社会開発協力部報告書

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ROYAL IRRIGATION DEPARTMENT
MINISTRY OF AGRICULTURE AND COOPERATIVE
GOVERNMENT OF THE KINGDOM OF THAILAND

DOK KRAI – MAB TA PUD WATER PIPELINE PROJECT IN THE EAST COAST AREA

GENERAL SPECIFICATIONS

AUGUST 1982

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GENERAL SPECIFICATIONS

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DIVISION 1. GENERAL REQUIREMENT

SECTION 1000. SUMMARY OF WORKS

1001. GENERAL

The General Specifications shall be read in conjunction with the Agreement, the Conditions of Contract, Particular Specifications, Drawings and Bill of Quantities, and the Contractor shall comply with all the provisions contained within these documents and the Engineer's instructions.

Locations and scope of the Works are described in the Particular Specifications.

The Contractor shall fully understand the site conditions and the detail extent of the Works and carry out the Works in accordance with the General and Particular Specifications and Drawings as well as the instruction of the Engineer.

The General Specifications describe the minimum required standard or criteria to be applied to the Works in general.

The Particular Specifications specify the individual items of the Works in detail and take priority of the General Specifications.

The Contractor shall furnish all labour, material, equipment, tool, transportation and necessary supply for execution of the Works in accordance with the General and Particular Specifications.

1002. STANDARDS

Whenever reference standards appear in these specifications, they are intended to be the latest available and materials meeting other internationally accepted standards, which ensure an equal or higher quality than the reference standards, are acceptable. Decisions as to equal or higher quality will be made by the Engineer.

The following is a list of internationally accepted standards. The respective abbreviation is given for each standard for clarity.

JIS	-	Japanese Industrial Standards
JRS	-	Japanese Railway Standard
JEC	-	Standard of Japanese Electrical Committee
JEM	-	Standard of Japanese Electrical Manufacturers Association
JWWA	-	Japanese Water Works Association
SSPC	-	Steel Structures Painting Council

AASHO	-	American Assoc. of State Highway Officials
ACI	-	American Concrete Institute
AGA	-	American Gas Association
AGMA	-	American Gear Manufacturers Association
AISC	-	American Institute of Steel Construction
AISI	-	American Iron & Steel Institute
ANSI	-	American National Standards Institute
API	-	American Petroleum Institute
ARI	-	Airconditioning and Refrigeration Institute
ASCE	-	American Society of Civil Engineers
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
AWS	-	American Welding Society
AWWA	-	American Water Works Association
BS	-	British Standard Specification
CIPRA	-	Cast Iron Pipe Research Association
CISPI	-	Cast Iron Soil Pipe Institute
CSA	-	Canadian Standards Association
DEMA	-	Diesel Engine Manufacturers Association
DIN	-	German Standards
Fed. Spec.	-	United States of America Federal Specification
IEEE	-	Institute of Electrical and Electronics Engineers
ISO	-	International Organization for Standardization
MWWA	-	Metropolitan Water Works Authority
NEMA	-	National Electrical Manufacturer's Association
NFPA	-	National Fire Protection Association
TIS	-	Thai Industrial Standards

1003. WORK SCHEDULE

The Works shall be carried out in accordance with the "Work Schedule" attached to the Contract Document.

In addition to the foregoing, the Contractor shall submit to the Engineer for his approval the program or the detailed work schedule in accordance with the Clause 43 of the Conditions of Contract.

At the end of each month actual progress for each activity shall be compared with the intended progress indicated on the detailed work schedule. The result shall be reported in the monthly progress report mentioned in Clause 1108 "Monthly Progress Reports and Site Meetings". Should the Contractor's activities be delayed, then the Contractor shall include in the monthly progress report a detailed description outlining all corrective actions he proposes to adopt to retrieve the intended schedule status.

SECTION 1100. GENERAL

1101. SETTING OUT

Bench marks and reference survey stations have been established at certain points on the site as shown on the Drawings. Before using any; of these reference points for setting out the Works, the Contractor shall undertake a survey check using the basic bench mark and satisfy himself as to their accuracy.

The Contractor shall carry out all additional survey works necessary to extend the survey network to the area of the Works and shall establish, maintain and preserve permanent monuments, bench marks, and reference stations.

The Contractor shall carry out the survey of profile and cross section to be required for setting out of structure in accordance with the instruction of the Engineer.

These survey results shall be submitted to the Engineer for his approval.

1102. ROYALTIES

Except where otherwise specified in the Particular Specifications, the Contractor shall pay all tonnage and other royalties, rent and other payments or compensation, if any, for getting stone, sand, gravel, clay or other materials required for the Works or any of them.

1103. DRAWINGS

The Drawings consist of Contract Drawings, Instruction Drawings and Shop Drawings.

(1) Contract Drawings

The Contract Drawings form a part of the Contract Documents and show the location, type and extent of the Works to be constructed under the Contract.

(2) Instruction Drawings

Instruction Drawings may be issued from time to time by the Engineer during execution of the Works to show sufficient dimensions, specific details and typical details defining the various features of the Works as required by the Engineer, based on the Contract Drawing or to revise the Contract Drawings taking into account the latest conditions which may be revealed during the progress of the Works.

The Contractor shall cooperate with the Engineer for preparation of Instruction Drawings by submitting the information resulting from conditions of site and works.

(3) Shop Drawings

The Contractor shall prepare all Shop Drawings based on the Contract and Instruction Drawings and obtain the approval from the Engineer.

All works shall be carried out in accordance with the levels, dimensions and details shown on the approved Shop Drawings. The Contractor shall also submit the descriptions for materials, equipment, construction systems, standards and workmanship related to the Shop Drawings to the Engineer for his approval.

1104. SCHEDULE OF SHOP DRAWINGS AND OTHER DATA

Within 15 days after the date of the signing of the Contract, the Contractor shall submit a schedule showing drawings and other data which are specified to be submitted for the Engineer's approval.

This schedule shall show the proposed dates of submission of the Shop Drawings and of other data, which dates shall be subject to the Engineer's approval.

The schedule shall be updated and re-issued once every two months until substantial completion of all Shop Drawings, and other data or such time as directed by the Engineer.

The Contractor shall schedule the dates of submission of Shop Drawings and other data to be furnished to allow ample time, but in no case less than 14 days unless otherwise specified, to permit the Engineer to check these Drawings and other data.

1105. SUBMISSION OF SHOP DRAWINGS AND OTHER DATA

Drawings, specifications and other data required to be submitted for approval as specified shall be provided prior to fabrication, construction or ordering of materials as applicable, as follows:

a) One (1) good quality sepia or polyester reproducible, printed on the face side and five (5) clear prints with black lines on a white background of each drawing and five (5) copies of specifications and other data shall be submitted to the Engineer for approval.

b) Revisions shall be described by number, date and subject in a revision block on drawings, on the front page of specifications and in a similar, readily identifiable place on other data. Additionally, each revision shall be clearly delineated on drawings, marked in the margin of specifications and similarly identified on other data.

c) For the Engineer's use, a blank space, measuring approximately 9 cm by 14 cm, shall be provided on drawings immediately above the title block, on the front page of specifications and in a similar space on other data.

One good quality sepia or polyester reproducible, printed on the face side and five prints with black lines on a white background, of approved drawings and six copies of approved specifications and other data shall be issued to the Engineer.

Within 30 days of issue of a Certificate of completion of the Works shown on the Shop Drawings, the Contractor shall submit to the Engineer two polyester reproducible films, thickness 0.075 mm, printed on the face side and two card mounted film negatives 35 mm x 45 mm in size, of each of the Shop Drawings, whereon shall have been incorporated all changes, revisions, corrections and approvals including the delineation thereon of any physical changes made during construction, assembly or erection, such that the drawings accurately represent that part or portion of the Works delineated thereon as it was completed and accepted by the Engineer. Size and title of drawings will be directed by the Engineer.

1106. APPROVAL OF SHOP DRAWINGS AND OTHER DATA

One print of Shop Drawings and one copy of Contractor's specifications submitted for approval will be returned to the Contractor marked either APPROVED or APPROVED EXCEPT AS NOTED, as applicable.

Drawings, specifications and other data marked APPROVED or APPROVED EXCEPT AS NOTED shall be deemed to authorize the Contractor to proceed with the construction or purchase of materials or equipment covered by such documents, subject to the corrections if any are indicated thereon or if described in the letter of transmittal.

Where a drawing, specification or other data are marked APPROVED AS NOTED, one good quality sepia or reproducible and three prints of the revised drawing and three copies of specification and other data showing the necessary corrections shall be submitted as aforesaid to the Engineer for approval.

The approval of the Shop Drawings, specifications, or other data by the Engineer shall not exonerate the Contractor from any of his responsibilities under the Contract. Any construction prior to approval shall be at the Contractor's risk.

Should an error be found in the Shop Drawings during the erection of structures or the installation of equipment, the Contractor shall correct the drawing thereon including the delineations of any changes found necessary at site and shall resubmit the drawing for approval as specified hereinbefore.

Approved Shop Drawings, specifications and other data shall be signed by both the Engineer and the Contractor and no departure from these documents shall be allowed without the approval of the Engineer.

The Engineer shall have full power and authority to order the Contractor to suspend or to stop such works that are not in accordance with the approved Shop Drawings or commenced before the issuance of such approved Shop Drawings.

1107. AS-BUILT DRAWINGS

(1) As-built Drawings shall be prepared and submitted by the Contractor to the Engineer before the Provisional Take-over. The As-built Drawings shall show all facilities under the Contract, thereby incorporating all changes, revisions and corrections including the delineation thereon of any physical changes made during construction, assembly or erection, such that the drawings accurately represent that part or portion of the Works delineated thereon as it was completed and accepted by the Engineer. Sizes and titles of drawings will be directed by the Engineer.

(2) Prior to the submission of the As-built Drawings, the Contractor shall take the Engineer's approval. Each As-built Drawing to be submitted shall contain one (1) original and three (3) blue prints and one (1) micro film.

1108. MONTHLY PROGRESS REPORTS AND SITE MEETINGS

Before the 10th of every month during the course of construction, the Contractor shall submit to the Engineer the monthly progress reports for the preceding month which shall include the following:

a) List of manpower employed during the report period.

b) List of constructional plant on Site in working order indicating their numbers of working days.

c) List of activities scheduled to be in progress and actually in progress during the report period, together with the Contractor's estimate of progress achieved up to the report date and actual/forecast start and/or completion date for each activity.

d) List of activities scheduled to be started within 2 months with forecast starting dates.

e) Five (5) sets of photographs which include number of selected views of executed work.

f) A progress graph chart showing the monthly progress of major work items together with their scheduled total achievements and their actual total achievements.

The Contractor shall participate in site meetings which will be conducted by the Engineer on a regular basis and at any time when called for.

1109. MONTHLY STATEMENT FORMS

The Contractor shall submit the monthly statements for payment include a summary sheet. Before any of the forms are printed, proof copies shall be submitted to the Engineer for approval. Seven copies of the completed statement with eight additional copies of the summary sheet will be required each month.

1110. SAMPLES

The Contractor shall submit samples of materials for the Engineer's approval. One of each approved sample will be retained for reference by the Engineer. Finished work shall match the respective approved samples.

SECTION 1200. TEMPORARY WORKS

1201. GENERAL

This Section covers temporary access, electrical power, water supply, sewage disposal, and telecommunication for construction purpose, contractor's camp, safety requirements and other temporary works.

The Contractor shall submit to the Engineer for his approval, the drawings and full particulars of the temporary works.

The submission to or approval by the Engineer of any such proposals by the Contractor shall not relieve the Contractor of any of his responsibility for the sufficiency of the temporary works for their intended purpose.

The Contractor shall also obtain any necessary approval from the local, statutory or other authorities before construction.

No house, office, store, workshop or other habitable buildings will be permitted underneath or within 10 meters of the nearest point in plan of any conductor of an overhead power line.

Unless otherwise specified, all temporary works shall be removed or otherwise disposed of to the satisfaction of the Engineer by the end of the Period of Maintenance. The site of temporary works shall be cleaned up, reinstated or arranged by the end of the Period of Maintenance to the approval of the Engineer.

1202. SITE PREPARATION

The Site will be handed over to the Contractor by the Employer for the performance of the Works.

When the Contractor intends to use the additional lands which are not provided by the Employer, the Contractor shall obtain those lands with the Contractor's own expenses, after taking the approval by the Engineer.

The Contractor shall clear the site in accordance with the Specifications and the instruction of the Engineer. The clearing work shall consist of removal of trees, bushes, roots and vegetation and elimination of unnecessary structures such as buildings, roads, waterways and other obstacles for the Works.

All usable materials such as trees recovered during clearances belong to the Employer. If the Employer orders to store such

materials under the Contract, the Contractor shall store them in the place to be defined by the Employer.

The destruction of vegetation by fire can not be carried out without the Engineer's prior approval.

The Contractor shall be, however, entirely responsible for consequences of such destruction by fire even though it may have been approved by the Engineer.

The Contractor shall prepare the necessary temporary facilities on site and shall keep them in good conditions during the execution of the Works.

Upon completion of the Works, the Contractor shall destroy all temporary facilities and clear away waste materials or rubbish of whatever kind remaining on the Works. Such refuse material shall be deposited at the place instructed by the Engineer.

1203. CONSTRUCTION PLANT AND EQUIPMENT

The Contractor shall furnish construction plant and equipment which will be efficient and appropriate to secure a satisfactory quality of the Works and a rate of progress which will insure the completion of the Works within the time stipulated in the Contract. If at any time such plant and equipment should appear to the Enigneer to be inefficient, inappropriate or insufficient for securing the required quality of the Works or for producing the satisfactory rate of progress, then the Engineer may order the Contractor to increase the efficiency, change the character or increase the number of plant and equipment and the Contractor shall conform to such order. The Contractor shall not be entitled to any extra payment or any other claims in complying with the above Engineer's order.

1204. TEMPORARY ACCESS ROAD

The Contractor shall construct and maintain temporary access roads to, in and around, the various working sites and designated borrow area.

Maintenance of temporary access roads shall include measures to control dust such as regular spraying of the road surface with water during dry periods and removal of hazardous mud during wet periods.

The road shall be made by the Contractor's own design and specifications, as approved by the Engineer.

1205. POWER SUPPLY FOR CONSTRUCTION

There is no supply of electricity for construction purpose by the Employer. The Contractor shall install a sub-station at the existing public power line or an electric generating plant and a distribution system of sufficient capacity and adequate reliability to meet all his power needs for the construction of the Works.

1206. WATER SUPPLY

The Contractor shall provide temporary water supply facilities for construction purpose from existing rivers, streams, ponds, or groundwater.

The Contractor shall install, operate and maintain an adequate supply of potable water to all staff quarters, labour camps, hospital and first aid stations, offices, laboratories, workshops, and other hutments and place of work on the site.

The supply shall be piped and continuously available at all housing sites, offices, camps and laboratories.

Potable water shall mean water free from harmful impurities.

1207. TELECOMMUNICATIONS

The Contractor shall provide a telecommunication system at the working sites of sufficient capacity and adequate reliability to meet all his telecommunication needs for the construction of the Works.

The Contractor shall submit the proposal of his own telecommunication system with sufficient details and drawings to the Engineer for his approval prior to construction.

The Contractor shall make all kinds of necessary arrangements to obtain approval of the authorities concerned for providing his telecommunication system.

1208. GARBAGE COLLECTION AND DISPOSAL

The Contractor shall maintain work areas, camp amenities and surroundings in a clean, sanitary and tidy condition.

An adequate number of garbage bins and skips shall be provided in appropriate locations. Garbage incinerators shall be located at the places directed by the Engineer.

Rubbish, garbage, and construction debris shall be collected in locations designated by the Engineer and shall be disposed of daily.

At the disposal area, exposed garbage shall be kept to a minimum and adequate vermin control and stray dog control measures shall be taken.

1209. CONTRACTOR'S CAMP

The Contractor shall construct staff quarters and labour camps at the location approved by the Engineer.

The Contractor shall provide and maintain temporary accommodation and living facilities including all necessary services for water supply, drainage, lighting, roads, paths, parking places, sanitation and refuse disposal, fire protection, commercial and recreation facilities for his staff and labour force and for the employees of his sub-contractors.

The Contractor shall ensure that the site is at all times kept in a clean and sanitary condition, and shall provide and maintain sanitary conveniences for the use of persons employed on the Works to the extent and in the manner and at such places as shall be approved by the Engineer, by the medical officer and by any local or other authorities concerned, and all persons connected with the Works shall be obliged to use these conveniences. Any employee found violating this requirement shall be liable to immediate discharge and to refusal of further employment on the Works.

1210. CONTRACTOR'S OFFICES, STORES AND WORKSHOPS

The Contractor shall provide and maintain such temporary buildings, offices, workshops and adequately fenced stores and delivery compounds as are necessary for the execution of the Works.

All such facilities shall be designed and submitted to the Engineer for approval prior to construction.

1211. HEALTH SERVICES

The Contractor shall make satisfactory arrangements for the provision of all medical, and health services for all persons employed by him and by any sub-contractors employed by him on the Works including the dependents of such persons (providing such dependents are resident at the site).

The Contractor shall also provide on-site medical, surgical and health services free of charge to such other persons (hereafter called Registered Persons), who may be designated by the Engineer, including employees of the Employer and the Engineer and their immediate dependents on the site. The standard of service and facilities to Registered Persons shall not be lower than that laid down for ordinary public hospitals and the extent of the service shall be not less than customarily provided by commercial firms of ordinary standing for persons of equal status in their employ in the opinion of the Engineer. The services listed below shall be excluded:

a) Special medical attention.

b) Surgical attention apart from first aid and minor injuries.

c) Hospital attention where the illness would normally require residence in hospital for more than fourteen days.

d) Dental treatment.

The Contractor shall employ a doctor and other qualified staff to enable him to fulfill his obligations under this Clause. The doctor shall have had about ten years professional experience or more, be adequately experienced in medicine, surgery and obstetrics.

1212. SAFETY PRECAUTIONS

(1) General

In the performance of the Works, the Contractor shall exercise every reasonable precaution to protect persons or property from injury. He shall erect and maintain all necessary temporary fencing, barricades, barriers, multilingual signs, and lights and provide fire alarm, fire extinguishing and fire fighting services at strategic points on the site. The Contractor shall adopt and enforce such rules and regulations as may be necessary, desirable or proper to safeguard the public, all persons engaged in the Works and its supervision and all traffic adjacent to thoroughfares.

The Contractor shall appoint a Safety Officer and hold regularly scheduled safety meetings with the Engineer and with his own supervisors and foremen.

Safety measures shall include but shall not be limited to the specific safety measures specified in this Clause.

(2) Road Safety

The Contractor shall install convey mirrors at road intersections, junctions and bends of poor visibility as well as priority signs.

