed with the Engineer that it is necessary to make an intersection or change of direction of any joint, other than a butt joint in a straight run, on site a preliminary joint, intersection or change of direction piece shall be made and submitted to such tests as the engineer may require.

1104 JOINT SEALANT

(1) Unless otherwise shown on the Drawings or ordered by the Engineer, joint sealants shall be a hot poured rubber bitumen compound for horizontal joints and either a bituminous compound or an electrometric two part polysulphide sealant for sloping, vertical and soffit joints.

(2) Bituminous compounds shall comply with BS 2499 for horizontal joints and BS 2499 type A1 for sloping or vertical joints. Polysulphide compound shall comply with BS 4254.

(3) Such joint sealants and the requisite priming materials shall be obtained from manufacturer's approved by the Engineer's instructions. The application of joint sealant shall not be commenced without the Contractor having first obtained the approval of the Engineer.

1105 COMPRESSIBLE FILLER

The Contractor shall supply and fix pre-moulded joint fillers in all expansion joints and where shown on the drawings. Unless otherwise specified, the joint filler shall be of resin or bituminous bonded cork such as "Hydrocor" as manufactured by Expedite. The filler shall be obtained from a manufacturer's approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions. The joint filler of the thickness specified shall be cut to shape and fixed to fill the whole space between the concrete faces of the joint sealer. Abutting pieces shall bed in close contact and the joints covered on each side to prevent the passage of cement grout.

1106 BITUMEN COATED JOINTS

Where the Drawings show bituminous paint between concrete faces, the Contractor shall clean and dry the face to which the paint is to be applied and shall then paint the bitumen on in two separate applications. The bitumen shall be straight run bitumen, grade 80/100 penetration, or other approved by the Engineer.

1107 BITUMEN SHEETING

The bitumen sheeting, laid on the horizontal top surface of expansion joint keys shall be a 10 mm thick material approved by the Engineer.

1108 DOWEL BAR AND CAP

(1) Where shown on the Drawings, dowel bars shall be incorporated in movement joints and bridge bearings. The dowel bars shall be a round mild steel bar of the diameter and length indicated on the Drawings and the top of the bar shall be covered with an approved dowel cap. The capped end of the dowel bar shall be sawn square; bar cropping will not be permitted.

(2) Where dowel bars are to be provided through movement joints the part of the bar to be free to move shall be coated with approved bond breaking bitumen paint and fitted with a compressible cap. The cap shall be of such a diameter to provide a sliding fit on the bar and of length indicated on the Drawings. The cap shall be partially filled with an approved compressible filler.

Chapter 12

1200 STEEL SHEET PILE

1201 GENERAL

(1) In BWDB, Steel Sheet Pile mainly used under Hydraulic Structure for seepage control. Steel Sheet Pile must be water tight. Steel Sheet Pile is not used as a structural element under Hydraulic Structure. Life time of Steel Sheet Pile shall be same as that of Hydraulic Structure. So, corrosion is the most critical issue for Steel Sheet Pile used under Hydraulic Structure. From corrosion point of view, thickness of whole section is very important. It is necessary to have a same thickness for the whole section.

(2) To make the wall of Steel Sheet Pile a water tight one, locking with adjacent Sheet Pile is the most important issue. For complete locking, efficient driving is essential. For complete locking and efficient driving, Steel Sheet Pile must be manufactured from hot roll.

(3) There is also other use of Steel Sheet Pile such as flood wall, earth retaining wall, shoring in foundation trench etc. Here Steel Sheet Pile used as a structural element. Here same thickness for the whole section is not necessary.

1202 SPECIFICATIONS OF STEEL SHEET PILE

(1) Steel sheet piling shall either be supplied by BWDB or by the contractor. This specification specifies steel sheet piles for use in cut-off wall of hydraulic structures except otherwise mentioned in the drawing. Only hot rolled steel sheet piles shall be used in cut-off wall of hydraulic structures except otherwise mentioned in the drawing.

(2) Steel sheet piles shall not show harmful defects under use. It shall be straight and out end surfaces shall be flat, for all practical purposes. It shall be adequately locked with adjacent piles during driving provided that they can be disengages for extracting.

(3) Joints of steel sheet pile shall be watertight provided their structure does not obstruct driving and extraction.

(4) Tensile strength of joints straight line-type steel piles shall not be less than 400 Ton/m.

(5) Steel sheet piles shall be classified in accordance with the cross sectional shapes given below :

U-type	:	It is roughly of U-shape with joints of piles when driven located on the neutral axis of the piling work.
Straight line type	:	It is of flat shape close to a straight line with high resistance to tensile force.

(6) Length of steel sheet piles shall be in terms of whole numbers of maters for standard lengths and shall be measured in divisions of 500 mm. There shall be one handling hole of diameter 25 mm to 60 mm, the centre of which is to be located 100 mm to 300 mm from one end.

(7) The size and weight of the steel sheet pile shall be as follows or equivalent to British Standard Specification.

(a) **U-Type Steel Sheet Pile**

Width (w)	Height (h)	Thickness (t)	Cross Sectional Area	Weight		Elastic Section Modulus	Moment of Inertia	Coating Area (both sides per pile)
				Per Pile	Per Wall			
mm	mm	mm	cm^2/m	kg/m	kg/m	cm^3/m	cm^4/m	m^2/m
400	85	8	-	35.5	88.88	529	4500	-
400	100	10.5	152.9	48	120	874	8,740	1.33
400	125	13	191.1	60	150	1,340	16,800	1.44
400	150	13.1	186	58.4	146	1,520	22,800	1.44
600	180	13.4	173.2	81.6	136	1,800	32,400	1.9
600	130	10.3	131.2	61.8	103	1,000	13,000	1.77
400	170	15.5	242	76.1	190	2,270	38,600	1.61
600	210	18	225.5	106	177	2,700	56,700	1.99
500	225	27.6	305.7	120	240	3,820	86,000	1.82

Tolerance in Thickness of Sheet pile : $\pm\ 0.50mm$

(b) **Straight line Type Steel Sheet Pile**

Width	:	400 mm
Height	:	44.5 mm
Thickness	:	9.5 mm to 12.7 mm
Weight/m of pile	:	54.2 to 60.8 kg/m
Section Modulus	:	47.8 to 48.3 cm^3

(8) Steel sheet shall be rolled from structural carbon steel and shall have the following Chemical and Mechanical properties:

(i) **Chemical Properties**

Phosphorous : 0.04% (max)

Sulphur : 0.04% (max)

(ii) **Mechanical Properties**

Tensile strength : 490 N/mm²

Yield strength : 296 N/mm²

Elongation : 15% (min)

1203 TREATMENT OF STEEL SHEET PILE

(1) All corrosion, rust and old paint shall be cleaned from the surface of Steel Sheet Plie with power brush as per direction of Engineer. (Item code 76-180)

(2) All corrosion, rust and old paint shall be cleaned from the surface of Steel Sheet Plie with sand blasting with coarse sand (FM>=3) as per direction of Engineer. (Item code 76-185)

(3) 1 (one) coat of Zinc phosphate shall be provided as primary coat. 2 (two) coat of coaltar epoxy coat shall be provided over primary coat as per direction of Engineer. (Item code 72-180)

(4) The top 300 mm length of steel sheet piles, to be embedded in concrete as shown on the Drawings. A 20 mm gap, filled with impregnated Hessian cloth or an approved filler, shall be maintained above the piles. The filler, used in accordance with the manufacturer's instructions, shall be kept in position with clips etc. or as approved by the Engineer.

1204 PILING EQUIPMENT AND WORKMANSHIP

(1) Not less than 14 days before any piling work is commenced the Contractor shall submit to the Engineer for approval full details of his proposed piling plant and detailed method statements for carrying out the work. Where applicable, such details shall include a full description of the piling frame, hammer, helmet and packing, methods of handling, pitching and supporting the piles before and during driving, the proposed driving procedure and such further information as the Engineer may require.

(2) The piling frame shall be of sturdy construction supported on an adjustable base, securely guyed and with ample toggle connections to leaders so that the pile is firmly held at all times. The type and weight of hammer shall be to the approval of the Engineer and the weight of the hammer shall be at least half that of the pile, in general, a heavy hammer with a short drop should be used in preference to a light hammer with a longer drop.

(3) The Contractor Shall not commence any piling until the plant and methods which he proposes to use have been approved by the Engineer but such approval shall not relieve the Contractor from any of his obligations and responsibilities under the Contractor. If for any reason the Contractor wishes to make any change in the plant

and methods of working which have been approved by the Engineer, he shall not make any such change without having Engineer's approval.

1205 RECORDS

The Contractor shall keep complete of all data as required by the Engineer covering the fabrication, driving and installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after installation of the piles.

1206 PROGRAMME AND PROGRESS REPORT

(1) The Contractor shall inform the Engineer each day of the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.

(2) The Contractor shall submit to the engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of piling works, as required by the Engineer.

1207 SETTING OUT

(1) The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker the position of pile line. The main setting out for piles is to be complete prior to commencement of piling.

(2) Notwithstanding such checking and agreement, the contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

1208 TOLERANCE

(1) Piles shall be driven accurately vertical and the permitted deviation of the pile centre from the centre line shown on the Drawings or setting out plan shall not exceed 50 mm measured at the working level of the piling rig, or other level agreed by the Engineer.

(2) The maximum permitted deviation of the finished pile shall be 1 in 75 from the vertical.

1209 DISTURBANCE AND NOISE

(1) The Contractor shall carry out the piling work in such a manner and at such times as to minimize noise and disturbance. No pile driving will be allowed at night without prior permission from the Engineer.

(2) The Contractor shall take precautions to avoid damage to existing services and adjacent structures. Any such damage shall be repaired to the satisfaction of the Engineer.

(3) The Contractor shall ensure that damage does not occur to complete piling works and shall submit to the Engineer for approval his proposed sequence and timing for driving.

1210 OBSTRUCTIONS

If during the execution of the works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer and submit to him details for the proposed methods for overcoming the obstruction. The Contractor shall proceed in accordance with the approved method.

1211 PITCHING AND DRIVING OF STEEL SHEET PILES

(1) All sheet piles shall be driven in presence of the Engineer, authorized representative and no pile driving will be allowed at night without prior permission from the Engineer.

(2) Piles shall be accurately pitched and driven in the position and to the lines shown on the Drawings within the specified tolerance. The lengths of piles shall be as shown on the Drawings or such other lengths as the Engineer may direct. Piles shall be driven in a sequence approved by the Engineer.

(3) The steel sheet piling shall be assembled against the guides so that each pile is rigidly supported and plumb at both edges and side. All temporary guide structures shall be removed, shall be adequately supported and restrained without damage to the piles or any coatings or preservative treatment, by means of leaders, trestle, temporary supports or other guide arrangements to maintain position and alignment. Handling, slinging and pitching of piles shall be by methods approved by the Engineer.

(4) Piles deflected from the proper lines shall, where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained. No forcible method of correction of the position or line of any pile will be permitted. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving. The cost of withdrawing, re-pitching, re-driving to the previous level and filling with non-plastic materials shall be borne by the Contractor.

(5) Piles ruptured in the interlock or otherwise damaged in driving shall be pulled and new pile should be driven. If at any time the forward edge of the piling wall is found to be out of plumb, the piling already assembled shall be driven to the forward edge plumb before additional piling is assembled or driven.

(6) The maximum permissible taper in a single pile shall be 20 mm per meter of length. Splicing of piles during driving shall not be allowed except where specifically approved by the Engineer. Where welding of piles is approved by the Engineer for field conditions, welding shall be done in accordance with the direction of the Engineer.

(7) No pile (or pair of piles) shall be driven to less than one half or more than two thirds of the specified depth before the next pile (or pair of piles) has been driven to one half of the specified depth.

(8) Corner joints and special piles shall be fabricated in accordance with the Drawings and Section 1500.

