

3. CONCRETE WORK

3.1 General

These Specifications apply to all concrete works and materials in connection with mass and reinforced concrete of structures which the Contractor shall provide for the fulfillment of his obligations.

All concrete works shall be performed as stipulated in these Specifications and as shown on the Drawings or as directed by the Engineer. The concrete works shall be carried out in the presence of the Engineer or the Engineer's Representative.

Not later than thirty (30) days prior to the installation by the Contractor of any Construction Plant and Equipment to be used for the processing, handling, transporting, storing and proportioning of concrete ingredients as well as for the mixing, transporting and placing of concrete and mortar, the Contractor shall submit flow charts, drawings and written descriptions to the Engineer to allow the full and proper assessment of his plans for the producing and placing of the concrete and mortar to be incorporated in the Permanent Works under the Contract.

After being installed, the operation of the plant, equipment and storage facilities shall be at all times subject to the approval of the Engineer.

If the Contractor intends to procure ready mixed concrete and mortar from manufacturers, the Contractor shall inform the Engineer in writing, at least thirty (30) days before commencement of concrete works, of his intention with detailed descriptions regarding the manufacturer's or supplier's name, location and capacity of his concrete plant and processing equipment, reputation and reliability of his products and others for the approval of the Engineer.

Without the approval of the Engineer, the Contractor shall not operate his plant and equipment of concrete processing and/or procure and purchase the ready mixed concrete from manufacturers or suppliers.

All proper precautions for safety and security shall be taken by the Contractor in accordance with the provisions stipulated in Sub-clauses G7.5 and G8.3. (15) of Vol. III, Part I-General Specifications. The Contractor shall not discharge directly disposal water from concrete placing and curing containing suspended and sediment matter into the existing drainage channels and

drain ditches in the Site.

Approval of plant and equipment or their operation, or of any construction procedure, shall not operate to waive or modify any provisions or requirements contained in these Specifications governing the quality of the materials or the finished work.

The Contractor shall not be entitled to any additional payment over the unit prices tendered in the Bill of Quantities for concrete by reason of any limitations in the batching, mixing, transporting and placing of concrete required under the provisions of these Specifications.

Prior to the commencement of concrete works, the Contractor shall establish at the construction site a laboratory furnished with required equipment and instrument necessary for performing day to day and routine tests. The Contractor shall operate and maintain the laboratory as directed by the Engineer during the Contract period and shall employ qualified supervisor and laboratory assistants to carry out the specified tests.

3.2 Cement and Admixtures

3.2.1 Cement

Cement used in the Works shall have a quality equivalent to that of Portland cement, ordinary type, as specified in No. 8 of JIS R 5210 and/or SNI 2049-90-A or ASTM Designation C 150, and/or as approved by the Engineer.

Prior to any cement being ordered, the Contractor shall inform the Engineer of the details concerning the type of cement to be purchased. Cement shall be delivered to the Site along with the manufacturer's quality and testing certificates. Upon receipt thereof, such certificates shall be submitted to the Engineer.

The Contractor shall provide adequate handling and storage facilities for the cement. Metal storage bins or silos at the batching plant for cement shall be weatherproof and shall be constructed so that there is no dead storage. If in the opinion of the Engineer, there is reason to believe that any dead storage exists in any bin, that bin shall be emptied and cleaned out at least once every four (4) months.

Cement delivered in bags shall be transported in a manner approved by the Engineer and shall be stored in completely waterproof warehouses with adequate provisions for preventing the

absorption of moisture, provided that the storage facilities shall be subject to the approval of the Engineer and so arranged as to permit easy access for inspection and identification of each cement consignment.

Cement shall be stored in a weatherproof warehouse having a floor more than thirty (30) cm above the ground level, and shall be used in such manner that the "first-in" can be "first-out". Proper spacing shall be provided between piles of cement. Not more than thirteen (13) bags shall be permitted to be placed in one (1) stack, or to a lesser number as directed by the Engineer when the storage period is expected to be longer than sixty (60) days. The cost of the cement warehouse shall be included in the lump sum price of the Contractor's temporary buildings stated in Item No. 0/05 in the Bill of Quantities.

No cement which has been stored at the Site for more than ninety (90) days shall be used in the Permanent Works unless a test proves it to be satisfactory.

If cement is damaged or deteriorated in consignment, handling or storage, it shall be promptly removed from the site of the works.

The Contractor shall take care to ensure that adequate stocks of cement are always available and shall within tenth (10th) day of each month inform the Engineer concerning the following data :

- The stock of cement on hand at the Site as of the last day of the preceding month,
- Cement delivery received during the previous month,
- Cement used in the Permanent Works during the last month, and
- Other data as required by the Engineer.

3.2.2 Admixtures

The Contractor may be permitted with the written approval of the Engineer the use of admixtures so as to improve workability and finishability of concrete and to promote other special properties.

Air-entraining admixture may be used in all concrete unless otherwise directed by the Engineer. This admixture used shall conform to ASTM Designation C 260 or equivalent approved by the Engineer. With the exception of air-entraining admixtures, the Contractor shall notify the Engineer of the sources of such admixtures as set-retarding, water reducing and strength acceleration agents from which admixtures will be obtained and shall furnish technical information and samples for testing at least ninety (90) days in advance of the time when these

agents are expected to be applied.

All tests for the admixture shall be made by the Contractor at his own expense and the results of tests shall be submitted to the Engineer for his approval.

The amount of agents used in each concrete mix and section of the concrete work where it may be used will be determined by the Engineer. The specified limits in respect of maximum slump, slump loss during transit and time allowed for concrete to remain in the mixer may be changed by the Engineer when approval to use the agent is given.

Liquid or powdered admixtures for concrete shall be kept in water-proof stores with adequate provision for the prevention of water absorption and direct exposure to sunshine. Storage shall be so arranged that the materials will be used in the order in which they arrive at the Site. If any admixture has an expiry date, it shall be conspicuously marked on the container. Sufficient quantities of admixture shall be kept in storage to ensure uninterrupted concrete placing.

All costs incidental to the use of admixtures shall be included in the unit prices per cubic metre stated in the Bill of Quantities for applicable items of concrete in which the admixtures are used and no separate payment for the same shall be considered by the Employer.

3.3 Aggregates

3.3.1 General

With the exception of ready mixed concrete intended to be procured or purchased by the Contractor from manufacturers, materials for production of coarse and fine aggregates shall be obtained from suitable quarry site approved by the Engineer.

All aggregate materials shall consist of hard, durable, clean minerals, produced naturally or manufactured, and must not contain substances which may impair the quality of concrete and reinforcing bars.

All necessary tests to be made by the Contractor on samples taken from possible quarry site indicate that it contains materials which, when processed, will be suitable for coarse and fine aggregates ; as well as, the quality of material available from the possible quarry site shall be assessed by the Contractor. All test results and information as to the materials shall be submitted by the Contractor to the Engineer for his approval.

The Contractor shall carry out the following tests with regard to samples taken from each stockpile in the quarry site in accordance with the specified standards and frequencies indicated in the table below :

Test Item	Test Standard	Frequency
Fine aggregate		
Grading	JIS A 1102 or SNI 1754-90-A	Once a week for each stockpile
Washing	JIS A 1103	When directed by the Engineer
Specific gravity and absorption	JIS A 1109 or SNI 1970-90-F	When directed by the Engineer
Moisture content	JIS A 1111 or SNI 1971-90-F	Once a day
Coarse aggregate		
Grading	JIS A 1102 or SNI 1753-90-F	Once a week for each stockpile
Unit weight	JIS A 1104	When directed by the Engineer
Specific gravity and absorption	JIS A 1110 or SNI 1969-90-F	When directed by the Engineer

The Contractor shall be required to pay by way of royalties or otherwise for materials taken from the selected quarry site and used in the work covered by these Specifications. The Contractor shall be responsible for the specified quality of all such materials used in Permanent Works under the Contract.

In case the Contractor intends to purchase the aggregates from other sources such as manufacturer or supplier, the Contractor shall submit to the Engineer for his approval all test results, data and information to prove physical and chemical properties and quality of the aggregates which will be purchased and used, at least thirty (30) days before the aggregates are required for use.