(3) Temporary Fencing

The Contractor shall erect, maintain and remove suitable and approved temporary fencing to enclose such areas of the Works within the site as may be necessary to the satisfaction of the Engineer. Where any temporary fence has to be erected alongside a public road, foot path, etc., it shall be of the type required by and shall be erected to the satisfaction of the authorities concerned.

(4) Lighting

The Contractor shall provide sufficient lighting to ensure that, in all places where the work is done at night.

a) Safe working conditions are provided both for the Contractor's personnel and for personnel of the Engineer.

b) The Works can be constructed in complete compliance with the Contract.

c) A complete inspection of all works in progress can be made by the staff of the Engineer.

Unless otherwise directed by the Engineer, the minimum intensity of illumination on ground or working surfaces to be provided for the various operations or work areas shall be as tabulated below:

Operation or Area	Minimum Intensity of Illumination in Food Candles
Earthworks and excavation	2
Bridges	2
Access and haul roads where cross traffic or other hazardous conditions exist	2
Concrete batching plant	4
Concrete placing	4
Maintenance shops and auxiliary buildings	5
Explosives storage area	2

Illumination for areas or operations not listed in the above table shall conform to the specified requirements for similar listed areas or operations.

All moving equipment or plant used during night operations shall be equipped with sufficient lights and reflectors to ensure safe working conditions.

Not less than 14 days before he proposes to start night operations, the Contractor shall submit to the Engineer his proposals for lighting in the areas in which he proposes to work at night.

The submission to or approval by the Engineer for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

(5) Work in the Vicinity of Electrical Equipment

a) Once any permanent electrical plant has been connected to any electricity supply, its operation and the completion of any outstanding work (such as painting, handrailing, etc.) on the plant shall be subject to a "permit to work" system in a form agreed between the Engineer and the Employer in accordance with the Employer's Standard Safety Regulations for such work.

b) While the plant is still under the control of a Contractor, the "permit to work" shall be endorsed by that Contractor.

c) Permits to work on plant which is handed over shall be under the control of the Employer.

(6) Explosives

In the use, handling, transporting and storage of explosives, the Contractor shall comply with the guidelines given in the local regulation. The handling or use of explosives shall be discontinued during the approach and progress of a thunderstorm. All persons shall be removed from danger areas to a place of safety during such periods.

The explosives storage shall be located as directed by the Engineer and shall be protected with an earth bund surround and enclosed with security fencing and provided with lighting to the approval of the authorities concerned.

1213. MAINTENANCE OF TRAFFIC

Where the Works will be carried out at the site on or near the existing road, the Contractor shall maintain vehicular and pedestrian traffic at all times. If the Contractor's operations cause traffic hazards, he shall repair the road surface, provide temporary way, erect wheel guards or fences or take other measures for safety satisfactory to the Engineer.

For the construction at the location of heavy traffic or at road junctions, and for structure lying across the road, the Contractor shall submit a work program showing number of labour and equipment, the expected amount of work to be done, detours and another necessary details to the Engineer for approval fifteen (15) days in advance of the starting of the Works.

Detours around construction site will be subject to the approval of the relative authorities. Where detours are permitted, the Contractor shall provide all necessary barricades and signs as required to divert the flow of traffic. While traffic is detoured, the Contractor shall expedite construction operation and the period be strictly controlled by the Engineer.

For road crossings or in heavy traffic locations, the Contractor shall carry out the Wroks at the time and within the working hours directed by the Engineer. After completion of the Works, the Contractor shall immediately make necessary backfill and pavement at the crossings.

1214. PROTECTION AND RELOCATION OF EXISTING STRUCTURE AND UTILITY

The Contractor shall assume full responsibility for protection of all structures and utilities, public or private, including poles, signs, services to buildings, utilities in the street, water pipes, drains, electric and telephone cables, whether or not they are shown on the Drawings.

The Contractor shall carefully support and protect all such structures and utilities from injury of any kind. Any damage resulting from the Contractor's operations shall be repaired at his own expense to the satisfaction of the owner(s) of the structures and utilities or the relative authorities.

It is the Contractor's sole responsibility to obtain all locations of underground structures and utilities. Services to buildings and accesses to buildings shall be also maintained.

Temporary removal or replacement of some existing utilities or structures as described in the Particular Specifications will be made by the respective owner(s) of the structures and utilities or the relative authorities.

In case the owner(s) or the relative authorities will allow the Contractor to do the work of replacement or removal, the Contractor shall carry out the work under the supervision of the owner(s) or the relative authorities.

1215. DIVERSION OF EXISTING FLOW

Where the Works require temporary diversion of flow in the river, stream, canal and waterway, the Contractor shall submit the detail proposal of the diversion works showing the construction plan and method to the Engineer for approval.

The Contractor shall ensure the original flow rate and water quality in the temporary diversion works. In case the flow rate and water quality will not be guaranteed, the Contractor shall compensate such water to meet the demand occurred at the downstream.

Any damage or blockage resulting from the Contractor's operation for flow diversion shall be made good at his own expense.

The Contractor shall remove all temporary diversion facilities after completion of the Works and restore the original feature of flow.

1216. CARE AND PROTECTION OF PROPERTY

All fences, walks, bushes, trees, shrubbery and physical features shall be protected and restored in a thoroughly workmanlike manner.

All existing pavements, sidewalks and waterways which are disturbed by the Contractor's operation shall be restored to their original or better conditions by using similar material approved by the Engineer.

1217. SIGNPOSTS AND NOTICE BOARD

The Contractor shall provide signposts and notice boards at the places indicated by the Engineer.

The signposts shall show the direction to the working site and the names of the work site, the Employer, the Engineer and the Contractor. The notice board shall describe the outline of project and illustrate the general plan of project.

The signposts for traffic control shall be required according to the regulations of the relative authorities in case a part of existing road will be occupied by the Works and detours will be provided.

DIVISION 2. EARTHWORK

SECTION 2000. EXCAVATION

2001. GENERAL

This Section covers stripping and excavation of various materials for structures and borrow areas, drainage of excavated areas, disposal of excavated materials and preparation of foundations.

2002. STRIPPING

a. Stripping shall consist of removal and disposal of topsoil and surface vegetation, tree stumps, roots and any other organic materials.

Stripping shall be carried out in such a manner that surface runoff is assured and impoundment of water is eliminated.

b. Stripping shall be performed only in such areas and to such depths as specified by the Drawings and Particular Specifications or directed by the Engineer.

2003. CLASSIFICATION OF EXCAVATION

(1) Rock Excavation

Rock excavation shall mean excavation of material which requires drilling and blasting prior to excavation. Boulders or detached pieces of solid rock less than one cubic meter in volume shall not be recognized as rock.

(2) Common Excavation

Common excavation shall include all materials other than rock.

2004. METHOD OF ROCK EXCAVATION

a. The method of excavation shall in every case be subject to approval of the Engineer and the Contractor shall make all necessary provisions to ensure the stability and safety of excavation and the adjacent structure.

b. The location and depth of holes for blasting shall be such and the quantity of explosives instantaneously detonated shall be such that the rock shall be taken out to the lines and grades

specified without overbreak or damage to the rock beyond the required limits of the excavation.

c. The maximum quantity of explosives per delay when blasting adjacent to concrete less than seven days old, or previously grouted rock shall not exceed;

Distance (m)	Explosives per Delay (kg)
15 - 30	1.0
30 - 60	2.5
60 - 90	5.0
90 - 120	10.0
Over 120	as approved by the Engineer

d. The maximum quantity of explosives per delay when blasting adjacent to concrete more-than 7 days old and adjacent to fill in place shall not exceed;

Distance (m)	Explosives per Delay (kg)
15 - 30	2.5
30 - 60	5.0
60 - 90	12.5
90 - 120	25.0
Over 120	as approved by the Engineer

e. The above distances will be measured along the shortest path between the fill, concrete or previously grouted point and the rock to be blasted.

f. Where the Contractor uses an explosive with any energy content differing from that of a 75 percent grade strength gelatinous high explosive, the allowable weight of alternative explosive shall be directly in proportion to the energy released on detonation of known weight of a 75 percent grade strength gelatinous high explosive and the energy released on detonation of the same weight of the alternative explosive.

g. The Contractor shall submit to the Engineer, in writing, a detailed plan of the excavation method at least 15 days before commencing the excavation, and shall not proceed with the excavation before such plan has been approved.

h. When the excavation has been completed to the lines specified or shown on the Drawings and the surfaces cleaned as specified, the Contractor shall notify the Engineer of his readiness for inspection and no excavation shall be covered with concrete or other material until it has been inspected and approved by the Engineer.

2005. STRUCTURE EXCAVATION

a. In general, structure excavation shall consist of excavation for permanent structures and their foundations within the lines, grades and profiles shown on the Drawings or directed by the Engineer.

b. The Contractor shall not excavate below the elevations or outside of the lines shown on the Drawings without the written instruction of the Engineer.

c. Berms in permanently exposed cuts shall be sloped towards the excavated face, graded to provide positive drainage away from the working area.

2006. TRENCH EXCAVATION

a. Trench excavation shall be made to depth and width as shown on the Drawings to provide suitable room for installing pipe and appurtenance structure, for bracing and supporting, for pumping and drainage facilities to render the bottom of excavation firm and dry.

b. Excavated material at trench, not required to be removed from the site, shall be so placed to inconvenience as little as possible the Works and vehicular and pedestrian traffic.

c. When asphaltic pavement is encountered, it shall be cut ahead by means of pneumatic or other tools to provide a uniform edge and minimize the amount of pavement disturbed. In case where a hole needs to be dug, pavement shall be cut to a square or rectangular shape.

d. Existing structures, pipes and conduits which are to remain or have been installed under the Works shall be protected from damage during all phases of Construction and shall be kept in full operation during the Works.

2007. BORROW AREA EXCAVATION

a. The Contractor shall submit to the Engineer for approval proposals including the drawings for excavation and working of borrow area showing the proposed extent of excavation required to expose and obtain approved borrow material.

b. The location of borrow areas and selection of materials shall be subject to the approval of the Engineer. When worked out, the borrow areas shall be left in a safe, neat and sightly condition sloped to drain properly. The Contractor shall excavate in the borrow areas in the location determined by the Engineer to obtain the type of material required for the Works.

2008. CLEANING OF PERMANENT STRUCTURE EXCAVATIONS

a. Excavations shall be cleaned, trimmed and all disturbed materials, other debris and water shall be removed before any structure or concrete or fill is placed.

b. Excavations for structure foundations shall be cleaned of all loose, fractured or unsuitable rock, fragments, spalls, dirt, grout from curtain and consolidation grouting, sand, gravel or other unsuitable materials. Unsuitable materials are defined as including, but not limited to, broken, sheared, chemically altered or badly fractured rock in seams, fault zones or local pockets of poor rock.

c. Cleaning shall be done by means of bars, picks and shovels, stiff brooms, hammers, high velocity air or water jets, or other means satisfactory to the Engineer. After cleaning and before any concrete or other permanent material is placed on the rock all standing water shall be removed and all flowing water shall be diverted from the foundation area.

d. Immediately following blasting and whenever necessary or required by the Engineer, the Contractor shall scale and remove from the surfaces of any excavation all loose, overhanging or otherwise dangerous rock. Enlargement of the excavation beyond the required limits shall not relieve the Contractor from the necessity of scaling. Any extra cost resulting from the overexcavation shall be entirely borne by the Contractor.

e. Excavations for foundations to receive fill materials shall be cleaned as specified in Section 2100 "Fill and Back-fill".

2009. USE OF EXCAVATED MATERIAL

Any excavated material, which conforms with specified requirements for use in particular sections of the Works shall be used accordingly. Material containing brush, roots or other perishable material will not in any event be considered suitable.

2010. PUMPING AND DRAINAGE FOR EXCAVATION

a. Before commencing the Works, the Contractor shall submit to the Engineer for approval his proposed program for dewatering excavation and keeping it from being inundated. The proposed program shall include the detailed description of all pumping arrangements, equipments to be employed and plan and section of any proposed dikes around excavation area. Earth dikes shall not be constructed within 5 meters of the top of slope of an open excavation. The area enclosed by the dike shall be sloped to drain to prevent ponding of water.

b. The Contractor shall construct all concrete work, pipelines and fill in the dry. The Contractor shall at all times during construction provide and maintain proper equipment and facilities to remove promptly and dispose of properly all water entering excavation, including groundwater, surface water and rainfall, and keep such excavation dry so as to obtain a satisfactory undisturbed subgrade foundation condition until structure, pipe or fill to be built thereon have been completed.

2011. SHEETING AND BRACING

a. The Engineer will require that the drawings for the sheeting and bracing system be submitted for approval at least fifteen days prior to the anticipated date of installation. Approval of the drawings by the Engineer is for approval only insofar as it affects the finished work, and such approval will not relieve the Contractor of the responsibility in any manner for the adequacy of the design for strength and for the safety of the laborers and inspectors working therein. If at any time during the course of the Works, the Engineer is of the opinion that at any points sufficient or proper supports have not been provided, he may order additional supports to be put in at the expense of the Contractor, and compliance with such order shall not relieve or release the Contractor from his responsibility for the sufficiency of such supports.

b. The Contractor shall furnish, put in place, and maintain such wood and/or steel sheeting and bracing as may be required to support the sides of excavations, to prevent any movement which could in any way diminish the width of the excavation necessary for proper construction, and to protect adjacent structures, utilities, roadways and bridges from undermining or other damage.

c. Care shall be taken to prevent voids outside of the sheeting, but if voids are formed, they shall be immediately filled with granular material and suitably compacted.

d. When any open excavation is carried out near or under any existing buildings, cables and paved roads, the Contractor shall provide the necessary shoring to prevent damage, whether such existing facilities are indicated on the Drawings or not.

e. The Contractor shall leave in place to be embedded in the backfill all steel and wood sheeting and bracing which the Engineer may direct him in writing to leave in place at any time during the progress of the Works for the purpose of preventing injury to structures, utilities, or property, whether public or private. The Engineer may direct that timber used for sheeting and bracing be cut off at any specified elevation.

f. All sheeting and bracing not left in place shall be carefully removed in such a manner as not to endanger the construction or other structures, utilities, or property. All voids left or caused by withdrawal of sheeting shall be immediately refilled with granular material by compacting with tools especially adapted to that purpose, by watering or otherwise as may be directed.

g. No wood sheeting or bracing is to be completely withdrawn if driven below the center line of any pipe, and under no circumstances shall any sheeting or bracing be cut off at a level lower than 30 cm above the top of any pipe.

Wood for bracing and sheeting shall be of adequate section and quality and shall be sound, and free from knots, twists or other weakening effects. Steel sheeting shall conform to ASTM A328, "Steel Sheet Piling". The sheeting shall be braced at all times to prevent slips and cave-in of walls or subsidence of adjacent areas.

2012. SPOIL AREA

a. Stripping and other material rejected as unsuitable by the Engineer shall be disposed of in spoil areas shown on the Drawings or designated by the Engineer. Stripped material taken out of borrow area may be disposed of in the worked-out sections of the borrow pits at locations approved by the Engineer.

b. Topsoil shall be stacked separately from rejected materials and in locations suitable for reclaim for final landscaping.

c. The spoil areas shall be left in a stable, safe, neat and sightly condition and sloped to drain properly. Unstable slopes or slippages shall be made good.

d. Spoil areas shall not be used as rubbish dumps.

SECTION 2100. FILL AND BACKFILL

2101. GENERAL

a. This Section covers the material to be used as fill and backfill and the placing, compaction and testing.

b. Material for fill and backfill shall consist of soil obtained from borrow area, excavation for structures and other sources as specified or directed by the Engineer.

The material shall be well graded as delivered to point of use. It shall be free of organic material including but not limited to roots and vegetable matter, decomposed or otherwise, organic soil or loam or any other material which in the opinion of the Engineer is unsuitable.

2102. BORROW AREA

a. Borrow area shall be stripped and graded to divert surface runoff from the area from which material is to be obtained. Ditching including diversion of natural water courses, construction of sumps and pumping therefrom shall be carried out as required to keep the working area and the excavated material free of impounding water at all times.

b. In case the Contractor may provide the stock pile area to stock material for convenience of construction method, the stock pile area shall be approved by the Engineer and shall be cleared, stripped, graded and compacted prior to the placement of usable material.

The material to be stocked shall be compacted so as to prevent seepage of rain and to keep the moisture content of material.

2103. FOUNDATION PREPARATION

a. The area of foundation for fill and backfill shall be excavated as shown on the Drawings or as directed by the Engineer. The Contractor may be required to perform additional excavation to ensure slope stability at his own expense.

b. Foundation preparation shall consist of scarifying to a depth of not less than 15 cm on exposed surface after excavation and compacting with at least 3 passes of the rollers specified in this Section. Before placing the first layer of fill and

backfill on this compacted foundation area, the surface shall be scarified to a depth not less than 5 cm, in order to roughen the surface and provide good bonding of the fill placed thereon.

2104. PLACING

a. In area inaccessible to the selected compaction equipment, the fill and backfill shall be placed in layer not exceeding 5 cm in thickness, and compacted using hand operated vibrating roller and/or mechanical tamper as approved by the Engineer. The placing of fill and compaction with hand operated equipment shall be continued as far as necessary in the opinion of the Engineer.

b. The fill and backfill shall be placed and spread in continuous layers parallel to the major axis of the structure. A layer shall not exceed 15 cm in compacted thickness except as mentioned in other Clauses of this Section.

c. The surfaces of the fill layers shall be sloped transversely at a grade of 5 percent so that surface shall drain freely and away from structures. The fill shall not be contaminated by other materials and it shall be free of lenses, pockets, streaks or layers that are more pervious and lumps or clods shall be broken down. Where the surface of the fill is considered by the Engineer to be too smooth for proper bonding with the next layer, such surface shall be scarified or harrowed as directed immediately prior to the placing of the next layer of fill.

d. Where the surface has dried too much for proper bonding, it shall be uniformly sprinkled with water and scarified, harrowed and mixed until the moisture content of the in-place material is within the required limits.

e. If the moisture content of the in-place material is higher than the limit required, such fill shall be scarified, harrowed and aerated until its moisture content is within required limits or it shall be removed from the fill site where directed by the Engineer.

f. The Contractor shall immediately suspend any or all fill placing operations when for any reason the Engineer considers conditions or procedures to be unsatisfactory.

2105. MOISTURE CONTROL

The Contractor shall conduct his operations so that the moisture content of the fill material at the time of compaction shall be as uniform as practicable and the Contractor shall control the placement moisture content within the specified limits unless otherwise directed by the Engineer.

2106. COMPACTION

a. Each layer of the fill material shall be compacted by an approved compactor so that the fill material shall form a single homogeneous mass.

b. When so directed by the Engineer hand operated heavy duty tamper and/or smooth faced vibrating rollers shall be used for the compaction of fill material placed in areas inaccessible to the selected compaction equipment. These tampers or rollers shall be air, gasoline or diesel powered. They shall be easily maneuverable and of sufficient capacity to obtain the specified density.

c. The dry density of the fill shall be at least 90 percent of the maximum dry density as determined by the compaction test performed in accordance with ASTM D698.