Chapter 13

1300 PILE FOUNDATION

1301 CONCRETE PILES

(1) Piles shall be either cast-in-place or pre-cast. Unless otherwise specified or directed by the Engineer, all materials for the manufacturing of piles shall conform to the provisions of section 800, "Concrete" and Section 1000, "Reinforcement".

(2) The Contractor shall submit to the Engineer for approval, the type of piles proposed if not specified on the Drawings, the construction method and method of placement and testing of the piles.

1302 MANUFACTURE OF PRE-CAST PILES

GENERAL

(1) Pre-cast piles shall be manufactured in a casting yard in accordance with the Drawings.

(2) Concreting shall be placed in one continuous pour for each pile. Concreting shall started from the head and be progressed to the driving end of the pile.

(3) Each pile shall be indelibly marked with its sequential number and date of manufacture.

REINFORCEMENT

(4) The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement shall be firmly secured. Diagonal fork spacers shall be of an approved pattern.

(5) Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided at agreed centers, designed to develop the full strength of the bar across the joint, provided with adequate links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the approval of the Engineer. Concrete cover shall be maintained at the joints.

(6) Welding of joints in main longitudinal bars will not be permitted unless agreed in writing by the Engineer.

FORMWORK

(7) Formwork shall comply with Section 900 of this Specification and as per standard schedule of Rates Manual except as specified below. The head of each pile shall be square to the longitudinal axis. Holes for toggle bolts shall be at right angles to the faces of the pile and lined with steel tubes or other approved material. Holes for

lifting, handling and pitching shall be formed in the positions and according to the details shown on the Drawings or otherwise approved by the Engineer, and lined with steel tubes.

(8) Details of all pile shoes shall be submitted to the Engineer for approval prior to fabrication or supply. All shoes shall be fitted to the reinforcement as shown on the Drawings.

CASTING TOLERANCE

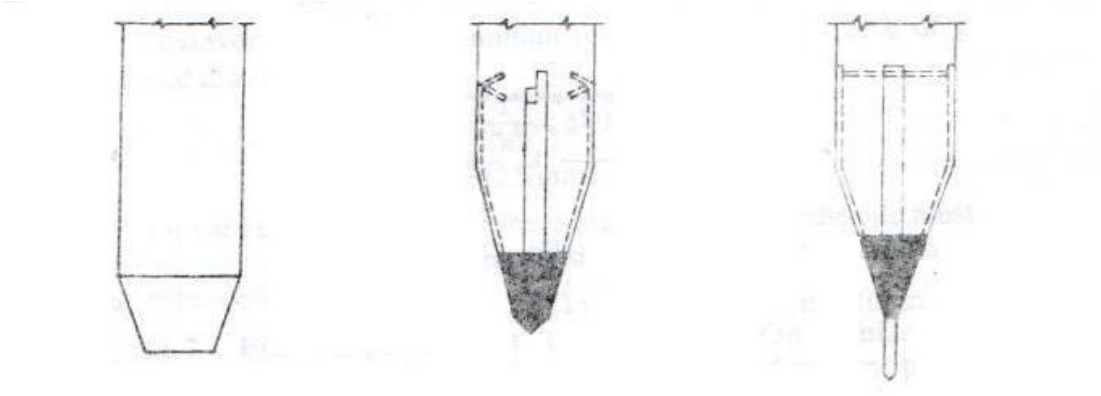
(9) The cross-sectional dimensions of piles shall not be less than those specified or shown on the Drawings and shall not exceed such dimensions by more than 6 mm.

(10) Unless otherwise directed by the Engineer, any face of a pile shall not deviate by more than 6 mm from a straight edge 3 m long laid on the face and the centroid of any cross-section of the piles shall not deviate by more than 12 mm from the straight line connecting the centroid of the end faces of the pile.

1303 PILE SHOES/HELMET

(1) Where applicable, pile shoes shall be manufactured by an approved supplier and consist of cast iron, cast steel or fabricated steel as shown on the Drawings.

(2) For driving into soft soil like loose filling, vegetable earth, river silt etc. the metallic shoe may not be used and pile cast with a blunt end will meet the requirements. This type is shown in Fig 13.1(a). When driving into hard rock or where heavy boulders are anticipated, a steel tapered shoe having a 7.5 cm to 10 cm diameter hardened steel rod projecting 15 to 25 cm is found satisfactory (Fig 13.1(c)). In all other cases, pile shoe shown in Fig 13.1(b) is commonly used.



(a) **(b)** **(c)**

Fig 13.1: Pile shoes

(3) Cast iron shoes shall be formed from chill hardened iron grade 10 in accordance with BS 1452 "Specification for Grey iron castings". Cast steel shoes shall be formed from steel to grade A, of BS 3100 "Specification for steel castings for general engineering purposes". Fabricated steel shoes shall be formed general steel to grade 43 A1 and steel straps and fastenings to Grade 43A of BS 4360 "Weldable structural steels".

(4) Casting shall be free from sand, honeycombing, porosity, blowholes or other defects. For cast shoes, straps and fastenings shall be of mild steel or wrought iron, cast into and running continuously through the base.

1304 HANDLING AND DRIVING PRE-CAST-PILES

(1) An equipment list with name plate data shall be submitted to the Engineer for approval before start of work.

(2) The precast piles shall be driven to a pre-planned sequence approved by the Engineer in presence of the Engineer's authorized representative. No pile driving will be allowed at night without prior permission from the Engineer.

(3) Before driving, the pile is held vertical at the specified location. For this, the pile laying on the ground has to be erected by being suspended by the crane at one point while the shoe of pile rests on the ground at the other end.

(4) Each pile shall be graduated in 30 mm intervals, and lifting points shall be marked as shown on the Drawings, with water proof paint. Piles are to be handled only when concrete has reached its characteristic strength as determined by field control test cylinders. Piles shall be handled carefully to avoid being dropped or severely jarred.

(5) Piles shall be protected with an approved cushion and cap while being driven. Pile driving shall be stopped when the maximum blows per 0.30 m reaches the number specified on the Drawings or if the pile head is damaged due to improper driving.

(6) Piles shall be rigidly secured by leads or temporary guide structure against lateral movement during driving and shall be driven without interruption from first blow of the hammer until the required penetration has been attained.

(7) Piles shall be driven to the positions, lines and elevations shown on the Drawings in accordance with the tolerances set out in Appendix A. If any piles are damaged or driven out of the Specified tolerance, the Contractor's proposed remedial measures shall submit to the Engineer for his written approval. Notwithstanding the Engineer's approval, the Contractor shall be solely responsible for the design and cost of the remedial works.

(8) The Contractor shall keep a pile driving register in a format approved by the Engineer, recording all data required by the Engineer covering dimensions, elevation of point, top elevation after cut off, type and weight of hammer, height of fall of hammer, number of blow for each 30cm, penetration per blow for the last 60cm. Five copies of the report shall be submitted to the Engineer before any payment will be made for this work.

1305 CAST-IN-PLACE CONCRETE PILES

(1) Cast-in-place piles shall consist of either : (a) Cast-in-place piles with steel shells or permanent casing or (b) drilled holes filled with enforced concrete.

(2) Contractor using steel shells or concrete casings shall submit design information and construction procedures to the Engineer for approval.

1306 DRILLING AND CONCRETING OF INSITU PILES

(1) All holes for concrete pile shall be drilled to the tip elevation shown on the Drawings. All holes shall be examined by the engineer for straightness and size. Any hole less than the diameter shown on the Drawings shall be rejected. Temporary casings shall be furnished and placed when required to prevent caving of the hole before concrete is placed therein. All holes shall be carefully cleaned and approved prior to placement of concrete.

(3) Bentonite circulation shall be used during drilling.

(4) Surface water shall not be permitted to enter the hole. If groundwater is entering the hole, the hole shall be completely filled with water and the concrete placed by tremie from the bottom of the hole to displace the water. The tremie discharge shall be kept well into the concrete and carefully withdrawn as the concrete is placed.

(5) Casing, if used in drilling operations shall be removed from the hole as concrete is placed therein. An initial jerk of 50 to 100 mm will be allowed to start removal of the casing, after which the casing shall be withdrawn smoothly without jerks. The bottom of the casing shall be maintained minimum of 1.5 below the top of concrete.

(6) The reinforcing steel cage shall be placed and secured symmetrically about the axis of the pile and shall be securely blocked to clear the sides of the hole. If the reinforcing steel cage rises during withdrawal of the casing, the pile will be rejected and replaced as directed by the Engineer.

1307 PILING EQUIPMENT AND WORKMANSHIP

(1) Not less than 14 days before any piling work is commenced the Contractor shall submit to the Engineer for approval full details of his proposed piling plant and detailed method statements for carrying out the work. Such details shall include where applicable a full description of the piling frame, hammer, helmet and packing, methods of handling, pitching and supporting the piles before and during driving, the proposed driving procedure and such further information as the Engineer may required.

(2) The type and weight of hammer shall be approved by the Engineer. The weight of the hammer shall be at least half that of the pile; in general, a heavy hammer with a short drop should be used in preference to a light hammer with a longer drop. As a guide to the Contractor, the weight of the drop hammer and

corresponding drop height for 300 mm × 300 mm pile size is tabulated in table 13.1. In no case shall the drop height exceed 1.2 m.

Table 13.1 : Recommended hammer weight and drop height for drop hammers

Length of pile (m)	Weight of Hammer (metric ton)	Drop Height (m)
6.00	1.5	1.10-1.20
7.00	1.5	1.10-1.20
8.00	2.0	1.00-1.10
9.00	2.0	1.00-1.10
10.00	2.50	1.00-1.10
11.00	2.50	1.00-1.10
12.00	3.00	0.75-1.00
13.00	3.00	0.75-1.00

(3) There are other pile driving method such as Vibro Hammer etc. Contractor will take due approval in writing which method he wants to adopt, as mentioned above, from the Engineer.

(4) The piling frame shall be of sturdy construction supported on an adjustable base, securely guyed and with ample toggle connections to leaders so that the pile is firmly held at all times.

(5) The Contractor shall not commence any piling until the plant and methods which he proposes to use have been approved by the Engineer but such approval shall not relive the Contractor from any of his obligations and responsibilities under the Contractor. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having approval from the Engineer.

1308 PROGRAMME AND PROGRESS REPORT

(1) The Contractor shall inform the Engineer each day of the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.

(2) The Contractor shall submit to the Engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of pilling works, as required by the Engineer.

1309 SETTING OUT

(1) The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker position of each pile. The main setting out for piles is to be completed prior to commencement of piling. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned and adequate notice for checking shall be given by the Contractor.

(2) Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

1310 TOLERANCE

(1) Piles shall be driven accurately vertical or to the inclinations shown on the Drawings. The permitted deviation of the pile centre from the centre point shown on the Drawings or setting out plan shall not exceed 50 mm measured at the working level of the piling rig, or other level agreed by the Engineer.

(2) The maximum permitted deviation of the finished pile shall be 1 in 75 from the vertical or 1˚ from the inclination shown on the Drawings.

(3) Forcible corrections shall not be made to concrete piles.

1311 DISTURBANCE AND NOISE

(1) The Contractor shall carry out the piling work in such a manner and at such times as to minimize noise and disturbance.

(2) The Contractor shall take precautions to avoid damage to existing services and adjacent structures. Any such damage shall be repaired to the satisfaction of the Engineer.

(3) The Contractor shall ensure that damage does not occur to complete piling and shall submit to the Engineer for approval his proposed sequence and timing for driving.

1312 OBSTRUCTIONS

If during the execution of the works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer and submit to him details of the proposed method(s) for overcoming the obstruction. The Contractor shall proceed in accordance with the approved method.

1313 TEST PILES

(1) Test piles shall be used for test driving either: (a) to determine the length of pre-cast pile from performance under driving and to ensure that the designed penetration; or, (b) for load tests to determine or verify the design capacity of piles

before manufacturing of all pre-cast piles or installation of cast-in-place piles for the work or both.