All costs incurred from production or purchase of the concrete aggregates shall be included in the unit prices per cubic metre of concrete stated in the respective items for the concrete structures itemized in the Bill of Quantities.

3.3.2 Fine aggregate

The term "fine aggregate" is used to designate aggregate in which the maximum size of particles is five (5) mm and the particles consist of innate materials.

The fine aggregate shall consist of clean, hard, dense, durable, uncoated rock fragments of proper gradation and shall be free from injurious amount of dirt, dust, silt, lumps, soft or flaky grains, shale, alkali, organic matter, loam and other deleterious substances. More than three (3) percent of material passing the 0.074 mm or No. 200 sieve by washing or more than one (1) percent of clay lumps or one (1) percent of shale shall not be contained. Use of sand deposited or obtained from beach or sea shall be prohibited without the written approval of the Engineer.

The fine aggregate to be used for concrete structures exposed or weathered shall be free from any substance which will discolour the concrete surface.

The fine aggregate shall be tested for sodium sulphate soundness in accordance with JIS A 1122 or SNI 1758-90-A for five (5) cycles and shall show the maximum loss of not more than ten (10) percent.

The fine aggregate shall be uniformly graded and when tested in accordance with PBI, 1971, N.I.-2 as stated below :

- Fine aggregate, less than two (2) percent (by weight) retained on 4 mm sieve
- Fine aggregate, less than ten (10) percent (by weight) retained on 1 mm sieve
- Fine aggregate, between eighty (80) to ninety five (95) percent (by weight) retained on 0.25 mm sieve or equivalent standard tabulated as follows:

Sieve Designation (Mean Opening (mm))	Standard % by Weight passing Individual Sieve
10	100
5	90 - 100
2.5	80 - 100
1.2	50 - 90
0.6	25 - 65
0.3	10 - 35
0.15	2 - 10

The fineness modulus of the fine aggregate shall range between 2.5 and 3.3.

The percentage of deleterious substances in the fine aggregate shall not exceed the following values :

Item	% by Weight
Clay lump	1.0
Material passing 0.074 mm sieve	3.0 *
Material retained on 0.297 mm sieve and floating on liquid having a specific gravity of 1.95	0.5

* If the material finer than 0.074 mm sieve consists of rock dust free from clay or silt, this percentage may be increased to five (5).

3.3.3 Coarse aggregate

The term "coarse aggregate" is used to designate aggregate in which the minimum nominal size is five (5) mm and which is reasonably well graded from five (5) mm to the largest size ; forty (40) mm for this Project, required in the concrete work. The coarse aggregate shall consist of crushed or unbroken stone, gravel and other innate materials with similar characteristics or a combination thereof. Coarse aggregate shall be clean, hard, fresh, unweathered, well shaped, dense, uncoated, durable rock fragments and free from objectionable quantities of flat or elongated particles, organic matter or other deleterious materials.

The coarse aggregate shall be of uniform grading with the maximum sizes as required for the various types of concrete in accordance with PBI, 1971, N.I.-2 as described below :

- Coarse aggregate, one hundred (100) percent by weight passed 31.5 mm sieve,
- between ninety (90) to ninety eight (98) percent retained on 4.0 mm sieve,
- The difference of accumulative weight between the respective sieves not more than sixty (60) percent by weight and not less than ten (10) percent by weight, and or equivalent to JIS Standard.

The coarse aggregate may be rejected if :

- The loss, using grading A in the Los Angeles abrasion test, exceeds ten (10) percent by weight at one hundred (100) revolutions, or forty (40) percent by weight at five hundred (500) revolutions.
- The weighted loss of the aggregate, when subjected to five (5) cycles of the sodium sulphate test for soundness, is more than twelve (12) percent by weight.
- The total percentage by weight of particles of unsatisfactory shape exceeds sixty (60) percent. A particle shall be considered to be of unsatisfactory shape if it has a maximum dimension exceeding three (3) times its minimum dimensions.

The coarse aggregate shall be finish-screened over vibrating screens mounted on the rock crushing plant or, at the option of the Contractor, the screens may be mounted on the ground adjacent to the rock crushing plant. Separation of the coarse aggregate into the specified sizes, after finish-screening shall be such that, when the aggregate is tested by the sieves designated in the following tabulation, the gradation obtained is as follows :

Designation of Coarse Aggregate	Standard Percentage by Weight passing Individual Sieve (%)							
	50 mm	40 mm	25 mm	20 mm	15 mm	10 mm	5 mm	2.5 mm
40 - 25	100	90-100	20-55	0-15	-	0-5	-	-
25 - 5	-	100	95-100	-	25-60	-	0-10	0-5

Handling and storing of coarse aggregate shall be in such a manner which would prevent its segregation or inclusion of foreign materials. The Engineer may require that coarse aggregate shall be stored on separate platforms provided at adequate locations.

In order to secure greater uniformity of the concrete mix, the Engineer may require that the coarse aggregate shall be separated into two (2) or more sizes. Different sizes of aggregate shall be stored in separate bins or piles sufficiently detached from each other to prevent intermixing.

The Contractor shall submit to the Engineer for his approval the detailed plans, drawings and other

particular description within thirty (30) days prior to installation of the concrete aggregates plant and equipment according to the provisions of Sub-clause G3.2. (5) of Vol. III, Part I - General Specifications.

In case the Contractor intends to procure or purchase the coarse aggregate from manufacturer or supplier, the Contractor shall notify the Engineer in writing at least thirty (30) days before the commencement of concrete work of his intention with detailed information and description as to the manufacturer or supplier accompanying with data and certificates to prove eligibility of the materials.

3.4 Water

Water for mixing concrete and mortar and for washing aggregates and for curing concrete shall be provided by the Contractor as prescribed in Sub-clause G8.3. (4) of Vol. III, Part I - General Specifications and shall be subject to the approval of the Engineer.

The water to be used in concrete and mortar shall be reasonably clean and free from injurious amount of silt, oil, acids, salts, alkali, organic and other deleterious substances. The quality of mixing water shall conform to the Standard of AASHTO T 26 (Standard Method of Test for Quality of Water to be used in Concrete).

If required by the Engineer, samples shall be taken from the proposed sources of supply and tested by comparison with distilled water. Comparison shall be made by means of standard cement test for soundness, time of setting and mortar strength. Indication of unsoundness, change in time of setting plus or minus thirty (30) minutes or more or decrease of mortar strength more than ten (10) percent compared with distilled water shall be sufficient cause for rejection of water being tested.

Sufficient water storage facilities shall be provided to ensure the continuous operation of concrete placing. The methods of delivering and storing water shall be subject to the approval of the Engineer.

All costs incurred from water used for concrete and mortar mixing, and aggregates washing shall be included in the unit prices per cubic metre of concrete or mortar stated for the respective items in the Bill of Quantities.

With the exception of the above, all costs brought from the plant, equipment, labour and materials for construction of water supply system furnished by the Contractor shall be included in the lump

sum price stated for Item No. 0/08 of the Contractor's temporary facilities in the Bill of Quantities.

3.5 Concrete Mix

3.5.1 Composition

Concrete shall be composed of ordinary Portland cement, water, fine and coarse aggregates and approved admixture, all well mixed and brought to the proper consistency.

3.5.2 Types of concrete

Types of concrete shall be designated by the following six (6) types of concrete including lean concrete. Each type of concrete shall be used in accordance with the Specification and where shown on the Drawings or where directed by the Engineer.

The various concrete types shall be typified on the basis of their cylindrical compressive strength at 28 days as well as on the maximum size of the coarse aggregates and slump of concrete as shown below :

Recommended Types of Concrete

Type of Concrete	Max. Size of Coarse Aggregate (mm)	28-day Cylindrical Compressive Strength (kg/cm ²)	Slump (cm)
1	25	270	8
2	40	240	10
3	25	180	8
4	40	180	10
5	25	100	10
6	40	270	2.5

The amount of water used in the concrete will be altered by the Engineer within the limits established by him for the water/cement ratios required to secure concrete of the proper workability, consistency, etc., taking into account the effect of the use of the admixtures approved and any variation in either or both the moisture content or grading of the aggregate as they enter the mixer.