2107. TESTING OF FILL

a. The Engineer will perform all tests of the material. Testing by the Engineer will be done as frequently as deemed necessary and the Contractor shall furnish labour and construction plant to assist in obtaining the samples for testing.

b. The Contractor shall, if directed by the Engineer, excavate test pits for inspection and testing of material. These pits shall be backfilled and hand tamped, as directed by the Engineer.

SECTION 2200. STONE WORK

2201. GENERAL

This Section covers the materials to be used and the placing for the stone works.

Stones for various purposes shall be the best of kind, sound and durable, free from flaws and from soft, weathered or decomposed parts. The borrow area and quarry site to collect stone material shall be proposed by the Contractor to the Engineer for his approval. When required by the Engineer, samples of stone shall be submitted by the Contractor and tested by the Engineer.

2202. RIP-RAP

(1) Material

The rip-rap material shall be either field stone or rough rock stone at quarry. Material shall conform to the following gradation requirements except otherwise mentioned;

a. Rock for Mortared Rip-rap

Diameter (cm)	Percent Finer by Weight
20.0	100
12.5	30 to 100
10.0	0 to 50
7.5	0 to 10

b. Rock for Dumped or Placed Rip-rap

Diameter (cm)	Percent Finer by Weight
40	100
20	30 to 100
15	0 to 50
10	0 to 10

The diameter of rock 10 cm or larger shall be determined by passing rock through a square opening with dimensions equal to the required diameter. The length of the rock shall not exceed 1.5 times the diameter.

(2) Mortared Rip-rap

Rocks shall be thoroughly wetted before placing. Selected rocks, roughly squared and pitched to line, shall be placed at all wall angles and at all wall ends.

50 mm weep holes shall be formed in the mortared face at 4 m spacing vertically and horizontally, unless otherwise shown on the Drawings. A minimum of two (2) weep holes shall be placed in each section of mortared rip-rap.

Within 24 hours after construction, the joints on all exposed faces shall be raked clear of loose mortar and pointed with the mortar specified. The texture of pointing shall match the texture of the rock used and shall be given a smooth finish. The rip-rap shall be kept wet while the pointing is being done.

The Contractor shall take measures to anchor existing rip-rap blankets as necessary to prevent sloughing or other movement as a result of adjacent river dredging or other works. The Contractor shall provide protective works as the Engineer may direct, in order to prevent construction operations endangering the long-term stability of existing rip-rap.

Mortared rip-rap shall be protected from the sun and kept moist for at least 3 days after pointing.

Any existing rip-rap or new work which is damaged shall be removed and replaced.

(3) Dumped Rip-rap

Rocks shall be placed to form a layer of rip-rap 0.30 m thick unless otherwise shown on the Drawings, measured perpendicular to the slope. The thickness may vary from a minimum of 0.25 m to a maximum of 0.40 m. The rock shall be placed in a manner which will preserve the thickness of the bedding layer. Rock may be placed by dumping from trucks, clamshell, wheelbarrow or other suitable construction equipment. Rock shall be distributed uniformly on the slope. Voids between large rocks shall be filled with smaller stones. Sorting and positioning of the rip-rap by hand is not required.

(4) Placed Rip-rap

Rock shall be placed to form a layer of rip-rap slope. The thickness may vary from a minimum of 0.25 m to a maximum of 0.35 m. Rock may be placed by dumping from trucks, clamshell, wheelbarrow or other suitable equipment. Final placement, positioning and sorting shall be accomplished by manual labor. Rock shall be distributed uniformly on the slope. Voids between large rocks shall be filled with smaller stones.

2203. Masonry

Squared rubble or ashlar shall consist of approved stones from quarries that are not less than 20 cm long, 15 cm wide and 10 cm thick. All stones shall be roughly squared and dressed smoothly on beds and joints for a distance of at least 10 cm from the exposed face. Bond stones shall be provided at the rate of at least one for each cubic meter of the works. They shall measure at least 15 cm x 15 cm on the face and extend for three quarters of thickness of the wall. Vertical joints shall not extend past more than three stones and the horizontal lapping of stones shall be not less than 10 cm the stone-work shall be made level at intervals of about 60 cm, and all stones shall be solidly bedded and jointed in mortar with flush joints as the work proceeds. The interior spaces in the wall shall be filled with small pieces of stones or cobbles grouted in position.

2204. Gabions and Sausages

a. Gabions and sausages consist of wire cages filled uniformly and compacted with approved stones which shall not be smaller than the size of the cage mesh. All wire used shall be in accordance with ASTM-A 475. The empty cages shall be placed to lines and levels as shown on the Drawings. The kind of stones used for the gabions and sausages shall be approved by the Engineer.

b. Cages of gabions shall consist of triple twisted wire netting with hexagonal mesh as shown on the Drawings.

SECTION 2300. PAVING

2301. GENERAL

This Section covers the materials, workmanship and methods to be employed in the construction and reinstatement of the paving works of road and yard.

2302. PREPARATION OF SUBGRADE

(1) Disturbed Subgrade

No subbase material for new or restored pavements shall be placed until the Engineer has inspected and approved the subgrade.

Backfilling of excavations and fill is specified in Section 2100 "Fill and Backfill". The required subbase material may be placed in conjunction with backfilling or at a later time. Exceptions to this are in sidewalks, where the specified backfill material shall be placed to the top of the excavation at the time of backfill. Prior to placing permanent pavement, the temporary paving, if any, shall be removed and the subbase reshaped and rolled. If the subbase has not been placed, the backfill material shall be excavated to the depth required to place the specified subbase.

(2) Existing Subgrade

New pavements are to be constructed with the subbase materials required on compacted subgrade. Where the existing material has been disturbed it shall be removed to depth required to reach undisturbed material and the first layer of new subgrade placed thereon.

The subgrade shall be shaped and compacted in accordance with the Drawings and the Specifications and completed at least 150 meters ahead of the placing of the subbase course material. Clay subgrade beneath pavements shall be compacted to a minimum of ninety percent (90%) of the maximum density determined from ASTM 698 Method A. Where, in the opinion of the Engineer compaction of the subgrade is not desirable, the compaction requirement will be waived.

2303. SUBBASE MATERIALS AND INSTALLATION

a. Granular materials required for the subbase of pavements shall be specified as below:

U.S. Sieve Size	Percentage by weight finer than size shown Material(A)	Material(B)
1"		100
3/8"		50 - 85
# 4	40 - 100	
# 10		25 - 50
# 20	25 - 95	
# 40	15 - 70	15 - 30
#200	0 - 15	5 - 15

The thickness of subbase materials as measured before compaction shall be not more than 20 cm as maximum. Maximum density of the compaction shall be kept not less than 93 percent of the Proctor maximum dry density.

b. Compaction equipment used in compacting subbase materials and asphalt wearing surfaces shall be the power rammer or frog-jump type compactor weighing a minimum of 50 kg or a roller of not less than 8,000 kg.

c. Subbase material which does not contain sufficient moisture to be compacted in accordance with the requirements of this section shall be sprinkled with water. The Contractor shall supply the necessary water at his own expense.

d. The finished subbase shall not vary more than 1.5 cm above or below the planned grade or any point. Subbase which does not conform to the above requirement shall be reworked, watered and thoroughly recompacted to conform.

f. Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with pneumatic tire rollers, three-wheel or tandem rollers, or other equipment approved by the Engineer. Rolling operations shall begin from the outer edge of roadbed toward the center, parallel to the centerline of the road; except on superelevated curves, where rolling shall begin at the low side and progress toward the high side.

2304. BASE COURSE MATERIALS AND INSTALLATION FOR PAVEMENT AND SIDEWALK

(1) General

Granular materials required for the base course of pavements shall be placed in layers and compacted in accordance with the

following schedules:

Maximum Layer Thickness	Required Compaction
20 cm	CBR - 60*

* ASTM D1883 Bearing Ratio of Laboratory-Compacted Soil (California Bearing Ratio)

Granular materials (Material (C)) required for the base course are specified as follows:

U.S. Sieve Size	Percentage by Weight Finer than Size Shown
2"	100
1 1/4"	62 - 92
1"	55 - 85
3/4"	50 - 80
3/8"	40 - 70
# 4	30 - 60
# 10	20 - 50
# 40	10 - 30
#200	0 - 2

All new and restored concrete sidewalks are to be constructed on a compacted base consisting of 10 cm of granular material (A). The base shall be compacted by two passes of a hand operated mechanical compaction equipment approved by the Engineer.

(2) Construction Procedure for Pavement Base

The base shall be granular material (C) placed and compacted to the depth indicated on the Drawings.

The rolling shall begin at the edges of the course and where curbs are not a part of the new construction, the roller shall cover 1.00 m of the shoulder and extend over the loose aggregate. The roller shall be operated forward and backward along the edges until the shoulder and the aggregate are thoroughly compacted.

After the shoulders and the edges of the base course have been firmly rolled, the rolling shall progress gradually toward the centerline, each proceeding rear wheel track being uniformly lapped by one-half the width of the compression wheel. In case of superelevated curves, the rolling shall begin at the low side and progress toward the high side, instead of from the edges to the centerline as heretofore specified.

Places inaccessible to roller shall be compacted by mechanically operated hand tampers.

Any irregularities that exceed the surface tolerances, as herein specified, shall be loosened and coarse aggregate removed or added as needed. The area so corrected shall then be rerolled as required above.

For bituminous pavements the Contractor shall spread a prime (tack) coat of rapid setting emulsified asphalt on the required basecourse surface and to the edges of existing bituminous pavement before spreading permanent bituminous pavement. Emulsified asphalt for prime and tack coats shall be homogenous and show no separation of asphalt after thorough mixing within 30 days after delivery. It shall conform to Grade RS-2K as specified in Table IV-6, Specifications for Cationic Emulsified Asphalts of the "Asphalt Handbook" published by Asphalt Institute. The rate of application shall be from 1.3 - 1.5 liters per square meter.

2305. BITUMINOUS PAVEMENT

(1) General

All new bituminous pavement shall be asphalt concrete as hereinafter specified. Bituminous surface treatment is specified where required to match existing pavement or where specifically called for.

(2) Bituminous Surface Treatment

The subbase shall be graded as shown on the Drawings or as determined by the Engineer, and shall receive the following bituminous surface treatment. Materials shall be granular material and rapid setting emulsified asphalt as hereinbefore specified, placed in two applications.

The first application of emulsified asphalt shall be made uniformly at a rate of 0.8 - 1.0 liter per sq. meter at a temperature in the range of 10 - 60°C on the surface of subbase course already treated with bituminous prime coat. Following the first application, the first application of granular material (D) shall be spread uniformly within the limits of 1 cu.meter per 65 - 75 sq. meters. The new surface shall then be compacted adding granular material (D), as required, to produce a dense even surface. All surplus granular material shall be swept off the surface and removed prior to the second application.

The second application of emulsified asphalt shall promptly follow. It shall be applied at a rate of 1.1 - 1.3 liters per sq. meter. Granular material (E) shall then be spread uniformly within the limits of 1 cubic meter per 120 - 150 sq. meters.

The granular material shall then be rolled and broomed until a smooth even textured surface is produced. The completed surface shall not be subject to traffic for at least 24 hours.

(3) Hot Mix Asphalt Pavement (Asphaltic Concrete)

Materials for hot mix asphaltic concrete shall consist of a mixture of asphalt cement and granular material (F). Asphalt cement shall be prepared by the refining of crude petroleum by suitable methods and shall be homogenous and free from water. It shall conform to Grade 85 - 100 as specified in Table IV-1, Specifications for Asphalt Cements of the "Asphalt Handbook". Asphalt Cement is to be added at 4.5 to 6.5 percent by weight of total mix.

Laboratory test specimens of paving mixes, combined in the proportions of the job-mix formula, shall be prepared and tested in accordance with the design procedures set forth for the Marshall Method of mix design and shall satisfy the requirements given below when tested in accordance with ASTM D1559, "Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus".

Marshall Stability, lbs	750 minimum
Flow, 0.01 in.	8 - 16
Percent voids in total mix	3 - 15

Use 75 blows/end compaction effort for this mix design.

The job-mix formula shall be submitted for the Engineer's approval and he may change the grading as well as the bitumen content to obtain optimum quality of the completed mix.

The temperature of the mixture when delivered to the job site shall be no less than 120°C. Placing of mixture shall be done under suitable weather conditions. The mixture shall be spread in one application to the required lines and grades. The mixture shall be compacted to 95 percent of the density obtained when laboratory samples are prepared using the proportion established by the job-mix formula and compacted by the Standard Marshall Method.

Granular materials of (D), (E) and (F) are shown as follows:

	Percentage by Weight Finer than Size Shown		
U.S. Sieve Size	Material(D)	Material(E)	Material(F)
1"	100		100
3/4"	90 - 100		70 - 100
1/2"	20 - 55	100	55 - 90
3/8"	0 - 15	90 - 100	40 - 80
# 4	0 - 15	20 - 55	30 - 55
# 8		5 - 30	
# 10			22 - 47
# 16		0 - 10	
# 20			16 - 38
# 40			12 - 32
# 50		0 - 5	
# 80			8 - 20
#200			4 - 8

2306. CONCRETE PAVEMENT

Concrete for restoring existing street surface shall be Class D and shall be reinforced as required to match the existing pavement. New concrete pavements unless otherwise specified herein or indicated on the Drawings shall conform to the construction methods for placing concrete, forms, reinforcement, joints, finishing and curing specified in the Division 3.

New concrete pavement for roadways and sidewalks shall be Class D. It shall be placed to the limits and thicknesses indicated on the Drawings.

Concrete pavement shall be placed in one course to the limits indicated on the Drawings. Slabs shall be constructed in checker board order. Concrete curbs shall be constructed as indicated. All exposed concrete edges shall be finished with an edging tool having a radius of 1 cm. Extreme care shall be exercised to prevent low spots where ponding could occur.

Concrete pavement shall be placed to the thicknesses indicated on the Drawings. Where existing reinforcing steel is removed it shall be replaced with equivalent steel.

The details of expansion, contraction and longitudinal, transverse joints and their location are indicated on the Drawings. Joints shall be filled with a mixture of asphalt and granular material (A) in proportions of 1 to 6. Longitudinal joints shall have dowels across the joints with the rods on one side of the joint wrapped in asphalt sheeting.

2307. SIDEWALKS

New sidewalks are to be constructed using precast reinforced concrete slabs to the limits and details indicated on the Drawings.

Existing sidewalks to be restored following excavations for the work shall be replaced to their original condition using similar materials and in equal thickness and appearance. Existing concrete tiles may be reused provided they are not broken. Concrete tiles for sidewalks shall be of the types similar in their configurations and qualities to the existing ones. Sidewalks constructed of cast in place concrete with and without reinforcing steel shall be restored to their original condition. New sidewalks are to be constructed in conformance with the Drawings.

2308. PAINTING LINES

Areas of new pavement indicated for parking shall be provided with white lines as detailed on the Drawings. Lines and arrows shall also be painted on new pavement to direct the flow of vehicular traffic.

White paint for concrete or asphalt paving stripes shall be a type specifically manufactured for this application containing reflective glass beads. It shall be highly abrasive and wear resistant. Samples must be submitted to the Engineer for final approval.

2309. MAINTENANCE

The Contractor shall maintain pavement placed under this Contract during the specified guarantee period and shall promptly refill and repave areas which have settled or are otherwise unsatisfactory for traffic.

DIVISION 3. CONCRETE WORK

SECTION 3000. CONCRETE

3001. GENERAL

a. This section covers the materials, workmanship, equipment and methods to be used for the production of aggregates and concrete and the requirements for the transportation, placing, curing and finishing of the concrete.

b. Unless otherwise specified, all materials, all methods and procedures for concrete works shall conform to applicable Standards of the American Society for Testing and Materials (ASTM) or Japanese Industrial Standards (JIS), where not covered by ASTM and JIS Standards, shall conform to the applicable Standards or Recommended Practices of the American Concrete Institute (ACI).

c. The following standards and other publications are referred to in this Section:

ACI 214	Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 302	Recommended Practice for Concrete Floor and Slab Construction
ACI 304	Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete
ACI 305	Recommended Practice for Hot Weather Concreting
ACI 318	Building Code Requirements for Reinforced Concrete
ASTM C 33	Specification for Concrete Aggregates
ASTM C 39 or JIS A 1108	Test for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 109	Test for Compressive Strength of Hydraulic Cement Mortars
ASTM C 127 or JIS A 1110	Test for Specific Gravity and Absorption of Coarse Aggregates

ASTM C 128 or JIS A 1109	Test for Specific Gravity and Absorption of Fine Aggreages
ASTM C 136 or JIS A 1103	Test for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C 150 or JIS R 5210	Specification for Portland Cement
ASTM C 151	Test for Autoclave Expansion of Portland Cement
ASTM C 184	Test for Fineness of Hydraulic Cement by No.100 and 200 Sieves
ASTM C 186	Test for Heat of Hydration of Hydraulic Cement
ASTM C 191	Test for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C 227	Test for Potential Alkali Reactivity of Cement-Aggregate Combination
ASTM C 260 or JIS A 1117	Specification for Air Entraining Admixtures for Concrete
ASTM C 451	Test for Early Stiffening of Portland Cement (Paste Method)
ASTM C 494	Specification for Chemical Admixtures for Concrete
ASTM E4	Standard Methods of Verification of Testing Machines
USBR	Concrete Manual

3002. PLANT

The Contractor shall submit to the Engineer for approval a complete set of drawings together with a detailed description of his proposed aggregate and concrete production plant and equipment and the proposed placing plant, equipment, and method of operation. This submission shall be made and approval obtained before any order to purchase, fabricate or ship such plant and equipment is made.

3003. CEMENT

(1) Type of Cement

a. The cement shall be ordinary Portland Cement which shall conform to ASTM C 150, and JIS R 5210. The use of any other type of cement shall not be permitted without the approval of the Engineer.

b. At least 30 days prior to the first delivery of cement, the Contractor shall advise the Engineer in writing of the mill from which the cement is to be supplied.

(2) Testing Cement at Source

a. The Contractor shall arrange for mill test sheets covering physical and chemical testing by the manufacturer for each consignment of cement and shall obtain the consent and cooperation of the manufacturer for independent testing to be carried out from time to time as directed by the Engineer.

b. The following tests shall be carried out in accordance with the Standards shown and the results forwarded to the Engineer on each consignment of cement:

1.	Soundness	ASTM C 151
2.	Time of Setting	ASTM C 191
3.	Compressive Strength	ASTM C 109
4.	False Set	ASTM C 451
5.	Fineness Tests	ASTM C 184
6.	Heat of Hydration	ASTM C 186

The complete test data as specified herein shall be supplied to the Engineer prior to shipment of cement to the site.