(2) The Contractor shall drive and/or install test piles as shown in the Drawings or as directed by the Engineer. The piles shall be located as such positions that they may be left in place to become an integral part of permanent structure.

(3) Test piles shall be of same type, size, depth and materials as the piles shown in the drawings and shall be driven with same Equipment and manner proposed to be used in the construction of other piles in the work.

(4) During driving, an accurate pile driving register shall be maintained in accordance with sub-clause 1304 (7). This record may be used to establish the method for driving the additional piles. Pile load test shall be undertaken with equipment approved by the Engineer and in accordance with the procedures stated hereinafter. The load test shall be applied vertically to the top of pile.

(5) In case of cast-in-place pile, load tests shall be carried out 28 days after completion of concrete operations. In case of pre-cast-pile, test pile shall be driven after it has reached its characteristics strength and load test shall be undertaken after certain rest period. A rest period shall normally be at least one week but in no case less than three days before the application of loads on test piles in clay and silty soils in order to permit the disturbed soil to regain most of its strength to avoid erroneous test results.

1314 TEST PILE DRIVING

(1) Test piles shall be driven in the vicinity of soil borings where the soil characteristics are known. Normally test piles shall be driven on locations where unfavorable site conditions exist, the bearing stratum is questionable and at all sites where total number of piles exceeds 20.

(2) When the test pile has been driven to its final depth, the Engineer shall verify the bearing capacity of pile based on the performance of driving and, if required, may arrange for piles used in the permanent works to be re-designed.

(3) If a test pile fails to reach a suitable design depth, the Engineer shall ask for fresh boring. The new borings shall be compared with the previous borehole results and pile driving records. Subsequently, the Engineer may arrange to re-design the pile foundation or request further load tests.

1315 LOAD TEST PROCEDURE

(1) Service Pile shall be loaded 1.50 times the design load and the Test Pile shall be loaded two times the design load.

(2) The resulting allowable loads shall not be more than one half of the test load which produces a permanent net settlement of not more than 0.00028mm/kg of test load nor 20mm (BNBC Code 1993).

(3) Net settlement at a test load is defined as the gross settlement minus the elastic compression i,e net settlement means total settlement minus rebound settlement of the pile.

(4) The head of the pile shall be cut off level in such a manner as to produce a horizontal plane bearing surface to support the load platform.

(5) Bags of earth or sand shall be loaded on a platform shall supported on the top of the test pile. The construction of the platform and the application of the loads shall be such that no lateral forces shall be applied to the top of pile and no impact will occur as the loads are placed. The weight of the platform shall be included in the calculated pile load but the supporting beams and the platform shall be in place on the pile when the "no load reading is made".

(6) Settlement shall be measured by survey level on a staff reading to 0.3 mm. Two bench marks shall be established on permanent objects near the test pile location. Settlement shall be determined by readings made on these bench marks and a permanent mark set in the pile head.

(7) The test load shall be twice the design bearing capacity of the pile and shall be supplied in increments of 25, 50, 75, 100, 125, 175 and 200 percent of the design capacity. Settlement readings shall be taken to an accuracy of 0.3 mm shall be taken before and after the application of each new load increment. Additional load shall not be applied until the rate of settlement under the previous increment is less than 0.3 mm in 1 hour or until 2 hours have elapsed, whichever occurs first. When loading has been completed, the full test load shall remain on the pile for 48 hours, or for a longer period if indicated by the rate of settlement of the pile, and settlement readings shall be taken during and at the end of the period.

(8) During the unloading of the pile, the rebound shall be measured when the loads remaining on the pile amounts to 75, 50, 25, 10 and 0 percent of the full test load, with decrements of load released at not less than half-hour intervals, and with measurements of the rebound being made immediately before and after each decrement. The final rebound shall be recorded 24 hours after the entire test load has been removed.

1316 TEST PILE REPORT

(1) A comprehensive report of the pile test shall be made by the Contractor. The report of the test shall include the following information:

(a) A pile layout plan showing the location, top elevation and depth of the test pile.

(b) A description of soil conditions at the location of the test pile.

(c) A description of the pile and its driving record, where applicable, including the number of hammer blows per 30 cm throughout the pile length the pile length and the final driving resistance in blows in last 30 cm of penetration.

(d) A description of the hammer and its actual rate of operation during the driving of the test pile.

(e) A tabulation of the loads and settlement readings during the loading and unloading of the pile.

(f) A graphic representation of the test results in the form of a time-load-settlement curve, and

(g) Remarks concerning any unusual occurrences during the driving or loading of the pile.

1317 FERROCEMENT SHEET PILE

GENERAL

(11) Ferrocement sheet pile shall be used only as cut-off pile. The width of each pile shall be limited to 650 mm and the depth of the cut-off shall however not exceed 2m and shall be provided for small hydraulic structure as provided in the Drawings.

MANUFACTURING

(12) Ferrocement sheet pile shall be pre-cast at the location of the work as per design and drawing.

(13) It shall be made of sand-cement mortar with leanest mix proportion of 1:2. Cement to be used shall be in accordance with clause 802 and F.M of sand shall be => 2.0. Sand-cement mortar shall develop a 28 days compressive cylinder strength of minimum 20 N/mm^2.

(14) M.S reinforcement of minimum yield strength 400 N/mm^2 shall be used.

(15) Formworks to be used shall be made of steel so as to achieve smooth finished concrete surface.

DRIVING

(1) All ferrocement sheet piles along the line of cut-off shall first be placed in row and in accurately vertical position before commencement of driving. Horizontal runners as pile guide to keep the sheet pile in positions should be used.

(2) During driving timber dolly approximately 100 mm thick using soft wood and resilient packing material shall be used.

(3) Driving should be in sequential order in each stage of driving. Care shall have to be taken so that difference in penetration length between adjacent sheet piles should not exceed 150 mm.

(4) In case of a situation the frictional resistance is so high that sequence of driving cannot be maintained, the driving shall be aided by water jetting if deemed appropriate.

1318 SAND COMPACTION PILE

GENERAL

(1) Sand compaction pile shall generally be used for improvement of sandy as well as clayey soil in alluvial plain, mostly plains, reclaimed land and marshy land. The equipment used for sand compaction piles are:

i) Derrick/Winch
ii) Casing pipe
iii) Drop Hammer

Drop hammer weighing 1.0 ton and above shall be of solid cylinder and sectional area shall be such that it can play within the casing pipe. Diameter of hammer section shall be about 6.0 to 8.0 mm lower than the opening of the casing pipe. The casing pipe shall be of Mild Steel.

CONSTRUCTION PROCESS

(1) A small hole of about 50 cm depth shall be made on the ground with the hammer.

(2) Casing pipe shall be installed at that point and kept vertical. The casing pipe shall be held in position with the wire rope connected to the winch i.e. downward movement of the casing pipe shall be restrained.

(3) Coarse sand of FM between 1.5 and 2.5 or sand gravel mix as provided in the design shall be placed within the casing pipe (250 mm to 300 mm dia) upto a depth of about 1.0 to 1.5 m, holding the casing pipe in position.

(4) The coarse sand or sand gravel mix placed at the tip of casing pipe shall then be compacted to form a solid mass by the hammer, holding the casing pipe in position.

(5) Casing pipe shall then be allowed to go downward with application of hammer blows on the shoe formed at the tip and shall be penetrated to the desired depth.

(6) As the casing pipe reaches the desired depth, the pipe shall be pulled back by about 30 cm. from the lowest position and then held firmly from the winch. Artificial shoe shall then be detached from the casing pipe with the hammer blows.

(7) The casing shall be drawn to a desire height, and discharged into the casing pipe to depth of about 1.5 to 2 times the drawn up height of the casing pipe.

(8) The discharged sand shall be compacted by the manner and the process of compaction shall continue until the casing pipe reaches the ground surface.

(9) The removed volume of sand or sand gravel mix. Measured on the ground shall be between 120% to 130% of the designed volume.

(10) Effect of improvement of the foundation soil shall be confirmed by SPT, CPT or any other method as approved by the Engineer, between and at the centre of piles so as to satisfy the desired bearing capacity.

Chapter 14

1400 WELL FOUNDATION

1401 GENERAL

(1) This section descries the construction of a well, taking it down to the desired foundation levels by open dredging or any other approved method of sinking through all kinds of soil strata and other materials, plugging the bottom, filling the inside and plugging the top of the well in accordance with the details shown on the Drawings and these specifications.

(2) Unless otherwise specified or directed by the Engineer, the materials for the construction of well foundation shall conform to the provisions of:

Section 700 Brickwork

Section 800 Concrete,

Section 900 Formwork

Section 1000 Reinforcement

(3) The concrete classes used in the well foundations shall be as tabulated below:

Well Component	Concrete Class
Bottom plug	M16
Curb	M20
Staining	M18
Top plug	F
Reinforced Concrete Capping	M20

(4) The staining members shall be constructed to the lines and levels shown on the Drawing either from Class M18 concrete or brick masonry.

(5) The well foundations shall rest on a firm stratum satisfying the desired bearing capacity at that level as indicated in the working drawing. The Contractor shall undertake confirmatory sub-soil investigations at the actual location of such well foundations.

1402 TEMPORARY WORKS

(1) The appropriate method for construction of the well shall depend upon field conditions, i.e. depth and flow of water actually encountered at the location of well foundation. The contractor shall construct any necessary diversion channel.

(2) In case of dry beds, the site shall be excavated down to 0.3 Meter above the sub-soil water level and properly leveled before the cutting edge in placed.

(3) When the wells are to be pitched in shallow water of depth less than 1m, an earthen/sand island shall be constructed raising the site of work, so as to make the construction in the dry. If the water depth is less than 1 m, simple sand inlands shall be constructed protected by laying a few rings of sand bags. Where the water depth is between 1 and 5 m, the sand island be made by driving sheet piling and filling inside or by driving two rings of poles with their inside filled with sand bags or other materials and the central space filled with sand.

(4) The area of island in these cases should be sufficient enough to allow adequate working space, at least twice the outer diameter of the well. The soil forming the island shall be such that it does not impede the sinking of the well. Islands shall be protected against scour and the top level shall be sufficiently above the anticipated water level during the construction period so that it is sate against wave action. The top surface of the island shall be adequately leveled and curb places or constructed thereon.

(5) In deep water or fast flowing water, the curb may be precast, floated and lowered in its final position with the help of necessary equipment. Under these circumstances, the curb should be built initially of sufficient height. The appropriate method to be adopted during actual construction shall be approved by the Engineer ten days in advance of the commencement of works.

(6) Suitable number of reference pillars shall be erected along both the axes of the well and axes clearly marked on the pillars which will help in determining shift and tilt of well at each stage of construction. Noting extra shall be paid to the Contractor for these and the rate of sinking shall cover these expenses as incidental thereto.

1403 LAYING THE WELL CURB

(1) The cutting edge shall be fabricated from mild steel rolled sections, angles and flats, as per details shown in the Drawing. The steel shall conform to the specifications ASTM A36.

(2) After staking out the structure centre line, the location of the centre point of well shall be correctly marked and the cutting edge places truly in position commensurate with both the axes of the well. The cutting edge shall be placed in a level ground and the starter bars shall be welded in position as indicated in the Drawings.

(3) Care must be taken to see that the bars are properly fixed to cutting edge in correct position with sufficient length for anchoring to the well. Curb and not to be displaced during concreting of well curb.

(4) In order to avoid any possibility of uneven settlement during concreting, the cutting edge may be supported on flat bottomed wooden sleepers underneath at appropriate intervals depending on which the cutting edge is placed. The sleepers

shall however be removed after the shuttering of the well curb has been stripped off once the concrete of the well curb has set. Precautions must be taken during the removal of the well curb has been stripped off once the concrete of the well curb has set. Precautions must be taken during the removal of the sleepers to prevent the well curb tilting as a result of any settlement that may occur.