The slump of the concrete mix shall be the lowest possible that will permit thorough compaction

with the equipment approved for the work. In general, slump would depend upon the type of application and not on the type of concrete. The application of each concrete mix to the structure will be made in principle as given below :

Type of Concrete	Application in Drainage Structures
1	Structures requiring high strength with relatively thin members such as, foundation pile, composite girder, etc.
2	RC bridge slab, pier and abutment, guardrail, curb stone, etc.
3	Secondary concrete or relatively thin structural member such as blockout of sluiceway, concrete pipes, etc.
4	Ordinary structural concrete with relatively thick member such as sluiceway, foundation concrete of revetment, concrete culvert, parapet wall, concrete wall, side walk of bridge, etc.
5	Base concrete and levelling concrete.
6	Concrete pavement.

3.5.3 Preliminary mixes

The Contractor shall propose the mix proportions to achieve the required strength and workability and the Engineer will specify the mix proportions found appropriate for the particular application. The Contractor shall undertake to provide a properly mixed concrete containing the constituents in the specified proportions tested in an approved laboratory using a sufficient number of samples to be representative of aggregates and cement to be used for the Works. The Contractor shall employ a competent and suitably qualified engineer to design the mix, to supervise and direct all stages in the preparation and placing of the concrete.

The preliminary mixes shall be prepared at least for three (3) different water-cement ratios which shall produce a range of strengths required for having adequate workability for compaction by the method to be used in placing. The amount of water used in the concrete shall be regulated by the

Engineer within the limits which will be established by him for the water-cement ratios required to secure the proper consistency of concrete, taking into account the effect of the use of the specified admixtures and any variation in either or both the moisture content or grading of the aggregate as they enter the mixer. For each grade of concrete, a set of six (6) cylinders shall be made from each three (3) batch.

From each set of six (6) cylinders, three (3) shall be tested at an age of seven (7) days and another three (3) at twenty eight (28) days in accordance with the specified standards. From the relationship derived between the strength and water-cement ratio a trend line shall be established reasonably.

If at any time during construction of the Works, the source of cement or aggregate is changed, the grading of the aggregate alters or the compressive strength of the concrete is not acceptable then further preliminary mixes shall be undertaken in the manner explained above.

3.5.4 Trial mixes of concrete

At least sixty (60) days prior to the start of permanent concrete work, the Contractor shall produce a trial mix for each type of the concrete specified under the supervision of the Engineer, using cement, admixture and the entire aggregate and by operating, batching and concrete mixing plants provided by the Contractor for the execution of the Works. Such trial mixes shall be continued until concrete complying with these Specifications is produced.

Where the Engineer has approved the concrete mix design for each type of concrete, the Contractor shall, before the commencement of concreting, have trial mixes prepared, preferably under the full-scale production conditions in the presence of the Engineer to ensure that concrete is sufficiently strong and workable and that segregation of the mix during transportation and placing does not occur.

For the trial mix, six (6) test cylinders shall be made by the Contractor and three (3) test cylinders shall be tested at an age of seven (7) days and the remaining three (3) at twenty eight (28) days in accordance with the specified standards. The target concrete mix shall be established through such procedure with consideration of a reasonable margin so as to enable the variations of the original source of cement, aggregate conditions and by the workmanship and construction plant employed for the Works to be controlled within an estimated range. The Engineer shall review all data of the specified mix proportions for each type of concrete as notified to the Contractor.

If the average value of the ultimate compressive strength of the three (3) cylinders taken from any trial mix is less than the specified twenty eight (28) day compressive strength given in Sub-clause 3.5.2 hereinbefore, the Contractor shall re-design to make a further preliminary mix, trial mix and set of test cylinders. If the workability and consistency required are not obtained in the opinion of the Engineer during any trial mix for any type of concrete, the trial mix shall also be re-designed by the Contractor.

Tests specified in Sub-clause 3.3 (Aggregates), 3.4 (Water) and 3.5 (Concrete Mix) shall be conducted by the Contractor in his laboratory or at an approved laboratory in accordance with the provisions of Sub-clause G8.3. (13) of Vol. III, Part I - General Specifications, thereof.

All cost incurred from trial mix and laboratory tests shall be deemed to be included in the respective items of works in the Bill of Quantities and no extra payment for the same shall be made to the Contractor.

The determination of the mix proportions by the Engineer shall not relieve the Contractor of his responsibilities for producing and placing concrete conforming to the specified requirements. 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.

3.5.5 Batching

The Contractor shall either provide batching equipment or may purchase concrete from manufacturers. The equipment shall be capable of combining the aggregates, cement, admixtures and water into a uniform mixture and of discharging this mixture without segregation. It shall also be capable of readily adjusting to compensate for the varying moisture content of the aggregate and to change the weights of the materials being batched.

The amount of each of the materials comprising the concrete shall be determined by weighing, except the amount of water and admixtures which will be measured either by volume or weight.

Unless the Engineer otherwise determines, materials shall be weighed within the following degrees of accuracy, inclusive of scale and operating errors:

Cement	plus two percent (+ 2 %)
Fine aggregate	plus two percent (+ 2 %)

Coarse aggregate	plus three percent (+ 3 %)
Water	plus one percent (+ 1 %)
Admixtures	plus one percent (+ 1 %)

Cement scales shall be in divisions of not more than two (2) kg and aggregates in divisions of not more than ten (10) kg both readily discernible. At the time of installation, or of reconditioning, the indicated weight at any point of scale shall not vary from the correct weight by more than zero decimal two (0.2) percent of the maximum marking of the scale. At any time of operation, the indicated weight at one point on the scale shall not vary from the correct weight by more than zero decimal four (0.4) percent of the maximum marking of the scale.

The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the accuracy of scale. Cement scale shall be tested not less than once a month with the standard weights and the result recorded. In addition, all scales shall be inspected and tested by approved technicians at least every six (6) months.

The following written, printed or graphic records shall always be kept at the equipment for each batch :

- (a) Weight of aggregates and cement
- (b) Amount of water used
- (c) Amount and kind of admixture added

3.5.6 Concrete mixing

(1) Mixing concrete by mechanical mixer

Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixers shall be restored or replaced when any part or section is worn twenty (20) mm or more below the original height of the manufacturer's design. Mixers and agitator which have an accumulation of hard concrete or mortar shall not be used.

When bulk cement is used and volume of the batch is one-half (0.5) m³ or more, the scale and weigh hopper for cement shall be separate and distinct from the aggregate hopper or hoppers. The discharge mechanism of the bulk cement weigh hopper shall be interlocked against opening when the amount of cement in the hopper is underweight by more than one (1) percent or overweight by

more than three (3) percent of the amount specified.

When the aggregates contain more water than the quantity necessary to produce a saturated surface-dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate. Water content and aggregate quantities shall be adjusted accordingly.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer by means that will not result in loss of cement due to the effect of wind, or in accumulation of cement on surfaces of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixture.

All concrete shall be mixed for a period of not less than 1.5 minutes (90 seconds) after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed.

The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water or mortar batching with same proportion of concrete to coat the inside of the drum without reducing the required mortar content of the mix. When mixing is to cease for a period of one hour or more, the mixer shall be thoroughly cleaned.

(2) Mixing concrete in truck

No truck mixer, unless otherwise specified in the Contract, shall be used for the Works.

(3) Mixing concrete by hand

In cases where the Engineer may authorize hand mixing, the mixing shall be done on a watertight platform and in such a manner as to ensure a uniform distribution of the materials throughout the mass. Mixing shall be continued until a homogeneous mixture of the required consistency has been obtained.

(4) Ready mixed concrete

Ready mixed concrete may be used with the written approval of the Engineer. Such approval will not be unreasonably withheld, but the Contractor shall satisfy the Engineer that the materials used in ready-mixed concrete comply with the Specifications in all respects. The specified requirements as to the sampling, preliminary and trial mixes, testing and quality of concrete of various types shall apply equally to ready-mixed concrete.

3.6 Equipment for Transporting and Placing Concrete

3.6.1 General

The methods and equipment used for transporting and placing concrete and the time that elapses during transportation shall be such that concrete having the required composition and consistency will not cause appreciable segregation of coarse aggregate, a slump loss in excess of two point five (2.5) cm, or a loss in air content before consolidation of more than one (1) percent in the concrete as it is placed in the work.