(3) Testing Cement at Site

The Contractor shall provide access to the Engineer for obtaining samples from storage as required for testing. This testing may include any or all of the tests specified above. Any consignment from which a sample has been obtained which does not meet the requirements of the Specification, shall be deemed defective and the cement shall be removed from the site as directed by the Engineer.

(4) Storage of Cement

a. Sufficient weatherproof, properly ventilated storage, including covered unloading bays, shall be provided at the site to ensure that no delay is caused due to shortage of cement and that sampling can be carried out at least 7 days prior to use in the Works.

b. Exterior surfaces of the cement silos shall be painted with white or other heat reflective paint.

c. Cement shall be used in the sequence in which it arrives. Silos shall be voided and cleaned out at least once every three months. If cement becomes lumpy due to partial hydration, it shall be removed from the site immediately. The maximum temperature of cement entering the batching plant shall be 110°F or 43°C.

3004. WATER

Water for concrete shall be clean, potable and free from injurious amounts of oil, alkali, salts, acid, silt, organic materials, or other deleterious substances. Sources and treatment of water shall be approved by the Engineer.

3005. Aggregates

(1) General

a. Concrete aggregates shall be obtained from borrow area subject to the approval of the Engineer. Unless otherwise specified, concrete aggregates shall conform with the requirements of ASTM C 33 and the specific gravity of saturated surface-dry aggregates shall not be less than 2.60 when tested in accordance with ASTM C 127 and C 128.

b. At least three months before production of aggregates is scheduled to start, the Contractor shall deliver a 200 kg representative sample of unprocessed material to the site testing laboratory and thereafter further samples shall be delivered as required by the Engineer.

c. Immediately after production of aggregates has commenced, the Contractor shall deliver representative samples of all sizes of aggregate to the laboratory as required by the Engineer. Further samples required for testing and control purposes shall be supplied as directed by the Engineer.

d. Production of aggregates shall be balanced between the different gradations to meet the requirements of construction and no claim by the Contractor shall be allowed in the event of wastage resulting from underproduction or over-production of different size fractions.

e. The work of obtaining aggregates from approved borrow area shall include drainage of the established borrow area, excavation of the borrow area and haulage to the aggregate processing and/or batch plant.

(2) Storage of Aggregates

a. All aspects of aggregate handling and storage are subject to the approval of the Engineer and shall be such as to eliminate segregation and breakage and prevent contamination by deleterious matter or aggregates of other sizes, and so that adequate supplies are available in advance of the requirements.

b. Each size of aggreagate shall be stockpiled at approved locations which shall be cleared and stripped. Stockpiles shall be sufficiently removed from each other to prevent the material at the edges of the piles from becoming intermixed. The bottom portion of the stockpiles within 30 cm of the ground shall not be used for production of concrete.

c. Stockpiles shall be free-draining and coarse aggregate stockpiles shall be kept continuously moist by spraying as necessary to control the water content as specified in this Section. Sprays shall be arranged so that the stockpiles are wetted uniformly.

d. The moisture content of the fine aggregate as delivered to the mixer shall be controlled so as not to exceed a value of 6.0 percent, expressed as a percentage by weight of the saturated surface dry aggregate. Variations in the percentage of free moisture in any aggregates shall be limited to less than 1.0 percent in any hour of mixing plant operation.

e. The Contractor may accomplish the required moisture control by use of covered storage, mechanical dewatering devices or any other satisfactory means or combination thereof. Conveyors between aggregate stockpiles and the batching plant shall be covered to prevent the moisture content being affected by the rain.

(3) Fine Aggregates

a. Fine aggregates shall consist of manufactured sand or river sand and shall conform to the requirements of ASTM C 33 when tested in accordance with ASTM C 136 or JIS A1103 except that material finer than No.200 sieve shall not exceed 2 percent.

b. Samples of fine aggregate together with the cement to be used for the production of concrete shall be tested according to ASTM C 227.

(4) Coarse Aggregates

a. Coarse aggregates shall be graded according to Table I when tested in accordance with ASTM C 136 or JIS A 1103.

TABLE I

Nominal Size U.S. Standard Sieve Size (sq.opening)	Percent Finer than, by Weight 3-1/2" to 1-1/2"	1-1/2" to 3/4	3/4" to No.4
4 inch	100		
3-1/2 inch	90 - 100		
2-1/2 inch	25 - 60		
1 inch		100	
1-1/2 inch	0 - 15	90 - 100	
1 inch		25 - 55	100
3/4 inch	0 - 5	0 - 15	90 - 100
3/8 inch		0 - 5	15 - 40
No.4			0 - 5

Coarse aggregates shall be washed between the last processing operation and the stockpile and shall be re-screened and washed immediately prior to being batched.

b. Samples of 3/4 inch to No.4 aggregates, together with fine aggregates and cement to be used for the production of concrete shall be tested according to ASTM C 227.

c. The weight of coarse aggregate having the ratio of largest dimension to smallest dimension of more than 3 shall be limited to not more than 20 percent. Sample shall be prepared in accordance with ASTM C 136 and or JIS A 1103.

3006. ADMIXTURES

(1) General

The use of all admixtures shall be subject to the written approval of the Engineer. The manner of use, storage, handling and measurement may also be subject to controls in addition to those specified below, depending on the manufacturer's recommendations and test results. Multi-purpose admixtures shall not be used.

(2) Air Entraining Agents

An approved air entraining agent shall be used to produce the specified amount of stable entrained air in the concrete mixture, and shall conform to the requirements of ASTM C 260 or JIS A 1118. The required air content of the concrete is as follows:

Maximum Aggregate Size (inches)	Total Air (%)
3	4 ± 1
1-1/2	5 ± 1
3/4	6 ± 1
Grout	as directed by the Engineer

(3) Water Reducing Admixture

A water reducing admixture that does not retard the initial set of the concrete may be required to be added to the concrete mix during mixing in the amount as directed by the Engineer. This admixture shall conform to the requirements of ASTM C 494, Type A.

(4) Initial Set Retarding Admixture

An initial set retarding admixture shall be added to the concrete mix during mixing where and in the amounts directed by the Engineer in order to obtain the necessary retardation of the initial set of the concrete. This admixture shall conform to the requirements of ASTM C 494, Types B and D.

(5) Calcium Chloride

The use of calcium chloride or of admixtures containing calcium chloride in the concrete is prohibited.

(6) Compatibility

The compatibility of admixtures, where more than one is used, shall be proven to the satisfaction of the Engineer and satisfactory test results obtained before incorporation in the Works.

(7) Storage and Dispensing of Admixtures

a. Admixtures shall be stored in suitable weatherproof buildings. Admixtures in solution shall be stored at a temperature not higher than 35°C. Powdered admixtures shall be put into solution prior to use in accordance with the manufacturer's recommendations.

b. Accurate automatic dispensing equipment shall be provided for the measurement of and for the introduction of the admixtures into the mixer. The individual admixtures shall be added separately to the concrete in the mixer during the first half minute of the mixing cycle.

3007. CONCRETE MIX DESIGN

(1) Mix Proportions

a. The Engineer will notify the Contractor of the mix proportions for the concrete to be used in the various portions of the Works. The exact proportions in which concrete materials are to be mixed will be varied by the Engineer from time to time during the performance of the Works.

b. Before mixing concrete for any structure or part thereof, the Contractor shall satisfy himself that the concrete mixed in the proportions determined by the Engineer will permit the Contractor to produce and place concrete complying with the specified requirements.

c. Compliance with concrete compressive strength requirements shall be based on compressive strength tests carried out by the Engineer on standard 15 cm diameter by 30 cm test cylinders of concrete at the age of 28 days in accordance with ASTM C 39 or JIS A1108. For concrete containing coarse aggregate over 50 mm size shall be removed from the concrete prior to the casting of the standard test cylinders.

d. The major classes of concrete and the aggregate sizes and the workability of concrete for various types of construction are set out in Table II.

TABLE II

Class of Concrete	Type of Construction	Design Strength 28 days kg/cm^2	Coarse Aggregate Max.size (mm)	Slump Max.(cm)
A	Prestressed Conc.	350	25	8
B	Underwater Conc.	240	25	12
C	Watertight Conc.*	210	25	8
D	Common Concrete	210	25	12
E	Non-Contractive Conc.	210	25	12
F	Architecture Conc.	210	25	18
G	Cinder Concrete	180	25	12
H	Dental Concrete	135	25	12

* Water-cement ratio of the watertight concrete shall be kept not more than 55 percent.

The selection of concrete mix shall be such that the maximum size of aggregate shall not be larger than:

i. One-fifth of the narrowest dimension between sides of forms;

ii. Three-quarters of the minimum clear spacing between reinforcing bars; or

iii. One-third the depth of slabs.

(2) Trial Mixes

At least 60 days prior to the start of permanent concrete work, the Contractor shall produce trial mixes for each of the classes of concrete specified, using the entire aggregate producing, batching and concrete mixing plant provided for the execution of the Works. Such trial mixes shall be produced until concrete complying with these specifications is produced.

(3) Dry Pack

The dry pack mix shall be proportioned by weight; one part cement to 2-1/2 parts of sand that will pass a No.16 screen. Only enough water shall be used to produce a mix which will stick together when moulded into a ball by slight pressure of the hands and will not exude water but will leave the hands damp.

(4) Mortar

a. Mortar to be used for joint treatment shall have the same sand, cement and air proportions as the mortar used in the mix of the concrete at the joint.

b. Mortar to be used for repair work shall have the same sand, cement and air proportions as the mortar used in the mix of the concrete to be repaired.

3008. FIELD QUALITY CONTROL

a. Concrete tests will be carried out by the Engineer in conformity with ASTM C 39 or JIS A1108 and test evaluation will be in accordance with ACI 214. The Contractor shall provide such assistance as may be required by the Engineer in procuring samples and transporting them to the site laboratory. Samples of fresh concrete will be obtained from the forms or as required by the Engineer.

b. Concrete samples taken for conducting strength test in accordance with ASTM C 39 or JIS A1108 will consist of 4 or more samples per pour. The Contractor shall arrange for temporary storage of fresh cylinders at or near the forms and shall maintain and protect the same under moist curing conditions for a period of up to 24 hours after the completion of the relevant

pour.

c. Where compressive strength tests are used to monitor formwork removal, two additional cylinders will be prepared and field cured under similar but not more favourable conditions than those existing for the member represented.

3009. BATCHING

(1) Type of Plant

The Contractor shall provide at the site at least one modern and dependable automatically or semi-automatically controlled batching plant capable of supplying concrete at rate adequate to meet the requirements of the work schedule.

(2) Measurement and Tolerances

a. Cement shall be weighed separately on an individual scale. Water shall be weighed separately on an individual scale or it may be measured by volume. All other ingredients shall be measured by weight except that liquid admixtures may be measured by weight or volume. Each aggregate shall be measured separately. If water is measured by volume, two flowmeters shall be installed in parallel so that no delay will result due to faulty operation of the meters.

b. The equipment shall be capable of controlling the delivery of each size of aggregate to the mixer within a tolerance of 2 percent, and in the case of water, cement and admixtures, within a tolerance of 1 percent.

3010. Mixing

a. Concrete shall be thoroughly mixed in a batch mixer of an approved size and type which will ensure a uniform distribution of the component materials throughout the mass.

b. The entire contents of the mixer shall be discharged from the drum before materials for a succeeding batch are placed therein. The materials composing a batch shall be deposited simultaneously in the mixer.

c. Water for the batch should be released first and continue to flow while the solids are entering the mixer, and should have completed flowing shortly after the last of the solids of the batch have entered the drum. This flow shall not continue for more than the first 25 percent of the mixing time.

d. The first batch of concrete materials placed in the mixer at the beginning of each period of mixer operation shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a period equal to, or in excess of, 75 percent of the time interval of initial set of the mix, the mixer shall be thoroughly cleaned.

3011. TRANSPORTATION

a. Concrete shall be transported from the mixers to the place of final deposit by methods which will prevent segregation, gain or loss of materials, and which are such that the maximum difference in the slump of samples of concrete taken immediately after mixing and immediately after deposition in the forms shall not exceed 2.5 cm.

b. Concrete shall be delivered to the forms not later than 45 minutes after the addition of mixing water. Where a set retarder is employed, this time may be extended at the discretion of the Engineer.

c. Delivery times shall be established by means of delivery slips made out at the mixing plant by the plant operator or the plant inspector as directed by the Engineer. Concrete arriving at the forms without a delivery slip will be rejected.

d. Where truck mixers are used, they shall be used in accordance with the applicable sections of ASTM C 94 and ACI 304. Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight and so constructed to ensure a uniform distribution of materials throughout the mass of concrete being mixed. All solid materials and admixtures for the concrete shall be accurately measured and charged into the drum at the batching plant. The truck mixer shall be equipped with an in-line flow meter by which the quantity of water added can be measured.

3012. PLACING AND HANDLING

(1) Cleaning

a. All equipment employed in the measuring, mixing, transporting and placing of concrete shall be thoroughly cleaned prior to each use. Concrete waste deposited in or on the equipment shall be thoroughly removed immediately after each use.

b. In preparation for the placing of concrete, all sawdust, chips and other construction debris shall be removed from the interior of forms. Prior to placing concrete on rock or on construction joints, the rock or joint surfaces must be thoroughly cleaned and kept in a saturated surface dry condition and the concrete placing must be preceded by a 1 to 2 cm thick layer of cement mortar with sand and cement in the same proportion as the mortar in the concrete to be placed. Wood struts, stays or braces in the forms are prohibited. Struts, stays and braces serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

(2) Placing

a. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes and pipes or conveyors, multiple or single, for conveying concrete from the mixer or hauling unit to the forms shall be permitted only upon written approval of the Engineer. In case an inferior quality of concrete is produced by the use of such conveyors, the Engineer may order discontinuance of their use and the substitution of a satisfactory method of placing. Open troughs and chutes shall be of steel or steel lined. Where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. Baffles or boxes or vertical drop pipes shall be arranged so that the concrete drops vertically from the delivery end of all conveying units and so that there is no segregation of the concrete mix. Free drop without control of trunks or baffles shall be limited to 1.2 m. Chutes shall furthermore be covered so as to give full protection from the sun's rays and/or rain. Chute profile shall be of circular cross section.

b. Buckets for the transportation and placing of concrete shall have a discharge area not less than 60 percent of the cross-sectional area of the bucket. The discharge gates shall be positively closing, shall be maintained in a watertight condition and the rate of discharge shall be readily controlled without any consequent segregation of the concrete.

c. The use of aluminum pipe or any other application whereby aluminum is in contact with moving plastic concrete is prohibited.

d. The use of pneumatic or pumping methods of placing and handling concrete shall be subject to the approval of the Engineer. Prior to the use of such methods, the Contractor shall submit for the Engineer's approval, the details of the equipment proposed, its arrangement and the proposed operating procedures. The Contractor shall produce and transport concrete using such equipment for the trial mixes until concrete is produced that conforms to these Specifications, excepting that the maximum slump may be increased to 10 cm. Pumping methods shall comply with the recommendations of ACI 304, "Placing Concrete by Pumping Method".

e. To avoid damage to fresh concrete from rainfall and runoff water, the Contractor shall maintain adequate protection as approved by the Engineer in a state of readiness for use as necessary.

(3) Compacting

a. Concrete during and immediately after depositing shall be thoroughly compacted. The compaction shall be done by mechanical internal vibration subject to the following provisions.

b. Vibrators shall be electric or pneumatic power driven type and shall operate at a speed, when immersed in the concrete, of not less than 9,000 revolutions per minute for vibrating heads less than 10 cm in diameter and not less than 7,000 revolutions per minute for vibrating heads of 10 cm or greater in diameter.

c. The Contractor shall provide a sufficient number of vibrators with mechanical means of handling if necessary, to properly compact fresh concrete immediately after it is placed in the forms and shall maintain at least one spare vibrator at the form.

d. In concrete having a placing rate greater than 20 cu.m per hour, compaction shall be accomplished using vibrators of 10 cm or greater in diameter.

e. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of a sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued at any one point to the extent that excess water or grout appears. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

f. Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. Vibrators shall not be used to transport concrete in the forms.

g. Concrete shall be placed in horizontal layers not more than 45 cm thick except as hereinafter provided. When less than a complete horizontal layer is placed in one operation, it shall be terminated using a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and to avoid surfaces of separation between the batches. The provision for bonding successive courses of concrete shall all times be subject to the Engineer's approval.

3013. GREEN-CUTTING

a. When successive lifts of concrete are to be placed, laitance shall be removed from the surface of the concrete from the previous lift by means of a high velocity air-water jet prior to pouring the subsequent lift. The timing of this operation shall be such that individual pieces of concrete aggregate shall be exposed but their bond with the underlying concrete will not be affected. If required by the Engineer, the surface shall be cleaned by wet sand blasting or wire brushes.

3014. JOINTS IN CONCRETE

(1) General

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

b. Construction joints, expansion joints and contraction joints shall be located in the positions shown on the Drawings or as required by the Engineer. The Contractor shall not be permitted to form any additional joints or deviate from the joints indicated on the Drawings either in design or location, without the written approval of the Engineer. Joints at exposed surfaces of concrete shall be straight and continuous as shown on the Drawings or otherwise specified.

c. To prevent feather-edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface will not be less than 50 degrees.

d. Disturbance of the new surface at a joint during the early stages of hardening except as specified for green cutting is prohibited and no work or traffic on the new concrete will be permitted until the concrete has hardened sufficiently to withstand such treatment without injury.

e. All surfaces upon which or against which concrete is to be placed shall be in a saturated surface-dry condition prior to being covered by fresh concrete.

(2) Preparation

Prior to placement of new concrete, all surfaces, upon which or against which concrete is to be placed, including surfaces of construction joints between successive concrete placements, shall be thoroughly cleaned of all loose particles, dried mortar or grout or other deleterious matter. Cleaning shall include thorough washing using air-water jets. Where directed by the Engineer, all laitance and loose or defective concrete not removed by green cutting operations, shall be removed by wet sand blasting. The aggregate of formed surfaces of construction joints shall be exposed. For construction joints between first and second stage concrete, only those areas around reinforcement need be exposed to the extent directed by the Engineer. On formed expansion and contraction joint concrete surfaces, the aggregate shall remain unexposed.

(3) Cold Joints

Cold joints shall be avoided. In the event of equipment breakdown, or if for any other reason continuous placing is interrupted, the Contractor shall thoroughly consolidate the concrete to a reasonably uniform and stable slope while it is plastic and if concreting is not resumed within 1 hour it shall be discontinued and not resumed until permitted by the Engineer. When concreting operations are resumed, the surface of the concrete at the joint shall be prepared as for a fresh pour, before being covered with fresh mortar and concrete.