1404 WELL CURB

(1) The dimension and shape of the curb shall be in accordance with the Drawings and the well curb shall be placed truly in position and level. The cutting edge shall be properly anchored to the well curb so that the well curb will be able to transmit Care must be taken to see that the vertical bars have been projected sufficiently beyond the top of the well curb to facilitate proper lapping with vertical bars of well staining.

(2) The curb shall be concreted in one continuous operation up to its full height. Since the concreting of well staining will be done with some time lag, provision of concrete shear keys at suitable intervals in zigzag manner shall be kept on the top finished level of well curb.

1405 STAINING

(1) The dimensions and shape of the well shall strictly conform to those shown in the Drawings. The staining member of the well shall be built in a straight line from bottom to top. The work being checked carefully with the aid of straight edges of lengths approved by the Engineer, plumb bob or spirit level shall not be used.

(2) Not be more than 2 m of the staining shall be built initially. Subsequent stages shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at a time, whichever is less. Work stages shall be planned to avoid the location of joints in the vertical staining bars.

(3) The height of staining shall be calibrated by at least 4 gauges distributed equally on the outer periphery of the well. Each gauge shall be in the form of a 10 cm wide strip painted on the well, with every meter shown in red paint. Further subdivision mark shall be shown in black paint. The gauge shall start with zero at the bottom of the cutting edge. The gauges shall be carefully marked with a measuring steel tape.

(4) The well staining shall be concreted in stages as described above. At the Completion of each stage construction, before the concrete sets, concrete shear keys in requisite numbers shall be constructed so as to make the concrete in the successive stages monolithic with the previous ones.

(5) Any concrete surface in the well staining which shows excessive honeycombing and exposure of reinforcement or exhibits and fault which, in the opinion of the Engineer seriously impairs its function may be declared defective concrete. Such defects shall be rectified by the Contractor to the satisfaction of the Engineer, see Section 900.

(6) Following the sinking of each stage, all damaged portions of staining at top of the previous stage shall be properly repaired before the construction of the next stage begins.

1406 SINKING

(1) All precautions shall be taken against possible damage to the foundations of structures in the vicinity of the wells prior to commencement of dredging of the material form inside the well. Dredging may be by manual or mechanical means.

(2) The method of sinking shall ensure that the well does not go out of position or out of plumb beyond the specified tolerance through all types of soils.

(3) The well shall be sunk by excavating material uniformly from inside the dredge hole. Pneumatic sinking may have to be resorted to where obstacles such as tree trunks, large size boulders, etc., are met at the bottom or when there are hard patches which cannot be removed by open dredging. The necessity for pneumatic sinking shall be decided by the Contractor and shall be undertaken only with prior written permission of the Engineer at no additional cost to the contractor.

(4) Sinking or loading of the well with kentledge shall be commenced only after the staining has been cured for at least 48 hours.

(5) The Contractor shall keep record of various strata of soil encountered during the sinking of the well. The record shall include the depth of, samples of soil in, and behaviour of sinking of well through, each stratum. This record shall be countersigned daily by the authorized representative of the Engineer and when completed shall be handed over to the Engineer.

(6) The well shall be sunk to the minimum depth of the founding level shown in the drawing. If the bearing capacity of the stratum at that level is less than the desired minimum for that level as indicated the Working Drawings, the sinking at a firm stratum deeper than the minimum depth shown, satisfying the desired bearing capacity for that level as indicated in the Working Drawing. The Contractor shall obtain approval of Engineer in regard to the final depth up to which a well is sunk.

1407 KENTLEDGE OR SINKING LOAD

Kentledge shall be placed in an orderly and safe manner and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the staining of the well. Where tilts have occurred or there is a danger of the well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

1408 DEWATERING OF WELL

Dewatering of well shall not be permitted as a means for sinking the well.

1409 WATER JETTING

Sinking of well may also be expedited, if necessary, by water jetting along the external surface of the well. All jets shall be arranged symmetrically to induce straight sinking.

1410 PRECAUTIONS DURING SINKING

(1) Where sinking is in progress, wells shall be sunk to sufficient depth below the designed scour level before the seasonal floods. In addition, they shall be temporarily filled and plugged before the on-set of the floods so that they do not suffer any tilt or shift.

(2) All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

(3) Dredged material shall not be allowed to accumulate over the well. It shall be dumped, as far away from the well as possible, and then continuously and simultaneously removed.

(4) A deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well; normally the depth of sump shall not exceed 0.5 m below the level of the cutting edge unless otherwise specifically permitted by the Engineer.

(5) If the well sinks suddenly with a jerk, the staining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

(6) In pneumatic sinking if permitted by the Engineer, the well shall not, at any time, be dropped to a depth greater than 0.60 m by the method of removing the air pressure therein.

(7) During final founding level, suitably designed cofferdam, if necessary, shall be constructed to prevent outside soil from falling inside the dredge hole.

(8) When sinking in clay, the work may be done in dry by dewatering but precautions shall be taken regarding the heaving or bursting of the base soil.

1411 TILTS AND SHIFTS

(1) Tilt and shift of each well shall be measured regularly during the entire sinking operation. Observations to this effect shall be taken at each stage of casting of the staining. Simultaneously as the sinking proceeds, necessary corrective measures be taken to contain the tilts and shifts within the permissible limits.

(2) Unless otherwise specified the tilt of any well shall not exceed 1 in 80 and the shift shall not be more than 150 mm, inclusive of any shift caused due to tilt.

(a) Remedial measures to be undertaken

In case of wells where the permissible limit (s) of tilt and or shift are/is exceeded, approved remedial measures shall be taken by the Contractor to bring the tilt(s) and/or shift(s) within these permissible limits, at no extra cost to the owner.

(b) Acceptance of wells with excessive tilt and/or shift

If the tilt(s) and/or shift(s) of any well exceed the specified permissible values, the well so sunk shall be regarded as not conforming to specifications and may be accepted by the Engineer, provided:

i. the tilt and/or shift in any direction do to exceed the extreme limits of 1 in 50 tilt and 300 mm shift.

ii. calculations for foundation pressures and staining stresses, accounting for the actual tilt(s) and shift(s) shall be given by the contractor for the approval of the Engineer and any remedial measures, required to bring the stresses within permissible values, (such as increase in the dimension of the well cap, provision of dummy weights of super-structure etc.) shall be carried out by the contractor and shall be got approved by the Engineer without claiming for any extra cost.

c) Action on rejection of a well

In the event of a well being rejected on account of non-compliance with the extreme tilt and/or shift mentioned above, the Contractor shall dismantle the rejected well to the extent directed by the Engineer and remove the debris. The Contractor shall further at his own risk and expense, complete the remaining work with a modified arrangement acceptable to the Engineer.

1412 INSPECTION OF BEDDING OF WELLS

After the well has been evenly seated on good hard strata, the Contractor shall arrange for the Engineer to undertake a thorough inspection in dry and visible conditions before the bottom plug is laid at no extra cost to the owner.

1413 BOTTOM PLUGGING

(1) Before bottom is plugged, test boring shall show that the soil properties of the founding strata encountered are similar to those adopted in the design, and that the founding strata extends for a twice the diameter or the least dimension of the well. In case the soil encountered is inferior to that adopted in design, the well shall be redesigned adopting the soil properties actually encountered and the founding level of the well duly revised.

(2) Each well, after being sunk to its final position and ensuring that the curb and whole staining has not developed cracks for its entire length, shall be suitable plugged at its bottom.

(3) The quantity of cement shall be increased by 25% according to Clause 822(9) for laying concrete under water. The mix shall have a slump of about 150 mm to permit easy flow of concrete through tremie pipe to fill up all cavities.

(4) Before commencing plugging, all the loose material from the bottom of the well shall be removed and the depth of the bulb below the cutting edge shall be more than $1/6^{th}$ diameter of the well. If the required bulb depth cannot be achieved, at site due to adverse soil conditions, the Engineer may permit the Contractor to plug the well with such depth as actually possible at site or as specified on the Drawings. The bulb shall then be filled with concrete in accordance with the Drawings.

(5) Concrete for the plug shall be laid by 'Tremie Pipe' method, or by skip boxes or by any other method approved by the Engineer. Concrete shall be laid evenly inside the well and care should be taken to avoid segregation. Care shall be taken to cause the least disturbance to the water inside the well while concreting the bottom plug.

(6) Concreting shall be done in one continuous operation till dredge hole is filled up to the required height and thereafter sounding shall be taken to ensure that the concrete has been laid to the required height.

(7) Concrete as laid shall not be disturbed in any way for at least 14 days. Soundings shall be taken at the close of concreting and for 3 days thereafter once every day to check any rise in the level of the bottom plug.

1414 TESTING WELLS

(1) If considered necessary by the Engineer, the soundness of the bottom plug shall be tested by dewatering the well to a depth of 5m below surrounding ground water level and then checking the rise of water. The rate of rise shall preferable be less than 10 cm/hour. In case the rate of rise is higher than 10 cm/hour, suitable remedial measures shall be taken to the approval of the Engineer.

(2) Testing shall be undertaken not earlier than 14 days after concreting.

1415 FILLING THE WELL

(1) If testing is not required, a minimum of 3 days shall elapse after the bottom plug has been accepted by the Engineer before the well is filled with sand.

(2) Before filling with sand, the height of the bottom plug shall be verified.

(3) Sand fill shall be clean and free earth, clay clods, roots boulders, shingle etc and be carried up to the height shown on the Drawings.

1416 TOP PLUG

After filling the sand up to the required height, top plug shall be laid over it. The thickness of this plug shall be as specified in the Drawings.

1417 LOAD TESTING OF FOUNDATIONS

(1) Where specified or required by the Engineer, load tests shall be performed after a well is sunk to its final level and before plugging. The loadings shall be either in the form of sand bags and rolled steel channel sections or by using hydraulic jacks and/or other suitable device.

(2) The Contractor shall prepare all necessary calculations and details of arrangements for such load test. The magnitude of the test load made and method of carrying out the test load and the observations to be made during and after placing the test loads in position, etc. shall all be got approved by the Engineer before

commencement of load testing and all this shall be done at no extra cost. The test loading of well shall be carried out on lines of following specifications in general.

(3) The well to be tested shall first be relieved of all kentledge and other superimposed loads, if any, and then filled inside to a depth of at least 3.0 meter above the cutting edge with sand. The sand filling may be done through water, if there is water standing in the well, but it shall be ascertained that the well has been evenly filled to a depth of not less than 3.0 m as above. Standing water need not be pumped out. But before commencing the loading it shall be allowed to attain a permanent level. No extra cost shall be payable for sand filling in the well before the test or for its removal after the test.

(4) Marks for taking levels will then be made on the well staining at upstream and downstream and on the left and right side of the well. The reduced levels of all these marks shall be recorded carefully before commencing the test load.

(5) The test load to be applied to a particular well shall be determined by the Engineer. The procedure of computing the test load shall be:

$$\text{Test Load} = \frac{\text{Staining Area}}{\text{Total Area of well}} \times (\text{Dead Load} + 2 \times \text{Live Load})$$

(6) The test load shall then be applied in equal increments. The load will then be allowed to remain for 12 hours and the levels of all the marks shall be recorded.

(7) Unloading shall be done in regular decrements of test increments adopted with an interval of 12 hours, between each unloading operation and the levels observed at each stage just after unloading as well as 12 hours after that i.e just before further unloading.

(8) The results of any settlement under the test load, recovery of settlement on removal of the test load and any permanent settlement of the well shall be noted. For this purpose the average of the readings of all marks shall be taken. The report including all graphical details and the tabulated results of loading unloading observations made regarding settlement recovery etc. respectively for the loading and unloading condition shall be furnished to the Engineer by the Contractor.

(9) Should any well be determined unacceptable form the results of the load test, the said well shall be sunk further and additional load test(s) shall be undertaken by the Contractor and the acceptable foundation level shall be determined.