In case that concrete is transported and/or placed by any of the types of equipment listed below, such equipment shall be installed and handled according to the following stipulations:

3.6.2 Agitator truck

The agitating speed of the drum shall be between two (2) and four (4) revolutions per minute. The volume of mixed concrete in the drum shall not exceed the manufacturer's rating nor exceed seventy (70) percent of the gross volume of the drum. Upon approval of the Engineer, truck mixers may be used instead of agitator trucks for transportation of concrete. The interval between feeding of water into the mixer drum and final discharging of the concrete from the agitator shall not exceed one (1) hour. During this interval, the mixture shall be agitated continuously at the above mentioned speed.

3.6.3 Non-agitator truck

Bodies of non-agitator trucks shall be smooth and watertight. Covers shall be provided when needed for protection against rainfall. The non-agitator truck shall deliver concrete to the work site in a thoroughly mixed and uniform mass.

Uniformity will be deemed satisfactory if samples from one-quarter and three-quarter points of the load do not differ more than two point five (2.5) cm in slump. Placing of concrete shall be completed within one (1) hour after feeding mixing water into the cement and aggregates.

Under conditions contributing to quicken stiffening of concrete or the air temperature is thirty degrees (30 °C) or above, the time limit for the final discharging of the concrete shall be less than one (1) hour.

3.6.4 Chutes

In general, transportation of concrete by the use of chutes will not be permitted unless approved by the Engineer. If approved, the chute shall have a section with round corners and shall have a properly fixed slope so as to allow the concrete to flow easily and without segregation. The lower end of the chute shall be provided with a drop chute or baffle plate and hopper not more than one and half (1.5) m in height to avoid segregation of falling concrete. Chutes shall be protected from direct rays of the sun.

3.6.5 Concrete pump or placer

The type and capacity of pump shall be determined to meet the specified requirements, taking into account the placing speed, construction schedule, quality of concrete, location to which concrete is poured, etc. Diameter of the delivery pipes shall be not smaller than three (3) times of the maximum size of aggregates to be used in the concrete.

Delivery pipes shall be so installed as to permit easy removal. Before starting the pump or placer operation, about one (1) m³ of mortar with the same proportion of water, admixture, cement and fine aggregate as designated for the regular concrete mix shall be passed through the pipe.

The pipe shall be set as straight and horizontally as possible to prevent clogging of the concrete mix in the pipe. Air boosters shall not be used except in conditions where the outlet of the pipe is

completely embedded at least two (2) m in fresh concrete. The supports of the pipe line shall be stiff enough to fix the pipes firmly without adverse effect on forms and reinforcing steels already set at the position. Care shall be taken to prevent leakage of the concrete mix from the pipe line or any other part.

3.6.6 Belt-conveyor

Transporting concrete by belt-conveyors will not be permitted unless approved by the Engineer. If authorized, belt-conveyors shall be used with such precaution that belts are protected from rain, wind and sunlight, and that a proper hopper or vertical chute is used at the end of each conveyor to limit the drop of the concrete being placed to a maximum of one and half (1.5) m.

Full details consisting of manufacturer's catalogs, blueprints, etc. for each type of the above described items of equipment shall be submitted to the Engineer. All such equipment shall be operated and maintained in accordance with the manufacturer's printed instructions.

Types of equipment other than listed above shall be approved by the Engineer at least thirty (30) days prior to their being used.

3.7 Placing of Concrete

3.7.1 General

No concrete shall be placed until all form-work, installation of parts to be embedded and preparation of surfaces involved in the placing have been completed by the Contractor, and inspected and approved by the Engineer.

Unless otherwise permitted by the Engineer, no concrete shall be placed in the rain or standing water, and in no case shall concrete be placed in running water.

Check of slumps shall be taken after concrete has been placed but before it has been consolidated. The use of buckets, chutes, hoppers, or other transporting and handling equipment which cannot readily handle and place concrete of such lesser slump shall not be permitted.

Communication facilities between the mixing plant and placing site shall be furnished, operated and maintained by the Contractor where necessary, or desirable as determined by the Engineer. No special payment or allowance will be made to the Contractor for providing such communication

facilities.

3.7.2 Preparation for placing

Immediately before concrete is placed, all surfaces of the formation foundation to which concrete is to be bonded shall be cleared of oil, mud, organic matter, wooden pieces, objectionable coating, debris, or other perishable materials by the use of high-velocity air-water jet or other effective means approved by the Engineer.

All surfaces of forms and embedded materials that have become encrusted with dried mortar from concrete previously placed shall be cleaned of all such mortar before the surrounding or adjacent concrete is placed.

The surface of soil or sand and gravel foundations to which concrete is to be placed shall be free from standing or running water, wooden piece or other objectionable materials mentioned above. For soil or sand and gravel foundation, the foundation shall be in a damp condition before placing concrete.

The surface of construction joints of old concrete to which new concrete or mortar is to be placed shall be roughened by chipping or other approved methods and then cleaned, and kept moist for a time specified by the Engineer prior to placing the new concrete. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coating and foreign materials.

The surface of all contraction joints shall be cleared thoroughly of accessions of concrete or other foreign materials by scrapping, chipping or other means satisfactory to the Engineer. Contraction joints will be filled with rubber joint filler or given a coat of a compound approved by the Engineer to prevent bonding with concrete to be placed on the other side of the joint.

3.7.3 Temperature of concrete during placing

Temperature of concrete when it is being placed shall be not more than thirty two degrees (32^o) C. The aggregates stockpiles shall be, in hot weather shield or sprayed with water and the mixing water shall be adequately cooled or insulated to ensure the temperature of concrete below the specified limit. The Contractor shall not entitled to any additional compensation on account of the requirements of this Sub-clause.

3.7.4 Concrete placed in water

Concrete shall not be placed under water except where inevitable in which case approval must be sought from the Engineer and the work shall be carried out under his meticulous supervision.

The quantity of cement in any type placed in water shall be increased so that the water / cement ratio of the mix is not more than 0.47. The slump shall be maintained below ten (10) cm to prevent segregation. Concrete shall be carefully placed in a compact mass, in its final position, by means of a trim, a bottom-dump bucket, or other approved methods. The detailed placing method in water shall be proposed by the Contractor for the Engineer's approval.

3.7.5 Concrete placed along the slope

If slump in concrete are so large that the placed concrete may possibly flow down along the slope, adequate forms shall be used to prevent the concrete from flowing down.

3.7.6 Placing

The Contractor shall keep the Engineer's advice as to when the placing of concrete is to be performed. Placing of concrete shall be made only in the presence of the Engineer or his representative.

Any concrete which has become so stiff that proper placing can not be assured unless retempered, except with the addition of water or of which the slump has been reduced by two point five (2.5) cm or more, as determined by the Engineer, shall be wasted to places designated by the Engineer, and no payment will be made to such concrete.

In so far as it is practicable, concrete shall be deposited directly in its final position and shall not be caused to flow in a manner to permit or cause segregation. Methods and equipment employed in depositing concrete in forms shall be such as will not result in coarse aggregate being separated from the concrete mass. The Contractor shall provide suitable methods to confine and control the falling concrete so as not to cause segregation or strike hard against the reinforcing bars and assembled forms. The vertical free drop of filling concrete shall not exceed one and half (1.5) m.

All formed concrete shall be placed in horizontal layers, the thickness of which shall not exceed forty (40) cm. The Engineer reserves the right to require less depths of layers where concrete in forty (40) cm layers can not be placed in accordance with the requirements of this Specification.

The height of one lift of concrete placing shall be as designated on the Drawings or as directed by the Engineer.

Struts, stays and braces, serving temporarily to hold the forms in concrete 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 other than metal shall be entirely removed from the forms and not buried in the concrete.

In the event of equipment breakdown, or if for any other reason continuous placing will be interrupted, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic. The cold joint shall thereafter be treated as a construction joint.