3015. CURING OF CONCRETE

a. All concrete shall be cured by maintaining its surface in a constantly moist condition for a period of at least 7 days after placing or until the surface is covered with fresh concrete.

All surfaces shall be protected from the sun's rays for at least 5 days after placing.

b. The surface of concrete, shall be moistened by covering with water-saturated material or by employing other effective means approved by the Engineer which will keep the surfaces to be cured continuously wet as soon as the concrete has hardened sufficiently to prevent damage.

c. Equipment for curing shall be available at the site before concrete placement is started and the water used for curing shall meet the requirements for water used for mixing concrete.

d. Steel reinforcement projecting from any placement shall be positively tied to prevent movement and possible de-bonding during placement and shall be protected from all disturbance for at least 24 hours after the completion of such placement.

3016. TEMPERATURE CONTROL

a. The Contractor shall apply any or all of the recommendations contained in ACI 305, "Hot Weather Concreting", to control the temperature of concrete as directed by the Engineer.

b. The Contractor shall establish and follow temperature control procedures that avoid the detrimental effects of high temperatures. The measures adopted shall be designed to prevent the temperature of placed concrete from rising above 49°C.

c. The temperature of the concrete as it is deposited in the forms shall under no circumstances exceed 33°C.

3017. TOLERANCES FOR CONCRETE CONSTRUCTION

a. Permissible surface irregularities for the various concrete surface finishes are specified in the subsequent Section of Finishing, and are to be distinguished from tolerances as specified hereunder. The intent of this Section is to establish tolerances that are consistent with modern construction practice, but which are governed by the effect that permissible deviations will have upon the structural action or operational function of the structure.

b. Subject to the requirements of Section 3018 "Finishing" and except as otherwise shown on the Drawings or required by the Engineer, deviations of concrete from the lines, grades and dimensions shown on the Drawings will be permitted within the following limits:

b-1. Variations of the constructed linear outline from established position in plan:

in any 3 m	6 mm
in any 6 m	12 mm
in any 12 m or above	18 mm

b-2. Variations from the plumb, from the specified batter or from the curved surfaces of all structures, including the lines and surfaces of walls and vertical joints:

in any 3 m	6 mm
in any 6 m	12 mm
in any 12 m or above	18 mm

b-3. As b-2 above, but for surfaces to be in contact with backfill:

twice the above dimensions

b-4. Variations from the level or from the elevations indicated on the Drawings:

in any 3 m	3 mm
in any 9 m or above	6 mm

b-5. As b-4 above, but for surfaces to be in contact with backfill:

twice the above dimensions

b-6. Variations in cross-sectional dimensions of columns, beams, buttresses, piers and similar members:

$\pm$ 6 mm

b-7. Variation in the minimum required thickness of slabs, walls and similar members:

$\pm$ 6 mm

c. The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the specified tolerance limits and shall ensure that the concrete is completed within these limits. Concrete work that exceeds the specified tolerance limits shall be remedied or removed as required by the Engineer.

3018. FINISHING

(1) General

a. Allowable deviations of concrete from the established lines, grades and dimensions shown on the Drawings or specified in Section of Tolerances for Concrete Construction, are defined as tolerances and are to be distinguished from surface irregularities as defined hereunder.

b. The finished surfaces of concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and other defective concrete and surface irregularities and shall be in accordance with the requirements for the particular class of finish specified herein or shown on the Drawings.

c. Finishing of concrete surfaces shall be performed only by skilled workmen.

d. Surface irregularities are classified as "abrupt" or "gradual". offsets caused by displaced or misplaced form sheathing or lining or form sections, or by loose knots in forms or otherwise defective form lumber, will be considered as abrupt irregularities and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities and will be tested by use of a template consisting of a straight edge, or the equivalent thereof for curved surfaces. The length of the template will be 1.50 m for testing of formed surfaces and 3 m for testing of unformed surfaces.

(2) Formed Surface Finishes

a. The classes of finish for formed concrete surfaces are designated by the use of the symbols F1, F2, F3 and F4, and shall be as follows:

a-1. Finish F1

Applies to formed surfaces upon or against which fill material or concrete is to be placed. The surfaces require no treatment after form removal except for repair of defective concrete and the specified curing. Surfaces to be submerged or below ground water level must have all form-tie holes filled as specified.

a-2. Finish F2

Applies to all formed surfaces not permanently concealed by fill material or concrete and for which no other finishes are specified. This finish shall present a uniform appearance and no special surface treatment will be required other than the repair of defective concrete, the filling of fastener holes, the removal of abrupt irregularities in excess of 6 mm and the reduction of gradual irregularities so that they shall not exceed 12 mm for the length designated.

a-3. Finish F3

Applies to formed surfaces prominently exposed to public view, the appearance of which the Engineer considers to be of special importance. On completion of the repair of defective concrete and filling of fastener holes, this finish shall present a surface of uniform appearance and texture. Surface irregularities shall not exceed 6 mm for gradual irregularities and abrupt irregularities exceeding 3 mm will not be permitted. In addition to the repair of defective concrete and the removal of fins, offsets and other irregularities, the surface shall, if the Engineer considers it necessary, be sack-rubbed to fill pits and air holes. Sack-rubbing shall be done as soon as the forms have been stripped and after any required patching and correction of major imperfections have been completed. The mortar to be used shall consist of 1 part cement to 2 parts by volume of sand passing a No.16 screen and shall be mixed with water to a creamy consistency. If required by the Engineer, the Contractor shall add white cement to the mix in order to obtain a colour and texture that will match the surrounding concrete surfaces. The rubbing shall be carried out in an approved manner so as to leave the surfaces of a uniform colour and free from mortar not used for filling voids. After surface treatment is completed, the specified curing shall continue for not less than 14 days.

a-4. Finish F4

Applies to some formed surfaces of water passages, as shown on the Drawings, where accurate alignment and density and evenness of surface are of importance. Hard, smooth, dense surfaces free from offsets, pits, voids and irregularities are essential and every care shall be taken in erecting forms and placing concrete to ensure that a high quality finish results. All abrupt irregularities shall be eliminated by wet grinding on a bevel of 1 to 20 ratio of height to length. Surface air holes of diameters greater than 12 mm shall be carefully filled with epoxy mortar as directed by the Engineer.

b. The Contractor shall, within 24 hours after form removal, treat abrupt irregularities where necessary to meet the following requirements. Sharp and uneven edges of abrupt irregularities shall be rubbed down and all edges shall be brought to a generally straight line for all finishes except F1. Curing interruption shall be limited to the minimum time and area practicable to perform this work.

(3) Architectural Finishes

Formed surfaces which are subsequently to be rendered, plastered or tiled shall be adequately dressed down, as soon as the forms have been removed, so that surface irregularities are not deeper than half the thickness of the rendering, plaster or mortar for tiles. Faces shall be roughened to allow adequate bond to be obtained by the mortar or plaster finish.

(4) Unformed Surface Finishes

a. The classes of finish for unformed concrete surfaces are designated by the use of the symbols U1, U2 and U3, except those for topping, and shall be as follows:

a-1. Finish U1 (Screeded Finish)

Applies to unformed surfaces that will be covered by fill material. Finishing operations shall consist of sufficient levelling and screeding to produce even, uniform surfaces. Surface irregularities shall not exceed 10 mm.

Finish U1 is also used as the first stages of finishes U2 and U3.

a-2. Finish U2 (Floated Finish)

Applies to unformed surfaces not permanently concealed by fill material or concrete. Finishing operations shall consist of sufficient levelling and screeding to produce even surfaces in which the surface irregularities shall not exceed 6 mm. Floating with hand or power-driven equipment shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in colour and texture.

a-3. Finish U3 (Trowelled Finish)

Applies to unformed surfaces where accurate alignment and evenness of surface are required for prevention of destructive effects of water action or as specified on the Drawings. Finish U3 shall be screeded and floated as indicated for finishes U1 and U2. Stage 3 shall consist of steel trowelling the floated surface as soon as it has hardened sufficiently to prevent excess of fine material being drawn to the surface. Steel trowelling shall be performed with firm pressure, such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface, free from blemishes and trowel marks. Abrupt irregularities will not be permitted.

a-4. Finish for Slabs to Receive Topping

Applies to structural slabs on which a separate topping will be placed. The finish shall be equal to Finish U1 except that before the concrete has fully hardened, the surface shall be broomed so that the aggregate at the surface shall become exposed. Alternatively, these slabs may receive Finish U1 and subsequently roughened by chipping or scarifying if approved by the Engineer.

b. Unless otherwise shown on the Drawings or directed by the Engineer, all surfaces which would normally be horizontal and exposed to the weather, shall be sloped for drainage approximately 10 mm per m of width. road surfaces may require to be sloped in more than one direction to facilitate runoff.

3019. REPAIR OF DAMAGED OR DEFECTIVE CONCRETE

(1) General

a. Repair of damaged or defective concrete shall be performed by skilled workmen only. No repair work shall be carried out until the Engineer has inspected the location of the proposed repair and has directed the method of repair.

b. The Contractor shall correct all imperfections on the concrete surface as necessary to produce surfaces that conform to the requirements specified in Section 3018 of "Finishing".

Unless otherwise approved by the Engineer, repair of imperfections in formed concrete shall be completed within 24 hours after removal of forms. Concrete that is honeycombed, fractured, or otherwise defective, and concrete which, because of excessive surface depressions, must be cut out and built up to bring the surface to the prescribed lines, shall be removed and replaced with drypack, mortar or concrete.

c. The Contractor shall correct abrupt or gradual irregularities which lie outside specified tolerances by rubbing with a carborundum stone or grinding where directed.

d. Material and procedures specified to suit individual types of repair and to reinstate structural capacity of members may include use, as approved by the Engineer, of a proprietary non-ferrous non-shrink grout, epoxy or latex-based bonding agent, epoxy compound and cementitious grout, mortar and concrete. The Contractor shall, whenever possible, perform repair of defects while the concrete is still green. Curing interruptions shall be limited to the minimum time and area practicable.

e. The holes left by removal of pipes, tie-rods or other accessories shall be reamed with suitable toothed reamers before being cleaned and filled with drypack as specified. All bulges or other projections on exposed surfaces shall be chipped and ground until a true smooth surface of matching colour and texture is obtained.

(2) Drypack

a. Drypack material shall be placed and packed in thin layers. Each layer shall be solidly compacted.

b. Drypack shall be used for filling holes having at least one surface dimension less than the hole depth, for narrow slots cut for repair of cracks, for grout pipe recesses, and for tie-rod fastener recesses. Drypack shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.

(3) Mortar

Mortar filling shall be placed under impact by use of a mortar gun, and may be used for repairing defects on surfaces designated to receive F1 and F2 finishes where the defects are too wide for drypack filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest the surface.

(4) Concrete Placement

a. Concrete filling shall be used for holes extending entirely through concrete sections, for holes in which no reinforcement is encountered and which are greater in area than 0.1 square meter and deeper than 10 cm, and for holes in reinforced concrete which are greater in area than 0.15 square meter and which extend beyond reinforcement. Holes less than 0.15 square meter in reinforced concrete which extend beyond the reinforcement shall be enlarged to permit satisfactory filling of the hole with concrete.

b. Defective concrete shall be cut out to a depth of not less than 25 mm in sound concrete in all directions so that the edges of each hole are sharp-edged and undercut to provide a key, and the hole shall be cleaned, brushed and soaked 12 hours before being refilled. The fillings shall be tightly packed and completely bonded to the surface of the holes. The mix proportions of the filling materials shall be such to provide a strong, dense repair which will avoid colour variations in surfaces exposed to view. Where required by the Engineer, the Contractor shall supply white cement in sufficient amount, as determined by trial by the Engineer, which, when blended with normal cement, will produce a finish of similar appearance to the adjacent concrete.

Non-shrink additives shall be used where a watertight joint is required. The surface of patches shall be smooth and flush with the surrounding concrete.

3020. EMBEDDED ITEMS IN CONCRETE

a. All items which are to be embedded in either primary or secondary concrete, shall be accurately set in place to conform to the required tolerances. All embedded items shall be thoroughly cleaned of rust, grease, paint, splashed mortar or other coatings that reduce bond. Prior to concreting, the Contractor shall satisfy himself that the parts are rigidly held and set to the required tolerance, and where so required by the Engineer, shall take formal delivery of the parts.

b. The methods and rates of placement of concrete around the embedded parts shall be approved by the Engineer. The responsibility for maintaining the required tolerances shall lie with the Contractor.

c. During concrete placing adjacent to embedded parts, vibrators shall not be allowed to touch any metal parts embedded in the concrete, and the concrete shall be placed in such a manner as not to disturb the embedded parts.

3021. DENTAL CONCRETE

Dental excavation shall be filled with concrete where required by the Engineer and as shown on the Drawings. After cleaning rock surfaces for placement of impervious fill, dental concrete shall be placed in horizontal lifts and each lift shall be compacted so as to thoroughly work the concrete into all irregularities of the excavation. Dental concrete shall not be used for the filling of voids in the foundations of concrete structures.

3022. SLUSH GROUT

a. Slush grout shall consist of a neat cement or a sand-cement grout as directed by the Engineer. the proportion of cement to sand in the sand-cement grout shall be 1 to 2-1/2 measured by weight. The grout shall be mixed in a mechanical mixer of appropriate size.

b. The grout shall be spread over the surfaces and stiff brooms shall be used to completely fill and seal all cracks, fractures, joints and other openings in the surface of the bedrock without having a layer of grout on the competent rock surfaces, as directed by the Engineer.

3023. SECONDARY CONCRETE

a. Unless otherwise directed by the Engineer, secondary concrete shall be placed from successive levels of not more than 1.8 m and the rate of placing shall not exceed 50 cm per hour.

b. Secondary concrete shall contain a non-shrink additive as approved or directed by the Engineer.

3024. EQUIPMENT AND COLUMN BASES

a. Equipment and column bases shall be grouted as shown on the Drawings or according to the requirements of the Engineer.

b. Materials used for the bedding grout shall be cement, water, fine aggregate and a non-shrink admixture approved by the Engineer. The proportions to be used shall be established by the Engineer.

c. All grout must be thoroughly mixed in a mechanical mixer and mixing shall continue for a minimum of three minutes after the addition of the last ingredient. Any grout left unused 1 hour after mixing shall be discarded.

d. All surfaces with which the grout will come in contact shall be thoroughly cleaned and shall be saturated surface dry at the time of grouting.

e. Forms shall be caulked to prevent any leakage and shall be built high enough to provide a small head above the base. Provision shall be made at the high points for air to be vented as it is displaced by grout. As the grout is being placed it shall be compacted by rodding or drag chains until all air pockets have been eliminated and the space to be grouted completely filled.

SECTION 3100. FORMWORK

3101. GENERAL

a. This Section covers the requirements for the design, material, fabrication, erection and removal of formwork for concrete.

b. The following standards are referred to in this Section:

ACI SP-4	Formwork for Concrete
ACI 347	Recommended Practice for Concrete Formwork

3102. LUMBER

a. All materials used in the fabrication and erection of forms shall be of adequate strength and quality for their intended purpose, to the approval of the Engineer. Suitable local timbers shall be used.

b. Forms shall be of straight lumber, shiplap, tongue and groove lumber, or plywood. Steel forms may be used only with the approval of the Engineer. All materials used in formwork shall be of a type and strength sufficient to withstand the pressures due to the concrete, and deflection shall be within the tolerances specified.

c. Where finishes F2, F3 or F4 are specified, forms may be of plywood sheathing or lining, or tongue and groove lumber, to the approval of the Engineer. However, each structure must be uniformly treated insofar as external visible surfaces are concerned.

d. Curved and double curved forms shall be sanded down and all joints filled with an approved wood filler so that the surface is perfectly smooth and tight.

3103. FORM TIES

Internal ties shall be bolts and rods and they shall be straight and so arranged that when the forms are removed, no metal shall be left closer than 5 cm to any exposed surface for all finishes. Form ties shall not be fastened to reinforcing steel or embedded parts. Wire ties will not be permitted.

3104. FORM OIL

All form surfaces shall be thoroughly cleaned before erection and shall be coated with a non-staining mineral oil or lacquer. All excess oil shall be wiped off prior to concreting and no oil shall be permitted on the reinforcing steel or other shall be permitted on the reinforcing steel or other embedded items. The use of all form coatings or lacquers shall be subject to the approval of the Engineer, and the Contractor shall be required to provide proof of compatibility between the product to be employed, the concrete itself, and any subsequent treatment that the formed surface is to receive. All form coatings shall prevent ingress of wood resins into the concrete surface.

3105. DESIGN

a. The Contractor shall design all formwork and falsework. Notwithstanding any approval given to the Contractor by the Engineer, the Contractor shall remain responsible for the safety and structural soundness of all formwork and falsework.

b. The Contractor shall submit the designs of all formwork and falsework to the Engineer for his approval. The Shop Drawings submitted for approval shall clearly indicate the dead and live loads assumed for the design, the maximum permissible rate of rise of concrete in the form, the dimensions of all structural members and the capacity of all ties, anchors and hangers.

3106. CONSTRUCTION

a. The construction of forms shall adhere to the Contractor's approved design and shall conform to the shapes, lines and dimensions of the structure as shown on the Shop Drawings. Failure or misalignment of the forms and any damage caused thereby shall be corrected by the Contractor.

b. At all unformed construction joints wooden strips of a minimum size of 5 cm by 5 cm shall be secured to the inside of the forms at the location of each joint to ensure a uniform finish to the outside edges of any lift of concrete. The upper layer of concrete shall be worked up to and under these strips so as to provide smooth edges.

c. Unless otherwise shown on the Drawings, exterior external arrises shall be chamfered 3 cm and interior external arrises shall be chamfered 2 cm.

3107. INSPECTION

Temporary openings shall be provided at the base of forms as necessary to facilitate cleaning and inspection. After inspection, these openings shall be closed in such a manner that leakage during concreting is prevented and that the concrete surface finish is not impaired.

3108. RE-USE OF FORMS

Forms shall be thoroughly cleaned and repaired to the satisfaction of the Engineer prior to re-use. Except where F1 finish is specified, metal patches shall not be allowed in the repair of forms.

3109. REMOVAL OF FORMWORK AND FALSEWORK

a. Forms shall be removed as soon as practicable and the recommendations contained in ACI 347 shall be used as a general guide for determining the time for stripping. In all cases, forms shall not be removed until such removal is authorized by the Engineer.

b. Notwithstanding the recommendations of ACI 347, forms or sections containing waterstops shall not be removed within 24 hours after the placing of concrete.