Chapter 15

1500 METALWORK AND WELDING

1501 STRUCTURAL STEEL WORK

(1) A list of standards is given below for the Contractor's guidance in addition to standards mentioned in the Specification and on the Drawings.

Structural steel Sections	
Part 1, Hot Rolled Sections	BS 4
Covered Electrode for the Metal-Arc	
Welding of Mild Steel	BS 639
Black, Hexagon Screws and Nuts	BS 4190
Steel Tubes and Tubular suitable for	BS 1387
Screwing to BS Pipe Thread	
Weldable Structural Steels	
Metal-are Welding of carbon and	
Carbon Manganese Steels	BS 5135

1502 NUTS AND BOLTS

Bolts, ragbolts, nuts and washers shall conform to BS 4190 as regards dimensions. Each bolt shall be provided with two washers and shall be long enough to show a full thread through the nut after fixing. External bolts and fixing rag bolts, nuts and washers shall be sheradised steel. Assemble nuts, bolts and washers or galvanized fittings or equipment shall be either galvanized or sheradised.

1503 STEEL PIPE

Steel pipe shall conform to ASTM Designation A53, Grade 4, galvanized standard weight (Schedule 40) or approved equal, unless otherwise specified on the Drawings.

1504 STEEL PLATE

Steel plates, shapes and bars shall conform to ASTM Designation A 36 or approved equal.

1505 HAND RAILING

(1) Hand railing shall be fabricated in accordance with the Drawings from galvanized iron pipes and fitting to BS 1387:1985 (Grade HFWZ) and painted in accordance with Clause 1708, if not otherwise specified in the drawing.

(2) Hand rails shall be furnished and installed according to the dimension and details shown on the shop Drawings and as directed by the Engineer. All bends shall be rounded and all melds ground smooth. Posts shall be set plumb in all directions.

1506 RUNGS

Rungs shall be fabricated in accordance with the Drawings from mild steel reinforcement bar, galvanized in accordance with Clause 1702 and painted in accordance with Clause 1710.

1507 TRASH RACKS, HOIST FRAMES AND OTHER MISCELLANEOUS METALWORK

All items shall be furnished and installed to the dimensions, details and special instructions shown on the Drawings and as directed by the Engineer. Prior to installation, the Contractor shall be furnished setting Drawings and directions for installation items having integral anchors which are to be embedded in concrete or masonry construction. The Contractor shall be responsible for delivery of such items to the job site in accordance with the approved construction Schedule.

1508 WATER LEVEL GAUGES

(1) Water level gauges shall be made from mild steel and to be coated with vitreous enamel. All cutting, drilling and punching of the plates shall be completed before the vitreous enamel is applied.

(2) The steel shall be machined smooth and be thoroughly cleaned to remove all rust, scale dirt and grease before enameling. The vitreous enamel shall have a minimum thickness of 0.5 mm on the numerical side and 0.25 mm on the reverse side and where the steel has been cut, punched or drilled.

(3) The face of the gauge shall be white and numeral and graduations shall be dark blue. Graduations shall be sharp and accurate to the dimensions shown on the Drawings or as directed by the Engineer.

(4) The water level gauges shall be extended from design bed level to about 2 meters above design full supply level and the zero level on each gauge shall be the design bed level. The reduced level for the zero gauges shall be shown on each gauge.

1509 PAINTING

Painting of all items described in the preceding paragraphs shall be in strict conformance to Section 1700.

1510 WELDING : GENERAL

(1) All welding shall be performed by certified welders and in accordance with American Welding Society (AWS) D1.1 "Structural Welding Code" or similar approved standard.

(2) Unless otherwise specified, all welding shall be performed by the shielded metal are processed with low hydrogen electrodes for manual welding.

(3) The Contractor shall be responsible for the quality of the welding performed by his welding organization. All welding by the Contractor shall be by the electric arc method using coated electrodes or other means whereby the air is excluded from the molten metal, and where applicable, automatic machines with correct procedure control shall be used.

1511 WELDING: WORKMANSHIP AND VISUAL QUALITY REQUIREMENTS

In addition, the conforming to the procedural and quality requirements set forth in the structural welding code and/or these Specifications, all manual welding shall meet the following requirements for workmanship and visual quality:

(a) Each weld shall be uniform in width and size throughout its full length and each layer of welding shall be smooth, free of slag, cracks, pinholes and undercut, and shall be completely fused to the adjacent weld beads and base metal. In addition, the cover pass shall be free of coarse ripples, irregular surface, non-uniform bead pattern, high crown, deep ridges or valleys between beads, and shall blend smoothly and gradually into the surface of the base metal.

(b) Butt welds shall be slightly convex, of uniform height, and shall have full penetration.

(c) Fillet welds shall be of specified size, with full throat and with each leg of uniform length.

(d) Repair, chipping or grinding of welds shall be done in such a manner as not to gouge, groove, or reduce the base metal thickness.

1512 WELDING REPAIRS

All weld defects which are determined unacceptable shall be removed by chipping, grinding, arc or flame gouging, following which the area shall be properly prepared for welding, repaired by an approved qualified welding procedure and re-tested as necessary. The Contractor shall establish before the cause of all defects and show that such defects have been corrected before welding will be permitted. All repairing shall be by and at the expense of the Contractor.

1513 PEENING

The Contractor will not be allowed to shot peen welds without prior approval.

1514 ELECTRODES

(1) All electrodes shall be purchased in sealed containers and shall be thoroughly dry when used. Electrodes, taken from sealed containers, shall be used within four hours. Electrodes not used within four hours shall be stored in electrode storage ovens. The electrode storage oven temperature shall be in accordance with the electrode manufacturer's recommendations. Electrodes with wet or damaged coatings shall not be used.

(2) Unless otherwise approved, electrodes for manual welding shall not exceed 4 mm diameter for out-of-position connections (other than the flat, position), and shall not exceed 5 mm diameter for work in the flat, IG position. Furthermore, the maximum width of any bead of welding, other than a cover pass, shall not exceed 3 times the diameter of the electrode being used.

(3) Subject to the approval of the Engineer, electrodes shall be carefully selected in order to provide metal welds with mechanical properties similar to those of the metal being welded, except that for welding higher strength steel to lower strength steel, the electrodes shall be chosen to provide metal welds with mechanical properties comparable to those of the lower strength material.

1515 CUTTING AND EDGE PREPARATION

Members of structural steel and miscellaneous metalwork which are to be joined by welding shall be cut accurately to size, and where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown. The edges of these members shall be sheared, flame-cut or machined to suit the required type of welding and to allow thorough penetration. The cut surface shall expose sound metal, free from laminations, surface defects caused by shearing or flame-cutting operations, or other injurious defects. The surface to be weld shall be free from rust, grease, paint and other foreign matter for a distance of at least 150 mm back from the edge of the weld.

1516 GRINDING WHEELS

Grinding wheels which leave a deposit detrimental to subsequent welding will not be permitted. Grinding wheels which are determined by the Engineer to be detrimental to welding shall not be used.

1517 QUALIFICATION OF WELDERS AND WELDING OPERATORS

All welders and welding operators assigned to the work shall have passed the qualification test for welding operators as specified in the AWS Structural Welding Code. If, as determined by the Engineer, the work of any welder appears questionable, such welder will be required to pass additional qualification tests to determine his ability to perform the type of work on which he is engaged. Such additional qualification tests for welders and the physical tests of the welded specimens shall be made in the presence of the Engineer. If required, the Contractor shall furnish to the Engineer a certified copy of reports of the results of physical tests of specimens welded in the qualification tests. Such qualification shall be by and at the expense of the Contractor.

1518 METHOD OF WELDING

(1) Wherever practicable, welding shall be carried out in the horizontal position. Vertical downward welding shall not be employed without approval of the Engineer.

(2) Extreme care shall be taken to ensure that correct welding sequences and procedures are observed to avoid any strains and internal stresses arising in welding.

(3) Members of structural steel and miscellaneous metal work which are to be joined by welding shall be cut accurately to size, and where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown. The edges of these members shall be sheared, flame cut or machined to suit the required type of welding and to allow thorough penetration. The cut surface shall expose ground metal free from laminations, surface defect caused by shearing or flame-cutting operations, or other injurious defects. The surfaces to be welded shall be free from rust, grease, paint and other foreign matter.

1519 WELDING OF STAINLESS STEEL

(1) Unless otherwise specified, all welding shall conform with AWD DI.J, electrodes used for welding of stainless steel shall be series E308 and electrodes used for welding of stainless steel to carbon steel shall be series E309.

(2) Welders and welding operators assigned to the work shall have passed the qualification test for welding operators as specified in Clause 1518.

1520 INSPECTION AND TESTING OF WELDS

(1) The following tests shall be carried out on the procedure qualification test plates and production test plates:

(a) Tensile and bend tests: all welds shall be subjected to visual inspection.

(b) The procedures of visual examination shall conform to the requirements of the ASME Boiler and Pressure vessels Code.

(2) The following defects are unacceptable unless otherwise noted:

(a) Dimensional defects such as insufficient throat or leg length, excess convexity, excess or insufficient reinforcement.

(b) Undercuts, overlap, blowholes, slag inclusion, seams and excess weave.

(c) Any crack or liner indication.

(3) Plates with laminations discovered during gas cutting, welding or any other time shall be rejected unless approval to repair the plate is obtained from the Engineer.

(4) Welds may also be subjected to any or a combination of the examinations as described or as may be required to establish the soundness of welds.

(5) The inspection procedure for testing of all welds shall be prepared on the above basis by the Contractor and submitted to the Engineer for approval before any fabrication work is started.

Chapter 16

1600 GATES AND HOISTS

1601 GENERAL

(1) The work covered by this section shall include the manufacturing, printing, packing, transportation to site, installation, site testing and remedying of defects. A detailed description of work to be undertaken is included in the Particular Specification.

(2) The work shall include anchor bolts, plates, angles, channel and other Technical Specifications, Drawings and Schedules. The services not expressly called for in the Specification or shown on the Drawings, but which are necessary for completion and proper operation shall be supplied and installed by the Contractor at no increase in cost to the Contractor.

1602 TRAINING TO PROJECT STAFF

(1) The Contractor shall provide training to BWDB staff for two days after taking over the mechanical/electrical installations. The cost of this training shall be included in the rates for supplying and installing.

(2) The Contractor shall provide operation and maintenance instructions for equipment, including instrumentation.

1603 MANUFACTURING DRAWINGS

(1) The Tender Drawings give the basic arrangements of the gate and stoplog assembly. The Contractor shall prepare a detailed set of manufacturing drawings indicating the tolerance specified or implied. Along with a schedule of materials, the Contractor shall also furnish the drawings deemed necessary, but not included in the Tender Drawings, for proper manufacturing, assembling, installation and efficient operation of gates/stoplogs. The drawings shall be prepared to the standard A1, A2, A3 and A4 sizes and the bottom right hand corner shall be used to indicate the title of the drawings, the signature of the Contractor's Engineer responsible, the date prepared and the drawings number.

(2) Before commencing fabrication all drawing shall be approved by the Engineer.

(3) The original tracing and as built drawings shall be submitted to the Engineer.

1604 MATERIALS

(1) Material will mean all ferrous and non-ferrous materials whether treated or machined, used to complete manufacturing and installation of gates, stoplogs and their lifting devices.

(2) Most of the materials of different components have been specified in the Drawings. If the contractor adds any materials in addition to those specified, but suitable to his construction, these shall conform to the materials listed below, unless otherwise noted in the contract and/or approved specifically by the Engineer:

(a) steel sheet for gates shall be of st 37 (DIN 17100-1966) ASTM A36 or SS41 (JIS G3101-1970) or IS-226.

(b) Steel profile shall be made of st 37 (DIN 17100-1966) or ASTM A36 or SS41 (JIS G3101-1970) or IS-226.

(3) At any stage of manufacturing, if any inferior material contradictory to standards or specification is discovered in any component or accessories irrespective of whether it is in a major or minor component, the component shall be rebuilt with parts of appropriate materials and all costs related to such revision of works will have to be borne by the Contractor. Payment to the Contractor will remain suspended until the required corrections are made and certified by the Engineer or his representative.