If concrete is placed monolithically around openings having vertical dimensions greater than sixty (60) cm, or if concrete in decks, floor slabs, beams, girders or other similar parts of structures is placed monolithically with supporting concrete, the following instructions shall be observed :

- (1) Placing of concrete shall be delayed not less than one (1) hour nor more than three (3) hours at the top of openings and at the bottom of bevels under decks, floor slabs, beams, girders or other similar parts of structures when bevels are specified and at the bottom of such structure members when bevels are not specified, but in no case shall the placing be delayed so long that the vibrating unit will not of its own weight readily penetrate into the concrete placed before the delay.
- (2) The last sixty (60) cm of concrete placed immediately before the delay shall be placed with as low slump as practicable and the Contractor shall ensure that thorough consolidation of the concrete is effected.
- (3) The surfaces of concrete where delays are made shall be clean and free from loose and foreign material when concrete placing is started after the delay.
- (4) Concrete placed over openings and in decks, floors, beams, girders and other similar parts of structures shall be placed with as low slump as practicable and the Contractor shall ensure that thorough consolidation of the concrete is effected.

The Contractor shall not be entitled to any additional payment beyond the unit prices stated in the Bill of Quantities for concrete by reason of any limitations in the placing of concrete required

under the provisions of this Sub-clause.

3.7.7 Compaction and consolidation of concrete

Each layer of concrete shall be immediately compacted and consolidated with suitable appliances so that the concrete is compacted to the maximum practicable density and closes snugly against all surfaces of forms and embedded materials. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly as specified.

In general, concrete shall be consolidated with electrical or pneumatic power driven, internal-type vibrators, operating at a speed of at least seven thousand (7,000) revolutions per minute when immersed in concrete. The vibrating head shall be inserted in concrete vertically and at least five (5) cm into underlying layer. Where it is difficult to use internal vibrators, concrete may be consolidated with the external-type form vibrators as discussed hereinunder or compacted with a hand plunger as directed by the Engineer.

Compaction of concrete in part of structures exposed to view shall be by immersion-type vibrators supplemented where directed by the Engineer, by approved heavy-duty form vibrators. Form vibrators shall be firmly attached to the form during compaction but the vibrators shall be capable of being quickly removed and re-attached to other positions on the forms and shall operate at speeds of at least eight thousand (8,000) revolutions per minute when vibrating concrete.

Care shall be taken to ensure that vibrations shall be made systematically and at such intervals that the zones of influence overlap and the concrete is properly compacted.

In the area where newly placed concrete in each layer adjoins previously placed and hardened concrete, more than usual vibration shall be performed, the vibrator penetrating deeply at close intervals along these contacts. Contact of the vibrating head with surface of the form shall be avoided.

3.7.8 Blockouts in concrete

Blockouts in concrete shall be constructed, as shown on the Drawings or as directed by the Engineer, to permit the installation and adjustment of metalwork for the mechanical equipment which is to be embedded in concrete. Such blockouts shall be filled with Type 3 concrete unless otherwise directed by the Engineer after the installation is completed.

Before type 3 concrete is placed in the blockouts, the existing concrete surfaces of the blockouts shall be roughened and cleaned. The roughening shall be performed by chipping or other approved methods and in such a manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface. After being roughened, the surface of the concrete shall be cleaned in accordance with the provisions of Sub-clause 3.7.2 and shall be sound and hard and in such a condition as to ensure a good mechanical bond between the existing and the new concrete. All concrete which is not hard, dense and durable shall be removed to the depth required to secure a satisfactory surface. After cleaning the roughened surface to the satisfaction of the Engineer, it shall be kept moist for at least twenty four (24) hours prior to placing the concrete in the blockout.

The Contractor shall place the concrete in blockouts in such a way as to ensure a satisfactory bond with the existing concrete, to secure complete contact with metalwork to be embedded in the blockout concrete and to avoid displacement of the metalwork being embedded. Where directed by the Engineer, concrete placed in blockouts shall contain an approved expander or shall be delayed between mixing and placing to reduce subsequent shrinkage. The cost of preparing the surface of the concrete against which blockout concrete is to be placed, shall be included in the unit price for type 3 concrete for the blockout.

Measurement, for payment, of blockout concrete will be made of the dimensions as shown on the Drawings or as directed by the Engineer and in accordance with the provisions of Sub-clause 3.14.1.

Payment for blockout concrete shall be made in accordance with the provisions of Sub-clause 3.14.1 at the unit prices per cubic meter tendered in the Bill of Quantities.

3.7.9 Construction and contraction joints

(1) Construction joints

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

Certain joints have been shown on the Drawings with full lines or broken lines as compulsory construction joints. These construction joints shall not be altered and no concrete shall be placed against the joint for at least three (3) days for sections up to ninety (90) cm in thickness and for seven (7) days where the thickness exceeds ninety (90) cm, unless otherwise approved by the

Engineer.

Other construction joints have non-compulsory locations. Subject to approval of the Engineer, the Contractor may vary the locations of this type of construction joint and the sequence of concrete placement where shown on the Drawings, provided that the Contractor shall make all necessary adjustments to the reinforcement to the satisfaction of the Engineer and without cost to the Employer.

In addition to those construction joints shown on the Drawings, the Contractor shall prepare his own drawings showing the locations of construction joints he desires to make including a sequence of concrete placement. The necessary reinforcement shall also be detailed on his drawings so as to match such joint. If approved, all necessary work related thereto shall be made at no extra cost to the Employer.

Construction joints shall be approximately horizontal or vertical unless otherwise shown on the Drawings or prescribed by the Engineer and shall be given the prescribed shape by the use of forms, where required, or by other means that will ensure suitable joining with subsequent work ; Provided, that unless otherwise shown on the Drawings, keyways will not be required at construction joints. All intersections of construction joints with concrete surface which will be exposed to view shall be made straight and level or plumb.

The surfaces of construction joints shall be clean and damp when covered with fresh concrete or mortar. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coatings, sand, sealing compounds if used, and other foreign material. The surfaces of all construction joints shall be roughened and then washed thoroughly. The roughening and washing shall be performed at the last opportunity prior to the placing of concrete.

The surfaces of all construction joints, including surfaces of blockouts shall be washed thoroughly with air-water jets immediately prior to placement of adjoining concrete.

All pools of water shall be removed from the surfaces of construction joints before the new concrete is placed.

The cost of construction joints shall be included in the unit prices per cubic meter tendered in the Bill of Quantities for the concrete which require such joints.

(2) Expansion and contraction joints

Expansion joints with the types shown on the Drawings shall be provided in wall, floor, etc., where indicated on the Drawings or as directed by the Engineer. The joint shall be made by forming the concrete on one side of joint and allowing it to set before concrete is placed on the other side of the joint. Waterstops and PVC pipes for dowel bars where those shall be necessary as shown on the Drawings or directed by the Engineer shall be embedded in the concrete first placed. Joint fillers as specified in Sub-clause 3.13.5 hereof shall be placed on the entire surface of concrete first placed at the expansion joint.

Contraction joints shall be located and constructed as shown on the Drawings or as directed by the Engineer. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. The surface of the concrete placed at contraction joints shall be cleaned and then coated with a curing compound, oil paint or other approved material to break the bond before concrete on the other side of the joint is placed.

The entire cost of constructing all joints shall be included in the unit prices per cubic meter tendered in the Bill of Quantities for the concrete which require such joints, except that payment for expansion joint filler, waterstops and anchor bars, as required, will be made as provided in Sub-clause 3.14.4.

3.8 Curing Concrete and Protection

3.8.1 General

All concrete placed shall be cured in accordance with the Specifications and as directed by the Engineer. The Contractor shall submit adequate curing and protection method for the Engineer's approval before actual concrete placement begins. The curing shall be applied so as to prevent loss of moisture from the concrete. Concrete shall be protected from heavy rains for twelve (12) hours, flowing water for fourteen (14) days and direct rays of the sun for three (3) days after placing. All concrete shall be adequately protected from traffic, fire or excessive heat including heat resulting from the welding of steel. Concrete surfaces of construction joints shall be water cured. The unformed top surfaces of walls, slabs and piers shall be moistened by covering with water-saturated material or by other effective means as soon as the concrete has hardened sufficiently to prevent damage by water. These surfaces and steeply sloping and vertical formed surfaces shall be kept completely and continuously moist, before and during form removal, by water applied on the unformed top surfaces and allowed to pass down between the forms and the formed concrete

faces. This procedure shall be followed by the specified water curing or membrane curing. The following curing methods shall be deemed to be applicable.