3110. CLASSES OF FORMWORK

a. Formwork shall be provided to obtain the formed finished surfaces specified in Section 3000 "Concrete" as follows:

a-1. Rough Plane Formwork

Rough plane formwork shall be used for flat concrete surfaces against which fill material or concrete is to be placed, for concrete surfaces to be submerged and for joints or boxes or checkouts where such will not be exposed to view. Rough plane formwork shall be used where F1 finish is shown on the Drawings or specified.

a-2. Smooth Plane Formwork

Smooth plane formwork shall be used for exposed flat concrete surfaces where F2, F3 or F4 finish is shown on the Drawings or specified.

a-3. Single Curved Formwork

Single curved formwork shall be used for single curved concrete surfaces where F2, F3 or F4 finish is shown on the Drawings or specified.

a-4. Double Curved Formwork

Double curved formwork shall be used for double curved concrete surfaces where F2, F3 or F4 finish is shown on the Drawings or specified.

SECTION 3200. REINFORCED STEEL

3201. GENERAL

a. This Section covers the material requirements, bending and placing of the reinforcing steel to be used in the concrete.

b. The following standards are referred to in this Section:

ACI 318	Building Code Requirements for Reinforced Concrete
ASTM A 497	Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement
ASTM A 615 or JIS G 3112	Specification for Deformed and Plain Billet-Steel bars for Concrete Reinforcement

3202. PLACING DRAWINGS AND BAR BENDING SCHEDULES

a. The size and spacing of the reinforcing steel shall be as shown on the Drawings. The Contractor shall prepare from the Drawings complete detailed reinforcing steel placing drawings and the bar bending schedules. The placing drawings and bar bending schedules shall be submitted to the Engineer for his approval before bar cutting and bending commences.

b. Reinforcing steel shall be cut and bent to conform to the bending details as shown on the Shop Drawings.

c. Bar bending schedules prepared by the Contractor shall conform in general to the concrete lifts shown on the Drawings. In the event that the Contractor requests changes in lift heights and the Engineer approves such changes, the Contractor shall revise or replace placing drawings and bar bending schedules to suit the changed lift.

d. Such bar bending schedules and placing drawings revised by the Contractor shall be submitted to the Engineer for approval prior to the Contractor's preparation for the revised pour.

3203. MATERIALS

a. Reinforcement shall be of deformed billet-steel bars and shall conform to ASTM A 615, Grade 60 or JIS G 3112.

b. Welded wire fabric for concrete reinforcement shall conform to ASTM A 497.

c. Tie wire shall be heavier black annealed iron wire. Preformed clips or attachments shall be of proper design and strength so that reinforcing bars are rigidly supported in position.

3204. PROTECTION

a. Reinforcing steel shall be stacked for storage purposes clear of the ground such that it will not become submerged in standing water.

b. Reinforcing steel shall be protected at all times from damage. When placing in the works, it shall be free from dirt, detrimental scale, paint, laitance, mortar, oil or other foreign substance.

c. Reinforcing steel embedded or partially embedded in the concrete shall remain completely undisturbed for a minimum period of 24 hours or longer if the Engineer so directs, after a unit of concrete placement has been completed.

3205. FABRICATION

a. Bent reinforcing steel shall be cold bent without the use of heat to the shapes shown on the Drawings.

Bars having cracks or splits on the bends shall be rejected. All bars shall be cut from stock lengths and bent in accordance with the Drawings. Bends shall be made in accordance with the bending details as shown on the Shop Drawings.

b. Bars shall be properly tagged for easy identification.

3206. INSTALLATION

a. Steel shall be accurately placed in accordance with the approved Shop Drawings. Bars shall be securely wire-tied at each intersection. Metal or concrete chairs and metal spreaders of approved types shall be used where necessary for support or spacing of steel bars.

b. All reinforcement shall be furnished in the full lengths shown on the approved Shop Drawings. Splicing of bars except where shown on the Drawings will not be permitted without the prior written consent of the Engineer. Bar splicing shall be by overlapping, as indicated on the Drawings. Splices may also be made by the use of approved couplings or by special welding

techniques as approved by the Engineer.

c. Welded wire fabric shall be placed and tied as indicated on the Drawings with minimum lap at joints of 15 cm.

d. Concrete protection for reinforcement shall conform to the requirements of ACI 318, unless shown otherwise on the Drawings.

SECTION 3300. PRESTRESSED CONCRETE

3301. GENERAL

a. This Section covers the materials, workmanship, equipment, manufacturing methods, placing, handling, curing and finishing of the prestressed concrete work.

b. The structural members shown on the Drawings have been designed as the references. The Contractor shall carry out alternative design based on his own construction method and submit it to the Engineer for his approval.

c. In this Section, reference is made to the following standards:

AASHTO	Standard Specification for Highway Bridges, 1973, and subsequent interim specifications
ACI 318	Building Code Requirements for Reinforced Concrete
ASTM A 416 or JIS G 3109	Specification for Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete
BS 153, Part 3A	Specification for Steel Girder Bridges

3302. SUBMITTALS

a. The Contractor shall submit to the Engineer the following descriptions, drawings and other information:

a-1. Detailed description, supplemented by drawings and manufacturer's literature, of his proposed prestressing system, equipment and fabricating methods for on-site fabricated prestressed concrete members.

a-2. Detailed description, drawings and manufacturer's literature for off-site fabricated prestressed concrete members.

a-3. Certified mill test results of prestressing tendons and typical stress-strain curves. The typical stress-strain curves shall be obtained by approved standard practices.

a-4. Erection drawings and detailed fabricating drawings of the prestressed structural members.

a-5. Detailed design calculations for designs other than shown on the Drawings.

a-6. Design calculations and drawings for the special reinforcement required for the performance of the anchorage supplied for post-tensioned structural members.

a-7. Description with drawings as required of the proposed methods and procedures and of equipment to be used for storage, handling and erection of prestressing components and of prestressed concrete members.

b. The Contractor shall obtain the Engineer's approval of these submissions before mobilizing equipment or ordering materials or commencing fabrication of prestressed concrete members.

3303. DESIGN

The Contractor's design shall be based on the same ACI and AASHTO standards or on other standards provided the use of such other standards has been approved by the Engineer. The Contractor shall provide the Engineer with full particulars of alternative design standards and obtain approval before submitting alternative design calculations.

3304. SAFETY

a. Prestressing operations shall be carried out only under the direction of an experienced and competent supervisor and all personnel operating the stressing equipment shall have been properly trained in its use. In addition to the normal precautions against accident which should be taken at all times for the whole of the works, special precautions shall be taken when working with or near tendons which have been tensioned or are in the process of being tensioned.

3305. DEFINITIONS

a. Tendon shall mean a complete assembly consisting of anchorage and prestressing steel with sheaths used for post-tensioning. The tendon imparts prestressing forces to the concrete.

b. Anchorage shall mean the stressing anchor and the fixed anchor consisting of bearing plates, anchor head, washers, sleeves and wedges appropriate to the system being used. Anchorage is the means by which the prestressing force is permanently transmitted from the prestressing steel to the concrete.

c. Prestressing steel shall mean a strand or strands used in pre-tensioning or that element of a tendon used for

post-tensioning which is elongated and anchored to provide the necessary permanent prestressing force.

d. Sheaths shall mean the enclosures provided around the prestressing steel to avoid temporary or permanent bond between the prestressing steel and the surrounding concrete.

3306. STRESSING COMPONENTS

a. Prestressing steel cable strands shall meet the requirements of ASTM A 416, Grade 270 and or JIS G 3109.

b. Anchorages for post-tensioning shall be of approved type and manufacture, appropriate to the system used. The anchorages shall develop at least 90 percent of the minimum specified ultimate strength of the prestressing steel, tested in an unbonded state without exceeding anticipated set. The anchorage shall be so arranged that the prestressing force of the tendon may be verified prior to removal of the stressing equipment.

c. Sheath materials shall be strong enough to retain its shape and resist unrepairable damage during construction. It shall prevent the ingress of cement paste from concrete. The inside diameter shall be at least 6 mm larger than the nominal diameter of the pre-stressing steel; the inside cross-sectional area shall be at least twice the net cross sectional area of the prestressing steel. Sheaths shall be capable of transmitting forces from the grout to the surrounding concrete.

3307. BEARING PADS

a. Bearing pads for prestressed concrete bridge beams shall be elastomeric bearings conforming to the AASHTO Standard Specification for Highway Bridges. The elastomer portion of the elastomeric component shall be 100 percent natural rubber or 100 percent neoprene.

3308. FORMWORK

a. Steel formwork, of pre-fabricated shapes or site constructed steel or timber forms shall be used as approved by the Engineer.

b. The faces of formwork in contact with the prestressed concrete shall be smooth and shall be constructed to achieve the concrete finish shown on the Drawings. Form shall be treated with a release agent to allow easy removal of the forms without damaging the concrete. Prestressing materials and reinforcement shall be kept free of the release agent.

c. Soffit forms shall be so constructed as to take into account the difference in load distribution before and after prestressing. Where the concrete casting must move along the formwork during the application of the prestressing force in post-tensioning or during the transfer of prestress in pre-tensioning, the formwork faces in contact with the concrete shall be designed to allow for this movement.

3309. PRE-TENSIONING

a. The manufacture of prestressed concrete beams shall be in accordance with the AASHTO Standard Specification for Highway Bridges, unless otherwise specified or directed by the Engineer.

b. Strands stressed at the same time shall be taken from the same parcel.

c. Strands shall not be welded or otherwise spliced within the length to be tensioned.

d. Kinked or twisted strands and strands which have become unravelled shall not be used.

e. The accuracy of all load measuring equipment shall be checked to the satisfaction of the Engineer at the start of work each day it is to be used and whenever the equipment is moved to a new position for prestressing.

f. Tensioning shall be carried out only in the presence of the Engineer.

g. The prestressing strands shall be stressed at a gradual and steady rate until they attain the initial tension shown on the Drawings.

h. The force in the prestressing strands shall be obtained from readings on a load cell or pressure gauge, and the extension of the strands measured. The two readings shall conform to the limits set by the Engineer.

i. Members shall be free to accommodate the horizontal and vertical movements due to the application of prestress.

j. When laboratory tests indicate that the concrete has attained the initial strength shown on the Drawings, the load shall be transferred gradually without severance of the tendons. The tendons shall then be trimmed back flush to the face of the concrete and the protection described on the Drawings applied to their ends.

k. All members shall be indelibly marked to show on which production line they were manufactured, the date on which the concrete was cast, the date on which the load was applied and if they are of symmetrical section, the face which will be upper most when the member is in its correct position in the structure.

l. The Contractor shall keep full records of all tensioning operations including the measured extensions, pressure gauge or load cell readings. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

3310. POST-TENSIONING

(1) Tendon Placing

a. Subject to the Engineer's instructions, tendons shall be placed in one of the following ways:

a-1. Pre-assembled tendons shall be placed as a unit prior to placing concrete; or

a-2. Bearing plates and duct sheaths shall be installed prior to placing concrete and after concreting, prestressing steel and anchorages shall be installed.

b. Supporting ties for pre-placed tendons shall be adequate to support the tendon weight. When only the sheaths are placed prior to concreting ties must resist buoyancy forces.

c. Strands stressed at the same time shall be taken from the same parcel.

d. Strands shall not be welded or otherwise spliced within the length to be tensioned.

e. Tendons shall be used strictly in accordance with the system which is being employed.

f. Strands shall not be kinked or twisted and individual wires or strands shall be readily identifiable at each end of the member. No strand which has become unravelled, kinked or twisted shall be used.

g. The number of joints in sheaths shall be kept to a practicable minimum and each joint adequately sealed against the ingress of any material. Joints in adjacent sheaths shall be staggered by at least 30 cm.

h. Sheaths shall be kept free of any matter detrimental to the bond between the sheath and the grout and, except for material sealing a sheath joint, between the sheath and the concrete.

i. Drains in sheaths shall be provided at low points if required by the Engineer.

j. The ends of sheaths shall be sealed and protected until the tendon is threaded through and the stressing operations are commenced.

(2) Placing Pre-Assembled Tendons

a. Each tendon shall be individually marked and clearly indentified for its location in the structural member. Tendons may be handled mechanically or manually. Care shall be exercised in unloading and handling the tendons to prevent damage to the sheaths. Belt or webbing slings are recommended when tendons are handled mechanically.

b. Placing the tendons shall normally precede placing reinforced steel, however a reinforcing cage may be used with open top stirrups to allow the reinforcing to be fabricated and placed prior to the tendon placement. Tendons shall then be placed down through the open stirrups and secured in final position.

(3) Placing Prestressing Steel after Concreting

a. Bearing plates and trumpet assemblies shall be bolted to blockouts and shimmed to the location where they are perpendicular to the tendon axis.

b. Sheath location shall not vary from the location shown on the approved Contractor's drawings by more than 6 mm at high and low points of the tendon profile. Where the tendon is near the neutral axis of the member, variations of tendon location of up to 25 mm are acceptable. Whenever possible, the sheaths shall be tied with tie wire to the stirrups at maximum spacings of 1.8 m. Ties shall be sufficient to prevent the sheaths from floating.

(4) Placing Concrete

a. Prior to placing concrete, tendon or sheath profiles shall be checked by measuring from the form soffit to the centre of the tendon or sheath diameter. If tendon sheaths have been damaged, repairs shall be made to prevent concrete from bonding to tendon or entering sheaths.

b. Horizontal alignment shall be checked to ensure minimum horizontal deviations. Care shall be exercised to prevent concrete entering pockets, sheaths or anchorage hardware.

c. Concrete shall be placed in such a manner that tendon or sheath alignment and reinforcing steel positions remain unchanged.

d. Special attention shall be given to vibration of concrete at tendon anchorages to ensure uniform compaction at these points. Concrete shall not be allowed to enter stressing pockets.

(5) Stressing Operations

a. When laboratory tests indicate that the concrete has reached the initial strength shown on the Drawings, stressing operations may begin.

b. Jacks used for prestressing shall be of the type applicable to the system adopted.

c. The accuracy of all load measuring equipment shall be checked to the satisfaction of the Engineer at the start of work each day it is to be used and whenever the equipment is moved to a different jack.

e. Tensioning shall be carried out only in the presence of the Engineer.

f. Immediately before tensioning, the Contractor shall prove that all tendons are free to move between jacking points and that members are free to accommodate the horizontal and vertical movements due to the application of pre-stress.

g. Tendons shall be stressed by experienced personnel only. The manufacturer's recommendations relating to stressing shall be strictly adhered to.

h. The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Engineer.

i. The prestressing steel shall be stressed at a gradual and steady rate until the initial tension shown on the drawings is attained.

j. The force in the prestressing steel shall be obtained from readings on a load cell or pressure gauge, and the extension of the strands measured. The two readings shall conform to the limits set by the Engineer.

k. When stressing from one end only, the pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.

l. When the initial stressing force, shown on the Drawings, including any overload of short duration, has been applied the tendons shall be anchored. The jack pressure shall then be released in such a way as to avoid shock to the anchorages or tendons.

m. If the pull-in of the tendons at completion of anchoring is greater than that stipulated by the Engineer, tensioning shall be carried out afresh.

n. If it is necessary to crop the tendons to enable the ducts to be grouted, this shall be delayed as long as practicable up to the time of grouting. In all other cases, unless agreed otherwise by the Engineer, the tendons shall not be cropped less than 3 days after grouting.

o. The Contractor shall keep full records of all tensioning operations including the measured extensions, pressure gauge or load cell readings and the amount of pull-in at each anchorage. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

(6) Bearing Stresses

a. End regions shall be designed as required by ACI 318.

b. As a guide for determining permissible bearing stress, the following formula may be used. Note that if requested by the Engineer, a refined stress analysis of experimental data shall be used.

$$f_{cp} = 0.6.\ f'_{ci}.\ (A^2/A_1),^{1/3}$$

where A_1 = bearing area of anchor plate of post-tensioning steel

A_2 = maximum area of the portion of the anchorage surface that is geometrically similar to and concentric with, the area of the anchor plate of the post-tensioning steel

f_{cp} = permissible concrete bearing stress under the anchor plate of post-tensioning steel with the end anchorage region adequately reinforced

f'_{ci} = compressive strength of concrete at time of initial pre-stress

(7) Grouting

a. Ducts formed by embedded sheaths shall be thoroughly cleaned by means of compressed air.

b. Ducts shall not be filled with water unless required by the Engineer. Where ducts have been filled with water, it shall be blown out by compressed air.

c. Ducts shall be grouted as soon as practicable but not later than 7 days after the pre-stressing steel in them has been stressed. Grout shall be injected in one continuous operation and allowed to flow from the vents until the consistency of the outflow is equivalent to that of the grout being injected.

d. The ducts shall be completely filled with grout containing an approved expanding agent.

e. Vents shall be filled consecutively in the direction of flow and the injection tube sealed under pressure until the grout has set. The filled ducts shall be protected to the satisfaction of the Engineer to ensure that they are not subject to shock or vibration for at least 24 hours after grout injection. Two days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good if necessary.

f. The Contractor shall keep full records of grouting including the date each duct was grouted, the proportions of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer within 3 days of grouting.

(8) Protection of End Anchorages

a. The Contractor shall place additional reinforcing steel if required in pocket or edge strip. To ensure neat placing of cove concrete in recesses, pockets or edge strips, forms shall be fitted securely against the previously placed concrete.

b. Non-shrinking or expanding grout of concrete may be used if approved by the Engineer. Cover concrete shall be placed with as low a slump as possible to avoid excessive shrinkage and shall be well vibrated or dry packed to ensure compaction around anchorage.

c. The use of calcium chloride or concrete admixtures containing calcium chloride in concrete or grout is prohibited.

d. Exposed end anchorages and/or wires shall be protected by adequate means, such as epoxy coating, asphalt base paint mastic and/or concrete cover.

3311. TOLERANCES

a. Precast prestressed sections shall be constructed to be dimension shown on the drawings or on the Shop Drawings. Deviations within the following limits will be permitted:

Length	± 12 mm
Width (overall top and bottom)	± 6 mm
Depth	± 6 mm
Stem width	± 3 mm
Horizontal alignment (deviation from straight line parallel to centre Line of member)	6 mm up to 12 m length 10 mm over 12 m length
Camber deviation from design camber	6 mm per 3 m but not greater than 20 mm total
Differential camber between adjacent members of same design	6 mm per 3 m but not greater than 20 mm total
Position of tendons	± 3 mm
Position of handling devices	± 15 cm
Position of deflection points for deflected strands	± 15 cm

SECTION 3400. WATERSTOPS, JOINT FILLERS, SEALS, SEALANTS AND BITUMINOUS COATING

3401. GENERAL

a. This Section covers the requirement for materials and installation of waterstops, joint seals, fillers, sealants and bituminous coating.

b. In this Section, reference is made to:

ASTM D 2628 — Specification for Preformed Poly-chloroprene Elastomeric Joint Seals for Concrete Pavement

3402. MATERIALS

a. Waterstops shall be extruded from a high grade unfilled compound with no reclaimed material permitted. The main constituent shall be natural rubber and the material shall be dense, homogeneous and free from porosity or other imperfections. They shall be Expandite or approved equal rubber waterstops, plain web sections. Intersection pieces shall be compatible with waterstops.

b. The Contractor shall supply samples and specifications of the waterstops proposed for the Engineer's approval. Waterstops shall not be ordered until the Engineer's approval has been obtained.

c. Joint seals shall conform to ASTM D 2628 and shall be Expandite Compression Seal or approved equal.

d. Joint fillers shall be Expandite Flexcell or approved equal.

e. Joint sealants shall be Expandite Plastijoint for vertical and inclined joints and Expandite Pli-estic for horizontal joints or approved equal.

f. Bituminous coating shall be Expandite Procfex bitumen EPC solution or approved equal.