(4) A list of standards is given below as guidance for the materials to be used in manufacturing of Gates/Stoplogs and hoists. A Contractor is permitted to use any standard equivalent to the specified one only after taking approval from the Engineer.

Hot Rolled Steel (Flats, Structural Shapes, Plate)	ASTM, A36 or BS 4848
Cold Rolled Steel (Shaft)	AISI, 1035 or BS 2994
Carbon Steel (Bolts-Nuts, Fasteners)	AISI, 1015
Stainless Steel (Stem, Stem coupling)	AISI, 303 or SUS, 304
Cast Iron (Housing, Gear, Shield)	ASTM, A48
Cast Steel (Wheel/Roller)	ASTM, A148
Phosphor Bronze (Bush, Bearing)	ASTM, B139C

1605 BUSHING

Wheel bearing of fixed wheel gates shall be provided with self-lubricating bearings in accordance to the Drawings. All other bearings and bushes shall be provided with grease ways and proper grease fitting for preventive maintenance.

1606 WHEEL ASSEMBLE AND RAIL

(1) Wheel assemblies, wheel pin and hinges shall have self-lubricating bearing. Wheels, bearings (bronze), wheel pins, etc, shall be assembled before being installed in the gates. The wheel pin shall be a cantilever type with the eccentric portion of it being properly aligned with the wheel tread faces (the eccentricity of pin has not been

shown in the drawing). If the Contractor wants to use self-aligning roller bearings for this cantilever pin, he will have to make other necessary corrections in the wheel assembly and shall have to submit detailed drawings in detail for approval by the Engineer.

(2) Standard rails, on which the wheels roll, shall be in accordance with the Drawings.

1607 RUBBER SEALS

(1) Rubber seals shall be moulded solid sections of the musical note type to the dimensions indicated in the Drawings. The material shall be a compound of natural rubber or a copolymer of butadiene or styrene or a blend of both and shall contain reinforcing carbon black, zinc oxide, accelerators, antioxidants, vulcanizing agents and plasticizer. The physical characteristics shall meet the following specification:

Tensile strength	20 N/mm²
Elongation at break	45%
300% modules	6 N/mm²
Durameter hardness (shore type A)	60-70
Water absorption (max)	5% by weight
Compression set	30%
Tensile strength after oxygen bomb against ASTM D572	80% of tensile strength
Tensile strength of vulcanized joints	10 N/mm²

(2) The seals shall be moulded in one piece for each straight length, without the inclusion.

1608 SIDE SLIDING STRIP, TOP SEAL PLATE AND SIDE SEAL PLATE

Side sliding strip, top seal plate and side seal plate shall be made from stainless steel (AISI, 303 or SUS, 304) in accordance to the Drawings.

1609 MISCELLANEOUS MATERIALS

(1) Wire rope for stoplog hoists shall be made from improved plough steel, galvanized, fibre cored and of the extra pliable type with 6/37 strand construction. Standard wire rope fittings shall be used.

(2) All fixing bolts and nuts shall be galvanized. All pins shall be of stainless steel.

1610 FABRICATION

(1) Components supplied shall be in good condition and marked as per the fabrication drawings for easy checking.

(2) Before being assembled, all the components shall be in good condition. If twisted on bent or damaged in any way they must be repaired, according to the Drawings and as per instruction of Engineer, before assembly.

(3) All tolerance and allowances for metal fits shall conform to the appropriate approved standard Journals and sliding surfaces shall be polished and finished with sufficient smoothness and accuracy to ensure proper operation when assembled.

(4) Cutting shall be done by machine, by sawing or by oxy-acetylene torch. Oxygen cut edges must have all gouges removed by grinding. All outside corners shall be clean and with a radius of the right dimension.

(5) Pin holes shall be bored to gauge, smooth and straight, and at right angles to the axis of the member. Boring shall be done after the member is securely fastened in position.

(6) Machining shall be by methods which result in a good final surface.

1611 EMBEDDED METALWORK

(1) Metalwork component to be cast into the structures shall be fabricated as per the Drawings. Unless indicated on the Drawings, the components shall not be painted but prepared in accordance with Clauses 827 and 1712 then firmly secured in position prior to concreting.

(2) The Contractor shall plan his concreting work so as to avoid risk of knocking or damaging the components. Second stage concreting shall be undertaken in accordance with Clause 828.

(3) Exposed surface second stage casting work shall be painted according to Section 1700.

(4) Welding during positioning of parts shall be done carefully, so that, vertical and horizontal levels of the exposed surfaces may not be disturbed due to heat, generated at the time of welding.

(5) Rubbing surfaces shall be cleaned before installation of gates or stoplogs.

1612 TOLERANCES

Tolerances for sealing surfaces, guides etc, shall be selected to prevent over stressing of the gate parts and to effect watertight seal. Tolerances for machined and fitted parts shall comply with the requirements of the specifications or standards. All tolerances and mans of adjustment shall be defined on the Contractor’s drawings and be subject to the Engineer’s approval.

1613 TESTS

(1) Tests shall include the assemble of components in the manufacturing shop as well as on site.

(2) All tests performed at shop or at site shall be witnessed by the Engineer or his representative and results recorded. If any defects are discovered, they shall be remedied and the tests repeated until satisfactory results are obtained.

1614 TESTS AT MANUFACTURER'S SHOP

GATES/STOPLOGS

(1) Gates/stoplogs, including seals, guide, and fixed wheels, where applicable, shall be assembled at the manufacturer's shop. While assembled, the gates and stoplogs shall be checked for dimensions, tolerance and accuracy of alignment. Any errors or misalignment discovered shall be promptly corrected. The seals shall be fitted to their supports during shop assembly. Sealing frames, track frames, side guide frames, lintel beams and sill beams etc, shall be checked whether satisfactorily manufactured or not. All dimensions of guides that correspond to the gate and stoplog dimensions shall be checked and any error and misalignment shall be corrected. Parts shall be clearly match-marked before disassembly for transportation.

GUIDE FRAME

(2) Appropriate sections of the stoplog guide frames shall be assembled and fixed in the shop to see that the guiding, bearing and sealing surfaces lie in a true plane for their entire length.

HOISTS

(3) The hoists shall be shop assembled and tested for smooth performance at normal operating speed and at no load. All lubrication, grease and oil required for the performance of tests shall be furnished by the manufacturer. If any defect is discovered it must be corrected and the entire test shall be repeated.

1615 INSTALLATION AND TESTS AT SITE

GUIDE FRAMES

(1) Guide frames shall be assembled in the blackouts and in the location shown on the Drawings. Concrete shall not be commenced unless the correct positioning of the frame has been achieved by adjustment of bolts and nuts and approved by the Engineer.

GATES / STOPLOGS

(2) The gates and stoplogs complete with seals, guides and fixed wheels wherever applicable, shall be assembled so as to attain a tight and water proof sealing at the base, at the top and at sides. The lifting and lowering of gates and stoplogs should be

achieved from the deck without under resistance. Except where water sealing is required, all metal to metal contract surfaces must be lubricated by the manufacturer during test operations. Any defects observed shall be corrected promptly and the test repeated. Any damage to the gate or components during installation and testing shall be repaired by the Contractor at no extra cost.

FLAP GATES

(3) Care shall be exercised in setting and adjusting pivots and sealing surfaces to assure that the gates hang properly, swing freely and seal uniformly around the entire perimeter. The gate frames shall be adjusted simultaneously with the gate pivot adjustments. The gates and components shall be handled carefully to prevent damage to sealing surfaces and racking, bending and/or otherwise preventing them from operating as required. Following installation and placement of second stage concrete, the gates shall be operated manually to demonstrate satisfactory installation and operation.

SLIDE GATES

(4) Care shall be exercised during the installation of embedded metalwork and gate guide to obtain proper alignment and insure that the appropriate components are plumb. The frames and wedges shall be adjusted as required to assure that the gates will slide freely and seat uniformly. Care shall also be exercised to prevent warping, racking, bending or other damage to the gate or components. Following installation and placement of second stage concrete, the gates shall be operated manually to demonstrate satisfactory installation and operation.

STOPLOGS

(5) The Contractor shall handle and store the stoplogs safely and securely from the time they are delivered to site until the time they are accepted by the Engineer. The installation of the stoplogs shall be performed in a workmanlike manner, and care shall be exercised to ensure that the stoplogs seat uniformly to the satisfaction of the Engineer.

1616 HOISTS

Before assemble and installation, all bearing surfaces, journals, grease and oil grooves shall be carefully cleaned and lubricated with approved oil and grease.

FLAP GATE HOIST

(1) The Contractor shall install gate hoists as shown on the Drawings. Approved manufacturer’s installation instruction shall be strictly and operated through an acceptance the hoist shall be closing of the gate to demonstrate satisfactory installation and operation under design load.

SLIDE GATE HOIST, STEMS AND GUIDES

(2) The Contractor shall install hoists on each slide gate as well as seems and stem guides as shown on the Drawings. Approved manufacturer's installation shall be strictly observed. Prior to acceptance, the hoist shall be lubricated and operated and operated through a complete cycle of opening and closing of the slide to demonstrate satisfactory installation and operation under design load.

1617 PAINTING

All exposed metal surface of the items described in the preceding paragraph shall be painted in accordance with the provisions of section 1700.

Chapter 17

1700 PROTECTION OF STEEL WORK

1701 SURFACES NOT TO BE PAINTED

(1) Bronze and brass surface of gear teeth, finished ferrous surfaces, surfaces in rolling or sliding contract after field assembly any wire ropes shall not be painted.

(2) All corrosion-resisting steel surfaces for bearings and machinery parts shall not be painted.

1702 GALVANIZING

(3) All materials to be galvanized shall be of the full dimensions required and all holes shall be drilled therein before galvanizing. Galvanizing shall be carried out by the hot-dip process as specified in BS 729 and the weight of coating shall be not less than the appropriate value tabulated below:

Table 17.1 Coating Weight[*a]

Category		Minimum average coating weight for any individual test area[*1] (g/m²)
Steel articles are not centrifuged*[c]	5 mm thick and over	610
	Under 5 mm but not less than 2 mm	460
	Under 2 mm but not less than 1 mm	335
Grey and malleable iron castings		610
Threaded work and other articles which are centrifuged *[d]		305

a) The coating weight per unit area of the surface is given in terms of g/m² of surface. If the coating thickness is required, the following conversion factor should be used, which assumes the density of the coating to be 7 g/cm³; 1 g/m² - 0.14 µm (305 g/m² - 1 oz/ft² - 43 µm – 0.0017 in).

b) For small articles the test area shall consist of the whole surface or agreed parts thereof. For large articles, e.g. structural steel sections, the minimum coating weight referred to in Table 17.1 shall be the average of determinations over a test area of 600 to 1200 mm².

c) Where the threads of bolts unsuitable for centrifuging are brushed after galvanizing, the coating weights on the brushed areas shall be exempt from the requirements of Table 17.1.
d) Bolts are galvanized after screwing unless otherwise specified. Bolts which are to be fitted with nuts are screwed to the tolerance laid down in the appropriate specification without allowance being made for galvanizing. The nuts are tapped up to 0.4mm oversize after galvanizing and the threads are oiled.

(4) Items to be galvanized shall first have all weld spatter, mill scale and other adherents removed after fabrication, then they shall be pickled and washed before being hot-dip galvanized. All parts shall be passivated after galvanizing in order to minimum discoloration.

1703 SHERADISING

The sheradising of items such as anchor bolts, nuts washers and other small articles, shall be as specified in BS 4921.

1704 PAINT

(1) All the paints shall be obtained from the same manufacturer and shall be compatible with the other paints in the same protective scheme. They shall be suitable for the climatic conditions in Bangladesh. The manufacturer and the formulation of the paints shall be subject to the approval of the Engineer. The Contractor shall supply to the Engineer samples of the paints at least a month before the paints are to be used in the works.