3.8.2 Moisture curing method

The concrete shall be kept continuously wet by the application of water for a minimum period of seven (7) days after the concrete has been placed.

The entire surface of the concrete shall be kept damp by applying water with nozzle. Cotton mats, rugs, carpets, or earth or sand blankets may be used to retain the moisture. At the expiration of the curing period, the concrete surfaces shall be cleared of the curing medium.

3.8.3 Curing compound method

Where approved by the Engineer, surfaces exposed to air may be cured by the liquid curing compound in accordance with ASTM C309, PBI,1971,N.I.-2 or equivalent.

The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film, and shall be of such character that it will harden within thirty (30) minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay, in the application of the curing compound, which results in any drying or cracking of the surface, application of water with an atomizing nozzle shall be started immediately and shall be continued until the application of the compound is resumed or started; however, the compound shall not be applied over any resulting free standing water. Should the film of compound be damaged from any cause before the expiration of seven (7) days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compound shall not settle hard in storage. They shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within one hundred and twenty (120) days after the date of manufacture, the Engineer may require additional testing before use to determine

compliance to the requirements.

Curing compound may be sampled by the Engineer at the source of supply and on the Site.

3.8.4 Form in place method

Formed surfaces of concrete may be cured by retaining the form-in-place. The forms shall remain in place for a minimum period of seven (7) days after the concrete has been placed, except that for members over fifty (50) cm in least dimension, the forms shall remain in place for a minimum period of five (5) days. Wooden forms shall be kept wet by watering during the curing period.

3.8.5 Steam curing method

If steam curing for precast units shall be made at the manufacture's factory, the Contractor shall submit the detail of curing procedure, all equipment and materials for the Engineer's approval.

3.9 Concrete Surface Finishes

3.9.1 General

The type of finish and the requirements for finishing of concrete surfaces shall be as herein specified or as indicated on the Drawings. Finishing of concrete surfaces shall be performed only by workmen who are skillful in that trade.

Unless inspection is waived in specific cases, finishing of concrete shall be performed only in the presence of the Engineer. Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the limits hereinafter specified. Surface irregularities are typified as "abrupt" or "gradual". Offsets caused by displaced form sheathing or lining or form sections, or otherwise defective form lumber will be considered as "abrupt" irregularities, and will be tested by direct measurement. 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 one and half (1.5) m for testing of formed surfaces and three (3) m for testing of unformed surfaces. All surfaces shall be sloped as indicated on the Drawings or, even if not indicated, sloped sufficiently to prevent accumulation of water.

3.9.2 Formed surfaces

The types of finish for formed concrete surface, except surfaces for which special finishes are required, are designated by use of symbols F1 and F2.

Finish F1 applies to formed surfaces upon or against which fill material or concrete is to be placed. Correction of surface irregularities measured as previously described shall be required only for depressions which exceed thirty (30) mm.

Finish F2 applies to formed surface which will be permanently exposed and where a reasonably attractive appearance is required. Surface irregularities measured as previously described shall not exceed ten (10) mm for abrupt irregularities and twenty (20) mm for gradual irregularities.

3.9.3 Unformed surfaces

The types of finish for unformed concrete surfaces are designated by use of symbols U1 and U2. The requirements of this Clause, however shall not be applied to unformed surfaces such as those specified in concrete floor finishes, and mortar under equipment bases.

Unless the use of other slopes or level surfaces is indicated on the Drawings or directed by the Engineer, surfaces which will be exposed to the weather and which are nominally level shall be sloped approximately one (1) vertical to fifty (50) horizontal. Unless otherwise specified or indicated on the Drawings, the types of finish shall apply as follows :

Finish U1 is a screeded finish applied to unformed surfaces which will be covered by fill material or by concrete. Finish U1 is also the first stage of finish U2. Finishing shall consist of sufficient levelling and screeding to produce uniform surfaces. Surface irregularities measured as previously described shall not exceed twenty (20) mm.

Finish U2 is a floated finish applied to unformed surfaces of waterways (sluiceway) or surfaces which will be generally exposed to view such as weir crests, stairway treads and landings, decks, sump inverts, tops of walls and piers and surfaces of gutters. Floating shall be started as soon as the screeded surface has stiffened sufficiently, and shall be minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities shall not exceed five (5) mm.

3.9.4 Monolithic concrete floor finish

Where monolithic concrete floor finish is shown on the Drawings, placing concrete shall proceed continuously for the full thickness of the course of slab without change in concrete mix. Mixing water shall be the minimum required for proper placing and will be specified by the Engineer. After placing concrete, floors and other surfaces shall be floated with a wood float to a true surface and to elevation as shown on the Drawings. Where indicated on the Drawings or in these Specifications, floor surfaces shall be steel trowel finished. Troweling shall be the minimum amount consistent with maintaining a smooth dense surface, and shall not be done until the mortar has hardened sufficiently to prevent excess fine material from being worked up the surface. The addition of water, dry cement, or dry cement mortar to the surface of the concrete to facilitate finishing will not be permitted.

3.9.5 Concrete surface finish for concrete bridge slab

After the concrete has been deposited in place, it shall be compacted and the surface shall be struck off by means of strike board and floated with a wooden or cork float. An edging tool shall be used on all edges and at all expansion joints. The surface shall not vary more than three (3) mm under a three (3) m straight edge. The surface shall have a granular or matted texture which will not be slipped when wet.

3.9.6 Repair of damaged or defective concrete surfaces

Defective concrete and concrete damaged from any cause shall be removed and replaced with acceptable concrete by the Contractor at no cost to the Employer. Irregularities of alignment due to inaccurate finishing of surface, bulging of forms, or other defects shall be rectified by and at the expense of the Contractor. Before final acceptance of the work, the Contractor shall clean all exposed concrete surfaces of all encrustations of cement, mortar, or grout, and shall remove all unsightly stains to the satisfaction of the Engineer.

Unless otherwise approved by the Engineer, repair of imperfections in concrete shall be completed within twenty four (24) hours after removal of forms, or in the case of unformed concrete within twenty four (24) hours after the placing of concrete. Fins and encrustations shall be neatly removed from surfaces for which F2 finish is specified and encrustations shall be removed from surfaces for which U2 finish is specified.

Repair of concrete shall be performed by skilled workmen. The Contractor shall keep the

Engineer advised as to when repair of concrete is to be performed. Unless inspection is waived by the Engineer, in each specific case the repair of concrete shall be performed only in the presence of the Engineer or his representative.

Concrete that is damaged from any cause and concrete that is honeycombed, fractured or otherwise defective, and concrete which must be excavated and built up to bring the surface to the prescribed lines because of excessive surface depressions, shall be removed and replaced with dry-pack mortar, or concrete, as directed by the Engineer.

The detailed and definite specifications for repair of damaged or defective concrete surfaces shall be approved or directed by the Engineer. The cost of all materials, labour and equipment required in the repair of concrete shall be borne entirely by the Contractor.

3.10 Quality Control

3.10.1 General

Various tests required to be carried out for quality control, test standards and frequency of testing shall be in accordance with Sub-clause 3.3.1 hereinbefore. In addition, following tests shall also be conducted by the Contractor.

3.10.2 Compressive strength test

During manufacture and placing of concrete, not less than two (2) samples during each day and not less than one (1) sample for each fifty (50) m³ of concrete shall be taken. Each sample shall consist of six (6) compression test cylinders. The cylinders ten (10) cm in diameter and twenty (20) cm high shall be moulded from each sample, standard cured and tested at seven (7) day testing for three (3) cylinders and twenty eight (28) day testing for the remaining three (3) cylinders in accordance with the requirements of JIS A 1132 or AASHTO T23. In case that maximum size of aggregate is forty (40) mm, the cylinders shall be moulded fifteen (15) cm in diameter and thirty (30) cm high.

The compressive strength of the concrete shall be deemed acceptable if the average of three (3) consecutive strength test results is equal to or exceeds the specified strength and no individual test result falls below the specified strength.