3403. INSTALLATION

Jointing of waterstops, where they cross or lap, shall be done in accordance with the manufacturer's instructions and as indicatd on the Drawings to ensure that a continuous watertight diaphragm is formed.

DIVISION 4. PILING WORKS

SECTION 4000. GENERAL ARRANGEMENTS

4001. GENERAL

a. This section covers the materials, workmanship, equipment and methods to be adopted for the piling works including pile pier of intake bridge as shown on the Drawings.

b. Where the design load capacity is shown on the Drawings the Contractor shall supply adequate piles of sufficient area and length. Calculations, showing the adequacy of piles, will be based on use of static formula using frictional resistance and bearing of the soils but shall be confirmed by pile-load tests at the commencement of work.

c. The piles shall not be handled or driven until the 28 day compressive strength of the concrete has been attained. The compressive strength shall be based on tests of cylinders cast from the same batches and cured under the same conditions as the pile concrete.

4002. SITE PREPARATION AND EXCAVATION

a. The Contractor shall be responsible for construction of any temporary site access and site grading required for installation of the piling. Construction of temporary roadways, site grading, drainage, excavation and other site work shall follow the requirements of Division 2 "Earth Work".

b. The Contractor shall submit a schedule indicating the location of all temporary access roads, temporary grading plans, and drainage for approval by the Engineer at least two weeks prior to the anticipated start of the Works. The Engineer may limit the amount of temporary fill placed beneath structures in order to avoid surface settlement which could induce drag loads on the pile foundations.

4003. MATERIALS OF CONCRETE PILES

(1) General of Concrete Piles

a. When concrete piles are manufactured off the site, the Engineer shall be advised six weeks in advance of placing of concrete so that the forms and reinforcing may be inspected.

b. All precast concrete piles furnished under this Section shall be new, undamaged members which have not been previously rejected for any reason and shall be manufactured especially for the Works. Members which are damaged or which do not meet the requirements of this Section shall be rejected.

c. Piles shall in all cases be stored and handled in accordance with the recommendations of the pile manufacturer. Particular care shall be taken to avoid dropping or severe jarring while in a horizontal position. If for any reason the pile is damaged or the reinforcement is exposed, its use shall not be allowed.

d. Concrete piles shall be so proportioned, cast, cured, handled and driven as to resist without cracking the stresses induced by handling and driving as well as by the design loads as shown on the Drawings. The piles shall have a uniform cross section, the length of which is embedded in the bearing soil.

e. Each pile shall be stamped or marked with the date of its manufacture, identification of dimensions and identification of manufacturer. Lifting hooks or points, shall be plainly marked on each pile.

f. The top of the pile must be perpendicular to the longitudinal axis of the pile, and the ends of any prestressing or reinforcing steel shall be cut flush with the top of the pile to prevent direct impact on the steel during driving. Pile top ends shall be plane surfaces which shall be perpendicular to the long axis of the pile within a tolerance of 10 mm per meter. Pile tips shall be tapered and include a cast iron cone shaped shoe.

g. The maximum sweep (deviation from straightness measured along two perpendicular faces of the pile while not subject to bend forces) shall not exceed 3 mm in any 3 m of its length. All corners shall be chamfered to 40 mm or rounded to 50 mm radius. A smaller chamfer or radius, not less than 19 mm may be used if approved by the Engineer. Forms for piles shall be such as to avoid the formation of fins at intersection of surfaces.

h. The unformed top surface of each pile shall be given a uniformly smooth finish to match the finished surface of the formed surfaces.

i. Small areas of honeycomb which are purely surface in nature extending to a depth of no more than 25 mm may be repaired in a manner satisfactory to the Engineer. Honeycomb extending to the plane of reinforcing will be cause for rejection subject to review by the Engineer.

j. The lateral reinforcement at both ends of the pile shall be spaced sufficiently close to resist impact stresses due to

driving and in no case more than 7.5 cm on centers. A minimum covering of 5 cm of concrete shall be provided over all reinforcements.

k. Piles shall be provided at the top with longitudinal reinforcing steel required to resist uplift loads and for unsupported lengths of piles. In the case of reinforcing steel to resist uplift loads on the piles the bar design shall be subject to the approval of the Engineer for the required tension load. Reinforcing steel required for unsupported piles under bridges and in similar locations shall be the sizes and lengths noted on the Drawings.

l. Following driving, the concrete at the top of the pile shall be broken away to expose the reinforcing steel which is to be incorporated in the structural concrete foundation of the structure. The reinforcing steel in the top of the piling shall not be installed in drill holes in the piling nor shall the reinforcing steel be extended by weldings. The reinforcing steel may be bent over in the pile concrete to reduce the amount of concrete to be broken away.

(2) Prestressed Precast Concrete Piles

a. Piles shall be manufactured by an established pile manufacturer.

Casting beds of concrete or other suitable, rigid construction shall be used. Forms shall be constructed of heavy gauge steel or other rigid and smooth materials; shall be adequately braced; and shall be free from dents, gauges or other irregularities.

Casting beds for fabrication of prestressed members shall have jacking equipment at one end and a rigid reaction frame or block at the other end. Equipment for measuring stress and elongation of the prestressing reinforcements shall be approved.

b. The use of steel forms on concrete founded casting beds is required unless otherwise approved in advance. Outer forms shall enclose all except the top horizontal surface. The side forms may have a maximum draft on each side not exceeding 20 mm per meter.

c. Prestressed piles longer than 20 m shall be designed for a two point pick up. Design bending moments shall be increased by a minimum of 40 percent to allow for impact during handlings.

d. Aggregates and cement shall be as specified in Division 3 "Concrete Work" with the following exception. Maximum size of aggregate shall be 20 mm.

Minimum concrete compressive strengths shall be:

280 kg/sq.cm at transfer
350 kg/sq.cm at 28 days
350 kg/sq.cm at driving

e. Prestressing reinforcement shall be furnished and installed in accordance with Division 3 "Concrete Work". Single wire prestressing reinforcement conforming to JIS 3536 "Uncoated Stress Relieved Wire and Strand conforming to ASTM A 416, "Uncoated Seven Wire Stress - Relieving Strand for Prestressed Concrete" shall be used.

f. Concrete shall have attained a compressive strength of at least 280 kg/cm^2 before the pretensioning stress on the prestressing wires or strand is released. Compressive strength shall be determined first by examining the rate of increase of strength as disclosed by the crushing of the test cylinders made in connection with the establishment of the design mix. In addition to this advance determination, a running check shall be made throughout the period of casting the prestressed members.

(3) Reinforced Concrete Piles

a. Aggregates and cement shall be as specified in Section 3000 "Concrete" with the following exception. Maximum size of aggregate shall be 20 mm. Minimum concrete compressive strengths shall be 240 kg/sq.cm at 28 days and at time of installation.

b. Allowable compressive stress in concrete for concrete in axial compression shall not exceed 61.5 kg per sq.cm.

c. Concrete reinforcement shall be furnished and installed in accordance with Section 3200 "Reinforced Steel".

4004. MATERIALS OF STEEL BEARING PILES

a. All steel for steel bearing piles shall be manufactured to JIS A 5525. If requested by the Engineer, the Contractor shall provide test certificates, analyses and mill sheets.

b. The root edges or root faces of lengths of piles that are to be butt welded shall not differ by more than 3 mm. Longitudinal seam welds in lengths of tubular piles forming a complete pile shall be evenly staggered. Welding shall be JIS G 3443, and all welders employed on permanent welding shall be qualified in the approved welding procedure laid down in the relevant JIS Z 3801. Copies of the certificates relating to the welders tests shall be made available to the Engineer on request.

c. Prior to any welding of piles for incorporation in the permanent works the Contractor shall carry out procedural trials as agreed with the Engineer. The accepted trial welds shall be retained and used as a standard for all subsequent welds.

d. A radiograph, 300 mm long, shall be taken at a minimum rate of one for every ten welded joints. The Engineer will require an increased rate initially and if unsatisfactory results are obtained. The acceptance standard for radiograph shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section 8, except that the maximum thickness of weld reinforcement shall be 44.5 mm.

e. The manufacturing tolerances of tubular piles shall be such that the actual weight of sections does not differ from the theoretical weight by more than -2 1/4% or +5%. The measured external circumference shall not differ by more than 1% from the theoretical value. The deviation from straightness shall not exceed 1 in 1000 measured over a 10 meter length.

SECTION 4100. PILE DRIVING

4104. LINES AND GRADES

a. The datum elevation and grid system are shown on the Drawings. Piles shall be located and staked out by the Contractor and the Contractor shall maintain all location stakes and shall establish all elevations required, including the elevation of the top of the pile prior to cutting off any length of pile. All location and survey stakes shall be checked on a regular basis to insure that pile driving operations have not caused movement of the stakes. Each pile is to be identified by number on Shop Drawings.

b. Within one working day after all of the piles in a cluster have been driven, the Contractor shall provide the Engineer with a written tabulation indicating the following information for piles driven in that cluster:

   a. Pile cluster designation
   b. Pile number
   c. Elevation of top of pile prior to cutting (measured to nearest 0.02 m)

c. Within two weeks after the completion of driving of all piles, or within two weeks of the completion of excavation required to expose the piles at the cutoff grade, the Contractor shall provide the Engineer with a certified plan showing the as-driven location of all piles driven within the structures.

d. As driven pile locations shall be surveyed and shown on the Drawing to the nearest 0.01 m.

4102. INSPECTION

Full-time inspection of all pile driving operations will be provided by the Engineer. No piles shall be driven except with the knowledge of the inspector assigned by the Engineer.

4103. DETERMINATION OF PILE LENGTH AND PILE LOAD CAPACITY

a. Design pile dimensions or design loads for piling are shown on the Drawings. Design dimensions include design pile cutoff grade and required pile tip elevation. The required pile tip elevation shall be continued by load test as specified.

b. Pile lengths shall be determined as the length from the pile tip elevation (confirmed by load test) to the design pile cutoff grade plus a length allowance required for reinforcing steel for

uplift load. Reference is made to Clause 4003 "Material of Concrete Piles".

c. Where pile loads are indicated, the required pile embedment shall be computed from static formula as directed by the Engineer.

Under certain structures, piles may be required to resist both compression loads and tension loads. The required pile tip elevation for both compression and tension loadings shall be confirmed by load testing. Only one pile shop shall be used for each design load condition. Pile length may be increased or decreased from the lengths shown on the Drawings, as a result of load test. The final determination of pile length shall be approved by the Engineer upon review of the pile load test.

d. Orderings, manufacturing and delivery of piles shall be planned in such a manner that changes in length of piles for piles not yet manufactured may be made if driving experience, as the work progresses, indicates to the Engineer the need for such changes.

4104. INSTALLATION OF PILES

a. Piles shall be driven with approved equipment. The leads of the pile driving rig shall be fixed at two points; the points shall be at least half the length of the leads apart in order to maintain the pile and hammer in axial alignment at the correct plan location during the entire operation. The leads shall extend down to the lowest point at which the hammer must operate.

b. Driving shall be accomplished using equipment that will hold the pile in the design alignment (vertical or battered) during the installation of the pile. The alignment of vertical piles shall be carefully checked by means of a carpenters level (a bubble level with a minimum length of 1.2 m), a transit, by sighting the axis of the pile against a string supporting a plumb bob. Alignment of batter piles shall be checked by transit or other methods approved by the Engineer.

c. The method of driving shall be such as not to impair the strength of the pile and shall meet with the approval of the Engineer. The Contractor shall submit a written statement describing the proposed equipment and shall obtain from the Engineer approval of the same before driving any piles.

d. The Contractor shall employ cushioning devices as are required to protect the pile from damage during driving.

Production piling shall be installed using the same equipment used to install the test piles including hammer size, drop, cushion block material and driving cap.

4105. DRIVING CRITERIA

a. As part of the preparation for pile driving, the Contractor shall mark each pile at 30 cm intervals along its entire length. In addition, the footage shall be marked and designated at 1.50 m intervals, starting from the pile tips.

b. When driving pre-cast concrete piles through soft clay soil or in predrilled or jetted holes, the ram velocity and stroke for the given hammer size shall be reduced to avoid critical tensile stresses in the pile.

c. Shattered, crumpled or otherwise damaged pile heads shall be cut back to sound material before continuing the driving.

d. Driving of all piles shall be continuous without intermission until the pile has been driven to its final elevation. The tops of piles shall be cut off true and level at the elevations indicated on the Drawings. All portions battered, split, warped damaged or imperfect in any way shall be removed or repaired to satisfaction of the Engineer.

e. Piles shall be driven to the required tip elevation shown on the Drawings and as confirmed by load test. Piles shall be driven into the same soil stratum as the test pile.

f. Where piles are driven as bearing piles into the sand stratum found below a depth of 20 meters the driving resistance of the test pile shall be used to establish the final driving resistance of the piles. The final driving resistance (number of hammer blows required to drive the pile in the final 15 cm) shall not be less than the final driving resistance of the test pile.

4106. TOLERANCES AND CRITERIA FOR ACCEPTANCE

(1) General

Piles shall be cut off at the required cut off elevation. Piles previously driven shall be protected from damage during construction in the immediate area and any damage to piles that cannot be repaired to the satisfaction of the Engineer shall be cause for rejection of the pile.

a. A pile shall be placed not more than 3 percent of its length out of pulmb from vertical. The measurement shall be made on that portion of the pile projecting above the cutoff grade. At least three measurements shall be made to confirm the alignment.

After completion of excavation the plan location of each pile shall be determined at the design cut off elevation.

b. A maximum lateral deviation from the correct location at cutoff elevation equal to 7.5 cm will be permitted for piles which have been driven without a follower or for piles which have been driven with a follower not exceeding 3 m in length. The lateral deviation will be increased in proportion to the length of the follower up to a maximum permissible lateral deviation of 15 cm for piles driven with a follower 5 m in length.

c. Where piles as installed exceed the specified tolerances, the Engineer shall then verify the total loads on individual piles, based on the calculations and survey information. If the load on any pile exceeds the specified load capacity, corrections shall be made in accordance with an approved design provided by the Contractor to the Engineer. This work shall be performed at the Contractor's own expense. Material supply and production of additional replacement piles and their installation to compensate for the piles driven out of the design location shall be at the Contractor's own expense.

d. The installation of replacement piles and other corrective measures shall in all cases be in accordance with the approved designs provided by the Contractor and approved by the Engineer.

4107. PILING RECORDS

a. The record of all piles installed shall be kept by the Contractor and a copy of the record of work made each day shall be given to the Engineer within 24 hours in a form to be approved by the Engineer.

b. On completion of the piling of any particular section, the Contractor shall deliver to the Engineer a drawing recording the final founding levels of all piles, together with any results of measurements carried out by the Contractor to prove the bearing capacity of any piles tested.

DIVISION 5. PIPE WORK

SECTION 5000. PIPING

5001. GENERAL

This Section covers all pipes, fittings and appurtenances to be furnished by the Contractor. In addition the Contractor shall furnish all labor, materials, equipment and incidentals required to install the piping, fittings and appurtenances as shown on the Drawings. The completed installation shall be fully functional as shown on the Drawings. The fittings are shown as a convenience to the Contractor. It may be necessary to supply and install additional fittings other than those shown on the Drawings or to install fittings in different locations.

Also this Section shall include the furnishing and installing of certain miscellaneous items and appurtenances as hereinafter specified. Work to be done shall include hauling, laying, installing, jointing, welding, insulating, wrapping, testing chlorinating and all other work necessary to produce a completed facility. The Contractor shall furnish and install couplings, fittings, gaskets, insulation, flanges, bolts, nuts, wall sleeves, wall pipes, harnesses and all other materials necessary to properly install the Works shown on the Drawings and as specified.

Certain piping systems are shown diagrammatically as an indication of the Works to be installed. The Contractor shall coordinate the Works so that all work may be installed in the most direct and workmanlike manner, and so that interference between piping, ducts, equipment, architectural and structural features and appurtenances and other work will be avoided.

The Works of installing pipe in earth excavations, earth fills and earth trenches is specified in the General Specification "Earth Works" of Division 2.

5002. SHOP DRAWINGS

The Contractor shall submit detailed working and Shop Drawings and schedules of all pipes, fittings and appurtenances in accordance with contract Drawings.

Shop Drawing shall include but not be limited to the following:

a. Lists and schedules of material, linings and coatings
b. Schedules of pipe lengths and thicknesses
c. Details of proposed joints, harnesses and installation details
d. Name of suppliers and identification of equipment to be supplied

e. Dates of delivery of materials to the site
f. Special closures

For prestressed concrete pipe and reinforced concrete pipe, the Contractor shall furnish all information related to placement of steel reinforcement, and a complete set of design calculations.

Installation manuals shall also be furnished when requested.

Shop Drawings shall show the locations of unions, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

The Contractor shall furnish a mill certified report, in triplicate, of the tests for each material to be utilized in the Works. The certifications shall contain the results of chemical and physical tests required by these Specifications for the materials.

For both shop and field welds of steel pipes, the following information shall be submitted:

a. Method of welding - automatic or manual
b. Type of welding rods
c. Method of preparing edges
d. Welding procedure
e. Cleaning of welds

The Contractor will submit samples of materials to be supplied under this section upon written direction of the Engineer.

The Contractor shall submit, for approval, exact details of various joints that are proposed for use on the Works.

5003. PIPES AND FITTINGS

Each pipe, fitting and casting shall bear clear and permanent markings showing the nominal diameter, class or schedule, type, year of manufacture and the manufacturer's name or trade mark. Markings on pipe lengths shall always be at the same end. Painting of data will be acceptable for all pipe material.

Pipes and fittings shall be compatible and have equal or higher pressure ratings as specified.

Pipes, fittings and appurtenances shall be installed in full conformance with the manufacturer's recommendations.

Bedding, hanger details, supports and wall and floor penetrations shall be as shown on the Drawings or specified in other Sections.

When cutting of pipe is required, the cutting shall be done by machine in a neat and workmanlike manner without damage to the pipe coating or lining. Cut ends shall be smooth and at right angles to the axis of the pipe. Pipe ends to be used with rubber joints shall be beveled and filed or ground smoothly to conform to the manufactured spigot end.