(2) The primer used beneath the coal tar/epoxy paint shall be specially formulated for the purpose. In selecting or formulating the zinc rich priming paint the Contractor shall give due regard to the period of storage and to the requirement that it shall give protection outdoors in Bangladesh for periods of possible up to six months.

(3) Coal tar/epoxy paint shall be such that the coating will not run or craze when exposed to direct sunlight on the site for prolonged periods after immersion in water.

(4) The Contractor shall supply and deliver to the site a sufficient quantity of priming paint to make good against any damage during supply and deliver to the site and sufficient paint required for the under coats and finishing coat. The supply and delivery of the paint shall be in accordance with programmes which the Contractor shall have previously agreed with the Engineer having proper regard to the shelf life of the paints and all to the approval of the Engineer.

(5) The paint shall be delivered in the paint manufacturer’s drums with seals unbroken. Each drum shall be clearly and indelible marked with a description of its contents, its date of manufacture, and the date before which it should be used. Each drum shall have a different serial number. The Contractor shall keep a record of the

delivery dates of each drum and shall make copies of the record available for use on request by the Engineer or the Employer.

1705 METALLIC ZINC

The metallic zinc to be added to the primers shall conform with ASTM designation D521.

1706 SHOP CLEANING AND PAINTING

(1) The Contractor shall prepare and paint the surfaces of steelwork before dispatch from the manufacturer's works as specified in this Clause.

(2) Steelwork surfaces to be painted shall be shot or grit blasted, and the maximum surface roughness of blasted steel shall not exceed an amplitude of 0.1 mm. A second quality surface finish is required is accordance with BS 4232.

(3) The blasting material shall be in accordance with BS 2451, and the following abrasive properly used can produce the required surface roughness:

Steel and malleable iron	: S 340 shot or G 39 grit
Chilled iron	: S 240 shot or G 24 Grit

(4) Blast cleaned surfaces shall receive their first coat of priming paint under warm, dry, dust free conditions within four hours of cleaning. Contract surfaces of joints made with friction grip bolts shall be left unpainted. Any paint that has been previously applied shall be removed by blast cleaning.

(5) Contract surfaces in welded construction that will be completely sealed shall be left unpainted. Surfaces which will be in contact with concrete when erected on site shall receive no treatment or painting.

(6) Contract surfaces or sub-assemblies which are put together at the manufacturer's works and which will be in permanent contact or concealment after shop assembly, other than those surfaces mentioned above, shall be cleaned and painted with one coat of priming paint before assembly and brought finally together while the paint is still wet.

(7) All rags, brushes and tools used for the surface preparations shall be clean.

(8) Surfaces contaminated with oil or grease shall be cleaned with white spirit.

(9) Surfaces to be painted shall be properly prepared and ample time shall be allowed for drying and hardening before the application of successive coats of paint, and no exterior painting is to be done in wet or foggy weather.

(10) Immediately before paint is applied the whole of the surface to be painted shall be thoroughly cleaned of all dust, loose paint or dirt, if necessary, by washing down with fresh clean water and dry before application of paint.

(11) The first coat of priming paint shall be applied by brush.

(12) The ideal temperature for painting lies within the range 15ºC to 32ºC with the ambient relative humidity below 90%. So far as is practicable all painting should be done when the ambient conditions are favorable and are like to continue so throughout the drying time of the paint.

(13) Before dispatch form the manufacturer's works, surfaces of steelwork which have been previously primed shall be Properly cleaned surfaces shall be cleaned and treated with one coat of a mixture of white lead and tallow or with approved varnish or plastic paints.

1707 PAINTING AT SITE

BLAST CLEANING

(1) All surfaces immediately prior to the application of primer shall be blast cleaned to bare metal.

(2) Only the following abrasive are to be used for blast cleaning; dry sand, mineral grit, steel shot or steel grit at the option of the Contractor. All abrasive shall be approved by the option of the Contractor. All abrasive shall be approved by the Engineer. The bare metal surface shall give the appearance of unpolished cast aluminum after blasting according to standards.

(3) As per possible blast cleaned surfaces shall be painted with primer on the same day and, if the cleaned surfaces become rusted or contaminated, the surface shall be recleaned at the Contractor's expense.

CLEANING

(4) Surface that has been previously painted shall be cleaned of all dirt, grease, loose paint or other foreign material before applying next coat.

(5) If any of the previous paint becomes loose, curled or loses its bond with the preceding coat, it shall be removed to sound-paint or metal surfaces and repainted at the Contractor expense as directed by the Engineer.

PAINTING

(6) During the erection of the gates the Contractor shall observe the following with regard to painting:

(a) Contract surfaces that will be completely sealed in welded construction shall not be painted;

(b) Surfaces which will be in continuous contact with concrete after completion of erection shall not be painted;

(c) Contract surfaces of sub-assemblies and other members which are put together at site and which will be in permanent contact with each other or concealed after erection (other than those mentioned in paragraphs (a) or (b) above), shall each be cleaned and painted with one coat priming paint before assemble and then assembled while the paint is still wet;

(d) Contact surfaces of joints made with friction grip bolts shall be left unpainted.

1708 PAINTING EXPOSED METAL ABOVE GATE DECKS

(1) Metalwork above the gate decks shall be painted with a primer coat, under coat and finish coat.

(2) Primer shall consist of self-cure zinc Silicate paint formulated to provide corrosion protection for metal surfaces under salt spray conditions. It shall contain a minimum of 95 percent metallic zinc by weight, which shall be added to the vehicle just before use.

(3) The under and finish coats shall be commercial quality machinery enamel for exterior metal surfaces under marine conditions and shall be compatible with the primer. The under coat shall be green and the finish coat shall be of aluminum colour. The aluminum pigment shall be in accordance with ASTM Designation D962, Type 2, class B and shall not be mixed with the vehicle until immediately before use.

1709 PAINTING EXPOSED METAL BELOW GATE DECKS

(1) Metalwork below the gate decks and subject to immersion in water, except steel piling, shall be painted a primer coat, two under coats and finish coat.

(2) The metalwork is to be sand blasted and immediately coated with a rust inhibitive primer.

(3) The primer shall consist of Epoxy Resin Varnish containing a minimum of 75 percent metallic zinc by weight which shall be added to the Epoxy Resin Varnish just before use. The hardener shall be added last in an amount equivalent to approximately 5 percent of the total weight. Minimum dry film thickness shall be 15 microns.

(4) After erection, the steelwork shall be painted a further two under coats of Coal Tar Epoxy Resin, compatible with the primer and equal to Amercoat No.78, applied to a dry film thickness of 200 microns per coat for a minimum total dry film thickness of 400 microns. The temperature during application shall be not less than 10 º C or more than 32 º C. It is important for bonding of the coats that the second under coat be applied immediately after the first under coat has become tack-free but before the firm-to-touch time has been exceeded by more than 50 percent. Tack-free conditions are defined by no paint adhering to the finger when touching the surface lightly. Firm-to-touch conditions is reached when turning the thumb through 90 degrees under light pressure will not distort the film, however, the paint can be dented by finger nail. The Coal Tar Epoxy paint shall be applied by the airless spray method to produce from thickness and quality of the layers.

(5) All finished surfaces of ferrous metals, including screw threads that will be exposed during transportation or while awaiting installation, shall be cleaned and given a heavy uniform coating of gasoline soluble rust preventive compound.

1710 PAINTING GALVANIZED STEELWORK

(1) All painted galvanized steelwork is to be painted under factory conditions as follows:

(a) one coat etching primer (20 microns);

(b) one coat calcium plumbate primer (50 microns).

(2) All galvanized steelwork is to be protected further at site as follows :

(a) All bare metal at site welds etc. is to be sand blasted and sprayed with zinc to a thickness of 100 microns applied in accordance with BS 2569, Part 1 “Sprayed Metal Coatings”.

(b) All areas treated in accordance with sub-clause (2) (a) above and all other damaged areas of paint work shall be made good and painted, as the case may be, to ensure that the full two coat treatment specified in sub-clause (1) (a) and (b) above has been achieved on all surfaces.

(c) Apply one final coat of micaceous iron oxide or one undercoat and one finishing coat of gloss enamel or of alkyd resin to all surfaces after erection. The color of the final coat is to be approved by the Engineer.

1711 PAINTING OTHER STEELWORK

(1) Where steelwork which is not galvanized and not subject to immersion in water or defined as “painting exposed metal above gate decks” and is required to be painted, it shall be sand blasted and painted under factory conditions as follows:

(a) one coat of epoxy primer (100 microns) ;

(b) one coat of red lead primer (50 microns);

(c) one coat of micaceous iron oxide paint (100 microns).

(2) The steelwork is to be further protected at site as follows:

(a) All damaged paintwork to be repaired and made good to ensure that the full three coat treatment has been achieved on all surfaces;

(b) Apply on final coat of micaceous iron oxide or one undercoat and one finishing coat of gloss enamel or of alkyd resin to all surfaces after erection. The color of the final coat is to be approved by the Engineer.

1712 STEELWORK EMBEDDED IN CONCRETE

Surfaces of steelwork to be covered with concrete are to be thoroughly cleaned and free from all dirt immediately before the concrete is placed in position. Steelwork is to be sealed at the junction with the concrete surface by a bead of alkali resistant mastic after concreting and before applying the final coat of paint.

Chapter 18

1800 MISCELLANEOUS MATERIALS

1801 TIMBER

Timber used in the permanent Works shall be of the best quality of its respective kind, thoroughly seasoned and matured, sound, straight, and fine in grains, free from sapwood, shakes, large or loose knots, worm holes, wanes, cracks and other on all four sides to the scantlings and shapes shown on the Drawings.

1802 STOP LOG

(1) All timber used in the construction of stoplogs shall be treated with a water repellant preservative creosote for a minimum period of 24 hours in accordance with BS 5268: part 5: 1977.

(2) Contact surfaces between steelwork and timber and all timber joints shall be coated with hot bitumen bedding compound immediately prior to bringing together. All nuts, bolts and washers in contact with timber shall be treated in a similar manner.

(3) Stoplogs complete with seals and guides shall be assembled so as to attain a tight and water proof sealing at the base, at the top and at sides. The lifting and lowering of stoplogs should be achieved from the Deck without undue resistance. Except where water sealing is required, all metal to metal contact surfaces must be lubricated during test operations as recommended by the manufacturer.

1803 BULLAH POLES

(4) Bullah poles shall be made sal, sundari, Gajari or any other approved local hard wood. They shall be matured, straight and free from large or loose knots, cracks and other defects.

(5) The diameter of bullah at its tip shall not be less than 100mm and at butt end as specified. The average diameter of bullah shall be measured at 1/3rd length from its butt end without bark.

(6) Bullah pole to be used as foundation pile placed above water table or within the fluctuation zone of water table shall be treated with a water repellent preservative creosote for a minimum period of 24 hours in accordance with BS 5268, part-5, 1977.

(7) A straight line drawn from the centre of the butt to the centre of the tip shall be contained entirely within the pile.

1804 GUNNY BAGS

The gunny bags used in the permanent works or temporary works may be new or old. Capacity bags is 75 kg or 50kg. The Contractor shall submit sample bags to the Engineer for his approval supply or work.

1805 GEO-JUTE

(1) Where specified in the Drawings, Geo-Jute shall be laid on the finished soil profile/slopes according to Drawing. The detailed application methods may differ from site to site but generally the steps are as follows:

- Geo-Jute is rolled along or down slopes and secured with wire staples.
- Geo-Jute must be laid loosely and evenly, without tension or stretch on either direction.
- Up-channel ends/embankment crest ends or shoulders are buried and stapled in a 15 mm deep slit trench, then fastened with a further five staples.
- Down-channel ends/embankment toes are folded under by 150 mm and secured with five staples.
- All terminations are buried in a 150 mm deep slit trench.
- Longitudinal edges are overlapped by 350 mm.
- Roll junctions are overlapped by 350 mm upper one over lower one and stapled.
- An additional row of staples is fixed at 100 cm centres down each strip.
- Erosion stops of folded Geo-Jute may be buried at critical points to control subsoil slippage as and when directed by the Engineer.