The test result shall be progressively analyzed and evaluated statistically. Evaluation shall be

made for more than ten (10) successive test results on the following basis :

- (1) The probability of strength test being below the specified strength in Sub-clause 3.5.2 herein shall not be more than twenty five (25) percent.
- (2) The probability of strength test being below eighty (80) percent of the specified strength in Sub-clause 3.5.2 herein shall not be more than five (5) percent.

If considered necessary by the Engineer, compressive strength of the placed concrete shall be checked by using Schmidt Hammer method. Frequency of this test shall be as directed by the Engineer.

3.10.3 Slump test

A slump test shall be made immediately before concreting is commenced and at all times when compression test samples are taken and at such other times when directed by the Engineer. The slump tests shall be in accordance with JIS A 1101, AASHTO T119 or SNI 1972-90-F.

3.10.4 Failure to pass tests

If the specified values are not obtained for compressive strength test on any concrete mix, no further concrete of that mix shall be placed in the works, and the Contractor shall establish the cause of the failure, provide three (3) cores taken in accordance with JIS A 1107 or AASHTO T24 for the further test and supply such remedies as are necessary for the Engineer's decision which may be one of the following :

- The Engineer may order the concrete corresponding to the cylinders to be cut out and replaced in accordance with Clause 50 of Vol. II, Part I - General Conditions of Contract.
- When the failure relates to concrete used in structural members which lend themselves to being load tested such as beams, columns or slabs, the Engineer may order the affected member to be so tested in accordance with his instructions. If cracking or any other sign of failure appears, the concrete shall be cut out to the extent ordered by the Engineer and replaced with sound material, otherwise the member may be accepted as satisfactory.
- When the failure, in the opinion of the Engineer, is slight and occurs in a continuing concreting operation for a large mass of concrete, the next works may be awaited and if the

failure then persists, the Engineer may order that concreting shall cease forthwith and not be resumed until further preliminary tests indicate that the mix has been corrected, otherwise the concreting may be allowed to continue with the same mix.

- When the failure is serious and relates to a concrete mass which lends itself to it, the Engineer may order one or more test cylinders to be drilled out and tested in accordance with the standards above in accordance with Clause 50 of Vol. II, Part I - General Conditions of Contract.

The cost of these tests including the provision and placing of jacks, kentledge, deflectometers, etc., and the cutting out and replacing or repairing concrete of inferior quality shall be borne by the Contractor.

3.10.5 Concrete material test

Where directed by the Engineer, the Contractor shall test concrete materials to be used in the Works in accordance with the following specifications at the frequency to be determined and directed by the Engineer :

Aggregates	JIS Standard	AASHTO Standard	SNI Standards
- Sieving analysis for coarse, fine aggregate and for stone fineness	A - 1102	T - 27	1968-90-F
- Weight of aggregates per unit volume	A - 1104	T - 19	1750-90-A
- Organic impurities in fine aggregate	A - 1105	T - 21	1755-90-A
- Specific gravity and water absorption test in fine aggregate	A - 1109	T - 84	1970-90-F
- Specific gravity and water absorption test in coarse aggregate	A - 1110	T - 85	1969-90-F
- Los Angeles abrasion test	A - 1121	T - 96	03-2417-1991
- Soundness of aggregates by use of Sodium Sulphate	A - 1122	T - 104	1758-90-A
- Sand equivalent test	A - 1137	T - 176	0351-89-A
- Fineness test on cement	R - 5201	T - 128	15-2530-1991
- Strength test on mortar specimens	R - 5201	T - 106	M-111-1990-03

3.10.6 Record of concreting and tests

An accurate and up-to-date record showing dates, times, weather and temperature conditions (when various positions of the works were concerted) shall be monitored by the Contractor and a quality control report based upon test results shall be submitted on the monthly basis to the Engineer for his review and the Project record. The Contractor shall also record the results of all tests of concrete and shall identify these results with parts of which the sampled material is representative.

3.11 Tolerance for Concrete Construction

Allowable deviation from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings are defined as "tolerances". Tolerances shall be inclusive of surface irregularities as defined in Clause 3.9.

The intent of this Clause is to establish tolerances that are consistent with modern construction practice, yet governed by the effect that permissible deviations will have upon the structural action or operational function of the structure. Deviations from the established lines, grades and dimensions will be permitted to the extent set forth herein. Provided that the Engineer reserves the right to diminish the tolerances set forth herein if such tolerances impair the functional behaviour of a structure. Where tolerances are not stated in the Specifications or Drawings for any individual structure or feature thereof, permissible deviation will be interpreted conformably to the provisions of this Clause.

The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits so as to ensure completed work within the tolerance specified herein. The concrete work that exceeds the tolerance limits specified in the following tabulation shall be remedied or removed and replaced at the expense of and by the Contractor.

Tolerances for Concrete Structures

1. Monolithic concrete structures

- | | |
|---|----------------------------------|
| (1) Departure from established alignment | 5 cm |
| (2) Departure from established profile grade..... | 5 cm |
| (3) Variation in thickness | |
| Minus | 2.5 % or 1 cm, whichever greater |

	Plus	5 % or 1 cm, whichever greater
(4)	Variation from inside dimension	0.5 %
2. Bridges, bridge abutments, bridge piers		
(1)	Departure from established alignment	5 cm
(2)	Departure from established grades.....	5 cm
(3)	Variation from the plumb or the specified batter in lines and surfaces of columns, piers, walls and in risers	
	Exposed in 3 m	1 cm
	Backfilled in 3 m.....	5 cm
3. General structures		
(1)	Variation from the level or from the grades indicated on the Drawings in slabs, beams, horizontal grooves and railing offsets	
	Exposed in 3 m	1 cm
	Backfilled in 3 m.....	5 cm
(2)	Variation in cross sectional dimensions of columns, piers, slabs, walls, beams and similar parts of the structures in paragraph (1) above	
	Minus	1 cm
	Plus.....	2 cm
(3)	Variation in thickness of bridge slabs	
	Minus	1 cm
	Plus.....	2 cm
(4)	Footings	
	(a) Variations of dimension in plan	
	Minus	1 cm
	Plus.....	5 cm
	(b) Misplacement or eccentricity 2 % of the footing width in the direction of misplacement but not more than	5 cm
	(c) Reduction in thickness	5 %
(5)	Variation in the size and location of slab and wall openings.....	5 cm
(6)	Deviation from the plumb or level of sills and side walls for gates and similar water tight joints.....	0.1 %
4. Placing of reinforcement steel		
(1)	Variation for protective covering.....	10 %
(2)	Variation from indicated spacing.....	2 cm

5. Laying of precast concrete units

- (1) Departure from established alignment 1 % of length of precast unit
not more than 5 cm
- (2) Departure from established grades 1 % of length of precast unit,
not more than 5 cm
- (3) Variation from the plumb of precast unit placed vertically in 3 m.... 1 cm

6. Placing embedded metalwork

- (1) Minus 6 mm
- (2) Plus 6 mm

7. Color of concrete

Abrupt changes in color of external concrete surfaces exposed to public view will not be permitted. The Contractor shall ensure that as far as possible these surfaces shall be of uniform color or that changes in color, where permitted, are gradual.

3.12 Formwork

3.12.1 General

The work shall consist of providing, erecting and removing concrete forms of sufficient strength with all necessary fasteners, bracings, etc. in conformity with the requirements specified hereinafter.

Form sheathing shall have such smoothness and uniformity as required to meet the requirements for tolerance and finish as hereinafter specified and shall be manufactured in such a way that any horizontal joints are not continuous across the entire formed surface. Forms shall be true to line and grade, mortar tight and sufficiently rigid to prevent objectionable deformation under load. Curved surfaces shall be formed to conform to the curve data shown on the Drawings ; construction of such curved section in chorded lengths will not be permitted except where such construction is shown on the Drawings or specifically approved by the Engineer. The surfaces of all forms to be in contact with the concrete shall be clean, rigid, and sufficiently tight to prevent loss of mortar. Responsibility for their adequacy shall rest with the Contractor ; however, the type, shape, size, quality, and strength of all material of which the forms are made shall be subject to the Engineer's approval. All forms shall be so constructed that they can be removed without damage

to the concrete. All exposed joints, edges, and external corners shall be chamfered not less than two (2) cm at forty five degrees (45°) except as otherwise shown. Internal corners shall be filleted where indicated or required by the Engineer.