The Contractor shall furnish and install transition pieces at all locations when one type of pipe joins a second.

5004. HANDLING

Care shall be taken during loading, transporting, and unloading to prevent injury to the pipes, fittings, or coatings. Under no circumstances shall pipes or fittings be dropped or rolled against one another. All pipes or fittings shall be examined and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

If any defective pipe or fitting is discovered after it has been installed, it shall be removed and replaced with a sound pipe or fitting in a satisfactory manner by the Contractor, at his own expense. All pipes and fittings shall be thoroughly cleaned before installation.

Special handling of pipes and fittings shall be in accordance with the manufacturer's instructions.

All pipes shall be bundled or packaged in such a manner as to provide adequate protection for the ends, threaded or plain, during transportation from the manufacturer to the Contractor. All special provisions for ocean shipment shall be provided.

5005. INSPECTION

The quality of all materials, the process of manufacture, and the finished piping shall be subject to inspection and approval by the Engineer. Such inspection may be made at the place of manufacture, or at the working site after delivery, or at both places, and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though ample pipes may have been accepted as satisfactory.

Inspections, at point of manufacture, will require the Contractor's and manufacturer's cooperation. The cost of foundry or shop inspection of piping approved for these works will be in accordance with the program set forth.

When any routine chemical analysis fails to meet the requirements of these specifications or when any specified test fails to meet the requirements, all pipe in the same sampling period shall

be rejected, except that any pipe that is subsequently retested and is judged acceptable, may be accepted.

All pipes, and appurtenances will be inspected by the Engineer upon delivery to the site and those pieces, not conforming to the requirements of these Specifications, will be rejected and must be immediately removed from the site by the Contractor. The Contractor shall furnish all labor necessary to assist the Engineer in inspecting the material.

On completing the installation, the inside of the pipe shall be carefully cleaned of tools, scrap, dirt and debris. The Engineer will make a full and complete inspection of all lines before accepting and the Contractor shall fully flush out the lines with water and air prior to inspection.

SECTION 5100. CAST IRON PIPE

5101. MATERIALS OF PIPE

All piping shall be designed for a minimum working pressure of 10.0 kgs per sq.cm unless noted otherwise.

Pipe shall be supplied in full lengths not to exceed seven (7) meters. Shorter lengths shall be provided where necessary to make closures.

Cast iron pipe shall be manufactured in accordance with one, but not more than one, of the following specifications as modified herein:

(1) AWWA C106 "Cast Iron Pipe Centrifugally Cast in Metal Molds for Water and Other Liquids. "This specification is for pipe diameter 75 mm to 600 mm (24 inches) inclusive.

(2) AWWA C108 "Cast Iron Pipe Centrifugally Cast in Sand-Lined Molds for Water and Other Liquids."

Cast iron shall have a minimum bursting tensile strenth of 1,260 kgs per sq.cm minimum ring modulus of rupture of 2,800 kgs per sq.cm.

5102. MATERIALS OF FITTINGS

Fittings shall be either ductile iron or cast iron. The pressure class of fittings and special castings shall be at least equal to the pressure class of the pipe to be installed.

All fittings shall conform to AWWA C110, "Gray Iron and Ductile-Iron Fittings, 2 in. through 48 in. "Sizes of fittings which fall between English sizes shall conform to the next largest English size. Details of fittings larger than 1,200 mm shall be approved by the Engineer.

If fittings and special castings, called for on the Drawings, are not covered in these specifications, the Contractor shall submit drawings or manufacturer's specifications for approval prior to casting.

5103. MATERIALS OF COATINGS AND LININGS

(1) General

All non-exposed pipe and fittings shall have a 30 mile coal tar enamel coat on the outside in accordance with applicable ANSI and

AWWA standards or a 16 mil coal tar epoxy coating approved by the Engineer unless noted otherwise.

All piping, which will be exposed to view in the finished work, shall be shop primed on the exterior, in accordance with the General Specification, Section 9400 "Painting" unless noted otherwise.

(2) Cement Mortar Lining

All pipes and fittings shall have a cement mortar lining and non-toxic bituminous seal coat on the inside in accordance with AWWA C104, "Cement Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings", except that cement mortar lining shall be as follows:

SCHEDULE OF MINIMUM CEMENT MORTAR LINING THICKNESS

Nom. Pipe Dia. mm	Lining Thickness mm	Tolerances for Pipe End mm
250 and under	4	+2
300 to 600	6	-1
700 to 900	8	+2
1,000 to 1,200	10	±3
1,350 and over	12	±4

Sand for cement mortar linings shall conform to ASTM C144, Aggregate for Masonry Mortar".

Linings of pipes that are damaged due to cutting shall be repaired in accordance with paragraph 4.7.3 of AWWA C104.

5104. JOINTS

(1) General

Piping shall be furnished with standard bell and spigot joints, mechanical joints, flanges or push-on joints as required by the Drawings or Particular Specifications.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Pipes and fittings for use with flexible couplings, transition couplings, or expansion joints shall have plane ends. Pipes and fittings for use with collars or sleeves shall have plane ends.

All joints for buried pipe over 300 mm in diameter which are not flanged, shall be harnessed. Harness details shall be submitted for approval including calculations for thrust.

(2) Mechanical Joint

Mechanical joint shall conform with all provisions of AWWA C111, "Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings".

Mechanical joint pipes and fittings shall be furnished complete with gaskets, glands, bolts and nuts.

Bolts and nuts shall be in accordance with AWWA C111, "Rubber Gasket Joints for Cast-Iron Pressure Pipe; and Fittings". Bolts and nuts shall be high strength cast iron; high strength, low alloy steel or ductile iron. Ductile iron bolts shall conform to JISG5502, "Spheroidal Graphite Iron Castings" type FCD40 or FCD45 or JIS G5702, "Blackheart Malleable Iron Castings", type FCM835. Regarding both of these specifications, the Engineer shall select the ductile iron.

Gasket shall be vulcanized natural rubber or vulcanized synthetic rubber. Reclaimed rubber shall not be used.

Gasket shall be lubricated with vegetable lubricant, soap or water as recommended by the manufacturer.

(3) Push-on Joint

Push-on joint shall conform with all provisions of AWWA C111, "Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings".

The plain end of the pipe shall have a slight taper to ease its sliding-fit with the gasket when the joint is made. Field cut pipe shall be ground to have a taper the same as the factory manufactured spigot ends.

Push-on joint pipe shall be furnished complete with gaskets and lubricant as recommended by the manufacturer.

Fittings for push-on joint pipe shall be mechanical joint fittings.

(4) Couplings

Flexible couplings shall be made with Dresser or Smith Blair Types couplings as hereinafter specified unless noted to be Victaulic. Collars or sleeves shall be used for buried conduits, unless noted otherwise.

Dresser couplings shall be style 38, Smith Blair shall be type 411, and match the type of pipe being connected to. Couplings shall be without pipe stops but with restraining bolts. Dresser or Smith Blair couplings shall be designed for the same pressure rating as the pipeline. Joint harnesses shall be provided on all unanchored bends and wherever else required.

Gasket shall be plain grade 47 unless temperature exceeds 100°C, in which case they shall be asbestos cement.

Victaulic couplings shall be type 41 or 44, as manufactured by Victaulic Company of America or Japan Ltd. Coupling gasket shall be of molded synthetic rubber conforming to ASTM D2000, Grade No.38 A615 A14 B13.

5105. INSTALLATION

(1) General

The installation of underground piping is specified in the General Specification in Section 5800 "Underground Piping and Fittings".

All work shall be in full conformance with the manufacturer's recommendations and the requirements of AWWA C600 "Standard Specifications for Installation of Cast-Iron Water Mains", except as otherwise provided herein.

The lining and coating shall be protected at all times, All repairs shall be the responsibility of the Contractor.

The Contractor shall furnish and install sleeves or wall castings for all pipes passing through masonry walls and concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all plans and figures which have a direct bearing on his pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

(2) Mechanical Joints

Mechanical joints at fittings and pipe shall be installed in accordance with the "Notes on Method of Installation" under ANSI A21.11, "Rubber Gasket Joints for Cast Iron Pressure Pipe and Fittings", and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before inserting the spigot into the bell of the joint. Bolts shall be tightened alternately on opposite ends of joint diameters and in rotation around the pipe. When properly assembled, the gland shall be equidistant from the bell face at all points.

(3) Push-on Joints

The method of jointing push-on joint pipe shall be in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be installed in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered

shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means.

(4) Flanged Joints

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed before fitting make up pieces, and the whole shall be joined so that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing piping to prevent damage to the pipe, lining or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

All piping shall have a sufficient number of flanged joints to allow convenient removal of piping.

Systems shall be arranged with low points and drains to permit complete drainage of the system. Fill connections for the purposes of testing shall also be provided on closed systems where required.

Adequate air vents shall be provided at high points in all liquid carrying pipes. Interior piping shall be rigidly supported as specified under the General Specification in Section 5700 "Pipe Hangers and Supports" of this Division.

Upon completion of installation and testing, the Contractor shall paint all exposed piping in accordance with the General Specification in Section 9400 "Painting".

SECTION 5200. DUCTILE IRON PIPE

5201. MATERIALS OF PIPES

All piping shall be designed for a minimum working pressure of 10.0 kgs per sq.cm unless noted otherwise.

Pipe shall be supplied in full lengths not to exceed seven (7) meters. Shorter lengths shall be provided where necessary to make closures.

All ductile iron pipes shall conform to AWWA C151, "Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand - Lined Molds," and the provisions contained herein.

Ductile iron shall exhibit the following physical characteristics: minimum tensile strength: 4,200 kgs per sq. cm, minimum yield strength: 2,950 kgs per sq. cm, minimum elongation 10 percent.

Rubber gasket joints shall conform to JWWA G110 "Centrifugally Cast Ductile Iron Pipes" and JWWA G111 "Ductile Iron Fittings".

5202. MATERIALS OF FITTINGS

Fittings shall be either ductile iron or cast iron. The pressure class of fittings and special castings shall be at least equal to the pressure class of the pipe to be installed.

All fittings shall conform to JWWA G111, "Ductile Iron Fittings, T-type Joint, for Water Works".

If fittings and special castings, called for on the Drawings, are not covered in these Specifications, the Contractor shall submit Shop Drawings or manufacturer's specifications to the Engineer for approval prior to casting.

5203. MATERIALS OF COATINGS AND LININGS

(1) General

All non-exposed pipes and fittings shall have a 16 mil coal tar epoxy coating unless noted otherwise.

All piping, which will be exposed to view in the finished work, shall be shop primed on the exterior in accordance with the General Specification in Section 9400 "Painting" unless noted otherwise.

(2) Cement Mortar Lining

All pipes and fittings shall have a cement mortar lining and epoxy powder coating on the inside in accordance with JWWA G 112. "Epoxy Powder Coating for Interior of Ductile Iron Pipes and Fittings for Water Works" except that cement mortar lining shall be as follows:

SCHEDULE OF MINIMUM CEMENT MORTAR LINING THICKNESS

Nom. Pipe Dia. mm	Lining Thickness mm	Tolerances for Pipe End mm
250 and under	4	+2
300 to 600	6	-1
700 to 900	8	+2
1,000 to 1,200	10	+3
1,350 and over	12	+4

Cement mortar linings shall conform to JIS A 5314.

5204. Joints

(1) General

Piping shall be furnished with standard bell and spigot joints, mechanical joints, flanges or push-on joints as required by the Drawings.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

Pipes and fittings for use with flexible couplings, transition couplings, or expansion joints shall have plain ends. Pipes and fittings for use with collars or sleeves shall have plain ends.

Pipe for use with Victaulic couplings shall have grooved ends up to 600 mm dia. and 600 mm and over shall have shouldered ends.

All joints for buried pipe over 300 mm in diameter which are not flanged, shall be harnessed. Harness details shall be submitted for approval including calculations for thrust.

(2) Mechanical Joint

Mechanical joint shall conform with all provisions of AWWA C111, "Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings" or equivalent.

Mechanical joint pipes and fittings shall be furnished complete with gaskets, glands, bolts and nuts.

Bolts and nuts shall be in accordance with AWWA C111, "Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings" or equivalent. Bolts and nuts shall be high strength cast iron; high strength, low alloy steel; or ductile iron. Ductile iron bolts shall conform to JIS G5502, "Spheroidal Graphite Iron Castings", type FCD 40 or FCD 45 or JIS G 5702, "Blackheart Malleable Iron Castings" type FCMB 35. For these two Specifications, the Engineer shall select the ductile iron.

Gasket shall be vulcanized natural rubber or vulcanized synthetic rubber. Reclaimed rubber shall not be used.

Gasket shall be lubricated with vegetable lubricant, soap or water as recommended by the manufacturer.

(3) Push-on Joint

Push-on joint shall conform with all provisions of AWWA C111, "Rubber Gasket Joints for Cast-Iron Pressure Pipe and Fittings" or equivalent.

The plain end of the pipe shall have a slight taper to ease its sliding-fit with the gasket when the joint is made. Field cut pipe shall be ground to have a taper the same as the factory manufactured spigot ends.

Push-on joint pipe shall be furnished complete with gaskets and lubricant as recommended by the manufacturer.

Fittings for push-on joint pipe shall be mechanical joint fittings.

(4) Couplings

Flexible couplings shall be made with Dresser or Smith Blair couplings as hereinafter specified unless noted to be Victaulic. Collar or sleeves shall be used for buried conduits, unless noted otherwise.

Dresser couplings shall be style 38, Smith Blair shall be type 411, and match the type of pipe being connected to. Couplings shall be without pipe stops but with restraining bolts.

Dresser or Smith Blair couplings shall be designed for the same pressure rating as the pipeline. Joint harnesses shall be provided on all unanchored bends and wherever else required or shown. Gasket shall be plain grade 47 unless temperature exceeds 100°C in which case they shall be asbestos cement.

Victaulic couplings shall be type 41 or 44, as manufactured by Victaulic Company of America or Japan Ltd. Coupling gasket shall be of molded synthetic rubber conforming to ASTM D2000, Grade No. 3BA 615 A14 B13 and/or equivalent.

5205. INSTALLATION

(1) General

The installation of underground piping is specified in the General Specification in Section 5800 "Installation of Underground Piping and Fittings" of Division 5.

All work shall be in full conformance with the manufacturer's recommendations and the requirements of AWWA C600 "Standard Specifications for Installation of Cast-Iron Water Mains" and/or equivalent, except as otherwise provided herein.

The lining and coating shall be protected at all times. All repairs shall be the responsibility of the Contractor.

The Contractor shall furnish and install sleeves or wall castings for all pipes passing through masonry walls and concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all plans and figures which have a direct bearing on his pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

(2) Mechanical Joints

Mechanical joints at fittings and pipes shall be installed in accordance with the "Notes on Method of Installation" under AWWA C111, "Rubber Gasket Joints for Cast Iron Pressure Pipe and Fittings" and/or equivalent, and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before inserting the spigot into the bell of the joint. Bolts shall be tightened alternately on opposite ends of joint diameters and in rotation around the pipe. When properly assembled, the gland shall be equi-distant from the bell face at all points.

(3) Push-on Joints

The method of jointing push-on joint pipe shall be in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be installed in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means.

(4) Flanged Joints

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed before fitting make up pieces, and the whole shall be joined so that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

In the event interference develops between piping and other appurtenances the Engineer will decide which work is to be relocated regardless of which was first installed.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing piping to prevent damage to the pipe lining or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

All piping shall have a sufficient number of flanged joints to allow convenient removal of piping.

Systems shall be arranged with low points and drains to permit complete drainage of the system. Fill connections for the purpose of testing shall also be provided on closed system when required.

Adequate air vents shall be provided at high points in all liquid carrying pipes. Interior piping shall be rigidly supported as specified under the General Specification in Section 5700 "Pipe Hangers and Supports" of this Division.

Upon completion of installation and testing, the Contractor shall paint all exposed piping in accordance with the General Specification in Section 9400 "Painting".

SECTION 5300. STEEL PIPES

5301. GENERAL

a. This Section covers the requirements for seamless and pipes, fittings and for joints in respect of the pipe end preparation for the conveyance of water.

b. It includes external and internal protections against the corrosive action of the surrounding medium or conveyed fluid.

c. Piping works described in this section shall include the exposed installation and underground installation for the purpose of the water conveyance.

d. The maximum sustained operating pressure at which pipes and fittings is intended to be used.

5302. MATERIALS OF PIPES

(1) Mill Steel Pipe

Steel pipe in sizes 300 mm and smaller shall conform to JIS G 3443 "Coating Steel Pipes for Water Works" and to JIS G 3452 "Carbon Steel Pipes for Ordinary Piping".

Steel pipe in sizes 350 mm and larger shall conform to JIS G 3443 "Coating Steel Pipes for Water Works" and to JIS G 3457 "Electric Arc Welded Carbon Steel Pipes".

(2) Fabricated Steel Pipe

Steel pipe shall be fabricated from steel plates and shall be fusion welded or electric-resistance welded, shop fabricated, tested and cleaned in accordance with AWWA C201 "Fabricated Electrically Welded Steel Water Pipe", and the steel plate shall be Grade B of ASTM A283 "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality" and/or JIS G3101 "Rolled Steel for General Structure".

Steel sheets and coils shall be Grade A of ASTM A 570 "Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality" and/or JIS G 3106 "Rolled Steel for Welded Structure.

The maximum allowable number of pipe seams shall be one (1) longitudinal seam and three (3) girth seam per length of approximately seven (7) meters. Longitudinal seams shall be staggered on opposite sides for adjacent sections. Spiral seam welding shall be in accordance with AWWA C 201.

5303. WALL THICKNESS

(1) General

Unless otherwise indicated on the Drawings, the required wall thickness of steel pipe shall be decided based on the conditions of internal pressures and external pressures to act on the pipe.

The nominal diameter of steel pipe shall be the inside diameter of the finished steel fabrication.

(2) Steel pipe in sizes 300 mm and smaller

The following schedule for the steel pipe in sizes 300 mm and smaller indicates standard wall thickness as stipulated in the standard of JIS B 3443 and JIS B 3452.

SCHEDULE OF WALL THICKNESSES FOR INTERIOR PIPING

Nom. Dia. mm	Wall Thickness mm
50	3.8
65	4.2
80	4.2
90	4.2
100	4.5
125	4.5
150	5.0
175	5.3
200	5.8
225	6.2
250	6.6
300	6.9

(3) Steel pipe in sizes 350 mm and larger

The following schedule for the steel pipe in sizes 350 mm and larger indicates minimum wall thickness as stipulated in the standard of JIS B 3443 and JIS B 3457.

SCHEDULE OF WALL THICKNESSES

Nom. Dia. mm	Wall Thickness mm
350 to 700	6.0
750 to 900	6.4
1,000	8.7
1,100	10.3
1,200	11.1
1,350	11.9