PROPERTIES OF GEO-JUTE

(2) Geojute to be used to protect the slope from water damage shall be 100% jute and comply with the following properties:

Properties	Test Standard	Test values
Mass per unit area	BDS ISO 9864	$\geq 627 g/m^2$
Thickness (under 2 kpa pressure)	BDS ISO 9863-1	$\geq$ 2.00 mm
Opening size O_{95}	BDS ISO 12956	<150 μm
CBR Puncture Resistance	BDS ISO 12236	$\geq$ 2500 N
Grab Tensile Strength (machine direction-MD)	BDS ISO 13934-1	$\geq$ 950 N
Grab Tensile Strength (cross machine direction-CMD)	BDS ISO 13934-1	$\geq$ 230 N

Properties	Test Standard	Test values
Grab Tensile Elongation, force-MD	BDS ISO 13934-1	≤ 35%
Grab Tensile Elongation, force-CMD	BDS ISO 13934-1	≤ 45%
Vertical Permeability	BDS ISO 11058	$\geq 1*10^{-3}$ m/s
Horizontal Permeability	BDS ISO 11058	$\geq 6*10^{-3}$ m/s

1806 PRECAST CONCRETE PIPE

GENERAL

(1) Precast concrete pipe, including cement, reinforcement and all other materials for pipe and pipe joints, shall be furnished by the Contractor. The type and size of the pipe of the pipe used in the various locations shall be as shown on the Drawings.

(2) All materials including cement, admixtures, aggregates and subsequent processing of concrete shall conform to the relevant clauses in Section 800 of the Specification.

(3) The Contractor shall supply concrete pipe for installation in hydraulic structures or other work, shall be made by the centrifugally spinning process. Concrete pipe strengths shall conform to the requirements of BS 5911. Pipe tolerances are to comply with B.S 5911.

LAYING OF CONCRETE PIPES

(4) Excavation of trenches for laying the pipe, backfill and all other related earthwork will conform to the provisions in section 300 of the Specification. Backfill shall be placed over the pipe from the excavated material to the required lines and levels as shown on the drawings or established by the Engineer.

(5) The concrete pipe shall be laid to the lines and grades shown on the Drawings or established by the Engineer, and to the specified tolerances.

(6) The Contractor shall furnish all materials incidental to the construction of pipe and joints. The laying and joining operation shall be performed in a manner compatible with the type of joints being installed and in accordance with good laying practice. The pipe trenches shall be kept free from water. The trench shall be carefully graded so as to provide a uniform support along the bottom of the pipe. At joints involving bells or collars, the excavation at the joint shall be of ample size to prevent the pipe bells or collars from coming into contact with the sub-grade. At all times,

when pipe laying operations are not actually in progress, the ends (openings) of all portions of structures shall be kept closed.

MORTAR AND GROUT FOR PIPE JOINTS

(7) Mortar for pipe joints shall be mixed in the proportion of not richer than one part of cement to one part of clean well graded sand and just sufficient water to obtain the proper consistency. To improve workability of the mortar the Contractor may add an air-entraining agent in the mortar. Cement and sand, and admixture if used, for mortar in joints shall be furnished by the Contractor and shall conform to the requirement of these materials as used in concrete pipe. Any mortar which has become so stiff that proper placement without re-tempering cannot be assured shall be wasted, and the Contractor shall prepare the mortar in small batches so as to avoid stiffening of the mortar.

1807 PVC Pipe

PVC pipe shall be of plasticized polyring/chloride and shall conform to British Standard BS 3500 : 1968/3506:1969 or equivalent. The pipe shall be laid and jointed in accordance with the manufacturer's instructions and to the Engineer's satisfaction.

APPENDIX - A

TABLE OF TOLERANCE

The following are the tolerances within which the works are to be executed :-

Item Description	Tolerance from Specifications	
	Upward	Downward
Earthworks		
Crest level of Embankment after compaction	+150	-00
Sides of Embankments per 10 m length	+150	0
Channel Water Way Area	0	0
Alignment of Channels per 20 m length	150	
Maximum for any reach	300	
Formation Level for structures	0	Filled with Blinding
Formation Level for Gabions	+50	-25

Note : The following tolerances shall apply to all wrought formed and fair or fine unformed finished.

Structures – Tolerances from Specified position

Maximum departure of plan position structure or element 25 mm

Structures – Tolerances from Specified Dimensions	Upward	Downward
Maximum departure in thickness or cross-sectional dimensions of Columns, beams, buttresses, piers, Wall footings etc, like up to and Including 500 mm thick (except tunnel and shaft linings)	+6	-3
From 500 mm to 1000 mm thickness	+10	-5
From 1000 mm to 4000 mm thickness	+10	-8
Over 4000 mm thickness	+25	-10

Surface – Tolerances form Specified Position	**Tolerances**
Maximum departure of vertical, sloping or curved surfaces including joint surface	25mm
Maximum departure of horizontal or Near-horizontal surfaces including Joint surfaces	20 mm

Surfaces-Tolerance on Straightness or Departure from Specified Curve	
General Surface :	**Tolerances**
a) Maximum deviation in horizontal or Vertical directions – gradual	12mm in 2m
b) Maximum deviation in horizontal or Vertical directions – abrupt	6mm
Surface in Contract with Low Velocity flowing Water :	
a) Maximum deviation in horizontal of flow or normal to flow – gradual	12 mm in 2 m
b) Maximum deviation in horizontal of flow or normal to flow – abrupt	4 mm
Surface in Contact with High Velocity Flowing Water	
a) Maximum deviation in horizontal of flow or normal to flow – gradual	3 mm in 2 m
b) Maximum deviation in horizontal of flow or normal to flow – abrupt (Grind to 1 in 50 level)	0

Reinforcement	**Tolerances**
Maximum departure in required bar spacing	25 mm
Stonework	$\pm$ 50 mm over
Pitching and Masonry	3 m
Gabions (Face of Basket)	+ 50 mm
Thickness of tipped rock or filter	+ 50 mm

	Tolerances
Shotcrete Departure of thickness or layers from nominal thickness	+15mm
Piles : Departure from specified position	50 mm
Piles : Deviation from vertical for vertical piles	1 in 75
Piles : Deviation from specified rake for raking piles	1 in 25

Concrete Piles casting tolerance	**Tolerances**
Maximum departure in thickness or cross-sectional area	+6mm
Deviation of pile face	6 mm in 3 m
Deviation of cross section centroid from straight line jointing end face centroid	12 mm

Timber piles tolerances	**Tolerances**
Deviation of cross section dimension	-6 mm
Deviation of cross section centroid from straight line joining end face centroid	40 mm

Tolerance for level of top of pile	**Tolerances**
Concrete piles	$\pm$ 15 mm
Timber pile	+12 mm

Blockwork/Brickwork	**Tolerances**
Verticality	$\pm$3 mm in 1 m
Line	$\pm$5 mm in 3 m
Finished level	$\pm$10 mm

APPENDIX – B

LIST OF BRITISH STANDARDS

The following is a list of British standard specifications and code of practice referred to in the Contract.

BS	4	Structural steel sections.
BS	12	Portland cement.
BS	21	Pipe threads for tubes and fittings where pressure-tight joints are made on threads.
BS	146	Portland cement and blast furnace
BS	153	Steel girder bridges.
BS	434	Testing zinc coatings on steel wire and for quality requirements.
BS	639	Covered carbon and carbon manganese steel electrodes for manual metal are welding.
BS	729	Hot dip galvanized coating on iron and steel articles.
BS	812	Testing aggregates.
BS	1199 & 1200	Building sands from natural sources.
BS	1377	Methods of test for soils for civil engineering purpose
BS	1387	Screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads.
BS	1452	Flake graphite cast iron
BS	1881	Methods for testing concrete.
BS	2451	Chilled iron shot and grit
BS	2499	Hot applied joint sealant for concrete pavements
BS	2569	Sprayed metal coatings
BS	2571	General purpose flexible PVC components fro moulding and extrusion
BS	2994	Carbon steel welded horizontal cylindrical storage tanks
BS	3100	Steel casting for general engineering purposes
BS	3148	Water for making concrete.
BS	3500	Methods for creep and ruptures testing of metal
BS	3506	Unplasticized PVC for industrial purposes
BS	4190	ISO metric black hexagon bolts screws and nuts

BS	4232	Surface finish of blast – cleaned steel for painting
BS	4254	Two-part polysulphide-based sealants.
BS	4360	Weldable structural steels.
BS	4848	Hot rolled structural steel sections.
BS	4921	Sherardised coating on iron and steel
BS	5135	Process of are welding of carbon and carbon manganese steels.
BS	5268	Structural use of timber
BS	5911	Precast concrete pipes and fittings for drainage and sewerage.

APPENDIX – C

Description of works	Requirement of Material						
	Unit	Brick (Nos.)	Cement (Bag)	Sand (cft)	Aggregate (cft)	Mortar (cft)	Thickness (mm)
Brick khoa	100 cft	850					
Brick work	100 cft	1150				36	
Brick wall (10" thick)	100 sft	960					
Brick wall (5'' thick)	100 sft	480					
RCC 1:1.5:3	100 cft		22	41	82		
RCC 1:2:4	100 cft		18	43	86		
RCC 1:3:6	100 cft		12	45	90		
Plaster (wall)	sft						12
Plaster (celling)	sft						10

Description of works	Ratio	Strength (mpa)	FM of Sand
Filter			FM = 1-2
RCC	1:1.5:3	25	FM >= 2.5
RCC	1:1.5:3	22	2 <FM≤2.5
RCC	1:2:3.5	20	1.8<FM ≤2.5
RCC	1:2:4	18	1.8<FM≤2.5
RCC	1:2:4	16	FM>1.5
CC	1:3:6	-	FM>=1.5
Plastering	1:3 to 1:6	-	FM>=1.3
Brick Wall	1:3 to 1:6	-	FM>=1.5
CC Block		Up to 15	FM>=1.5
CC Block		>15	FM>=2
Brick Block			FM>=1.5

UNIT WEIGHT OF VARIOUS MATERIALS

Sl. No.	Materials	Unit weight
1.	Cement	50 kg per bag/1440 kg per cum
2.	Sand, Dry, clean	1500 kg per cum
3.	Geobag, after sand fill	1500 kg per cum
4.	CC Block	2250 kg per cum
5.	Stone Boulder	2600 kg per cum
6.	Water	980 kg per cum
7.	Earth, Dry	1600 kg per cum
8.	Earth, Moist	1764 kg per cum
9.	Earth, Saturated	1927 kg per cum
10.	Concrete (RCC)	2407 kg per cum
11.	Iron (wrought)	7800 kg per cum
12.	Cast Iron	7222 kg per cum
13.	Teak wood	682 kg per cum
14.	Sal wood	995 kg per cum
15.	Lime	674 kg per cum
16.	Surki	1010 kg per cum
17.	Tiles	128 kg per sqm
18.	Brick	3.64 kg per No
19.	Asphalt	2300 kg per cum
20.	C.I. Sheet (Depending on Gauges) Cast Iron	102 kg per bundle
21.	16 BWG sheet	11.50 kg per sqm
22.	Corrugated asbestos sheet	16 kg per sqm
23.	Coal	800 to 900 kg per cum
24.	Cement Plaster	2080 kg per cum
25.	Wire barbed Ordinary for fencing	0.13 kg per meter
26.	Sand stone	2240 to 2400 kg per cum
27.	Shingles	1444 kg per cum
28.	Petrol	642 kg per cum

29.	Paints ready mixed with Zink	2400 kg per cum
30.	Lead	11350 kg per cum
31.	Brick Masonry	1800 to 1950 kg per cum