3.12.2 Material requirement

All materials for form sheathing shall be subject to the approval of the Engineer. Lumber shall be sound, straight, free from warp, decay and loose knots and shall be dressed smooth and uniform in width and thickness prior to fabrication of form work. Forms to be used in concrete for water passages which will ultimately be exposed to view shall be faced with either plywood (symbolized F2) or other wood (symbolized F1) and shall be free of all defects which will be reproduced as blemishes on the concrete surfaces.

Where plywood is used, it shall be non-warping, non-wrinkling and manufactured with special waterproof glues. In so far as is practicable, plywood sheets shall be of uniform width and length.

Timber sheathing or lining shall be of such kind and quality or shall be so treated or coated that there will be no chemical deterioration or discolouration of the formed concrete surfaces. The type and condition of form sheathing and lining, the ability of the forms to withstand distortion caused by placement and vibration of the concrete, and the workmanship used in form construction shall be such that the formed surfaces will conform to Sub-clause 3.9.2 hereinbefore pertaining to finish of formed surfaces.

Form sheathing and lining shall conform to the requirements authorized by the Engineer.

3.12.3 Placing and preparation

Forms shall be placed so that the joint marks on concrete surfaces are in alignment both horizontally and vertically, and the joints between surfaces shall be smooth. All edges or corners of the concrete exposed permanently shall be chamfered as shown on the Drawings or as directed by the Engineer.

Before placing concrete, all forms shall be rigid and tight and shall be thoroughly cleaned, and all wooden chips, saw dust, dry mortar lumps, foreign matter, and excess water shall be removed from the forms. The surface of the forms shall be oiled with a refined mineral oil of a type approved by the Engineer. The form oil shall be applied before the reinforcing steel is placed. Forms, which have been left in place for such a period that they have dried out, shall receive further surface

treatment as directed by the Engineer.

Where forms for continuous surfaces are placed in successive lifts, care shall be taken to fit the forms tightly over the entire surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface.

Forms to be used more than once shall be maintained in serviceable condition and shall be thoroughly cleaned before being reused. Forms on exterior faces on walls shall be kept clean by means of splash boards whenever practicable.

Immediately before concrete is placed, precautions shall be taken to see that all forms are in proper alignment, and that all form supports and scaffolding (if any) are thoroughly secure and tight.

The rate of depositing concrete in forms shall be such to prevent deflections of the forms or form panels in excess of the deflections permitted by the Specifications.

Form for exposed concrete surface shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or walls. Undulations exceeding either two (2) mm or $1/270$ of the centre distance between studs, joists, form stiffeners, or walls will be considered to be excessive. Should any form of forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

All exposed surfaces of similar portions of concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, colour and appearance. Forms for exposed surfaces shall be made of form materials of even thickness and width and with uniform texture and constructed with triangular fills at least twenty (20) mm wide attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp edges of the concrete.

Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placement.

Wire ties passing through the forms shall not be used unless authorized by the Engineer. The ties shall be constructed so that removal of the ends or end fasteners can be accomplished without

causing appreciable spelling at the faces of the concrete. Recesses resulting from removal of the ends of form ties shall be filled in accordance with the provisions stipulated in Sub-clause 3.9.6.

Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorage for fastening form support to concrete will not be permitted.

3.12.4 Removal of forms

The Contractor shall not remove forms until the concrete has hardened and is of sufficient strength to carry its own weight safely, together with any construction loads likely to be imposed upon it. Forms shall be removed only with the approval of the Engineer in a manner which will prevent injury to the concrete and, in general, the form shall be left for periods not less than forty eight (48) hours after the concrete is placed, or as directed by the Engineer. In no case, however, the Engineer's consent for removal of forms relieve the Contractor of his responsibility for the safety of the work.

When concrete strength tests are used for removal of forms and supports, such removal of forms and supports shall be in line with the following :

Requirement for Removal of Forms

Item of Work	Minimum Time		Minimum Percentage of Design Strength
Centering under girders, beams, frames or arches	14 days	or	80 %
Floor slabs	14 days	or	70 %
Mass concrete	2 days	or	70 %
Sides of beams and all other vertical surfaces	1 day	or	70 %

In order to determine the condition of column concrete, forms shall be removed from columns before releasing support from beneath beams and girders.

The forms may be left in place when, in the opinion of the Engineer their removal would endanger the safety of the structure, and when the forms so left intact will not be exposed to view in the

finished structure. All other forms shall be removed whether above or below the ground line or water level.

To facilitate finishing, forms used for ornamental work, railings, parapets, and exposed vertical surfaces shall be removed in neither less than twelve (12) nor more than forty eight (48) hours depending upon the weather conditions. In order to determine the condition of concrete in columns, forms shall always be removed from them before the removal of supporting pole from beams and girders.

3.12.5 Support and scaffolding of form

Support of form shall be made of timber or metal, to keep the form conforming to the shape, lines and dimensions of the members as shown on the Drawings and shall be so rigidly constructed as to prevent deformation due to load, drying and wetting, vibration and other causes. The support shall be designed to carry the maximum loads which may be imposed.

Scaffolding shall be built on foundation of sufficient strength to carry the loads without appreciable settlement and its type and structure shall be approved by the Engineer. Extent of chamber of form shall be decided after approval by the Engineer.

No separate payment shall be made for support and scaffolding of form and these costs incurred by the Contractor shall be included in the respective form works stated in the Bill of Quantities.

3.13 Reinforcing Bars and Other Miscellaneous Items

3.13.1 General

This work shall consist of furnishing, fabricating and placing of steel reinforcements and other miscellaneous items of the type, size, shape, and grade required in accordance with these Specifications and in conformity with the requirements shown on the Drawings or as directed by the Engineer.

The Contractor shall prepare the delivery schedule of these reinforcing bars to provide with sufficient stocks of bars to commence cutting and bending reinforcement for a structure at least sixty (60) days before the scheduled placement of concrete around the reinforcement. The delivery schedule is to be based on the Contractor's detailed construction programme, including amendments, if any, as reviewed by the Engineer.

3.13.2 Reinforcement bars material requirement

The Contractor shall furnish, cut, bend, and place all steel reinforcing bars as indicated on the Drawings or as directed by the Engineer. Except where shown otherwise on the Drawings, the reinforcing bars shall be deformed steel bars, shall be made by an approved manufacturer, and shall comply with JIS G 3112, SD 295, SNI 2052-89-A or approved equivalent. All reinforcements when surrounding concrete is placed, shall be free from loose, flaky rust and scale, and free from oil, grease or other coating which might destroy or reduce its bond with the concrete.

Reinforcing bars shall be sampled by the Engineer either at the source of supply or at the point of their distribution, or both. Contractor shall notify the Engineer in advance to permit sampling and testing before shipment is made. Engineer may select two (2) or more samples from each size at random representing five (5) tons or fraction thereof of each size and direct the Contractor to get the selected samples tested at an approved laboratory at the Contractor's cost. Reinforcement shall only be allowed to be placed at work site if duly certified by the laboratory to the satisfaction of the Engineer. In no case, the Engineer's consent shall relieve the Contractor of his responsibility for supplying and placement of correct type of reinforcing bars in concrete.

3.13.3 Fabrication and assembly

The Contractor shall prepare at his own expense all detailed reinforcement drawings. These drawings shall include all bar-placing drawings, bar-bending drawings, bar lists and any other reinforcing drawings as may be required to facilitate fabrication and placement of reinforcing bars. Such drawings shall be approved by the Engineer before the fabrication and placing of reinforcing bars. Clear distance between bars or between bars and concrete surfaces, and details of hooks, bends, splicing and anchorage shall all conform to the standard details shown on the Drawings.

Bending of bars with the aid of heat shall not be performed unless otherwise approved by the Engineer. Permission may be granted on specific request and submission by the Contractor of his proposed method including precautions to assure that the particular steel bars will not undergo any injury whatsoever. Such permission shall not relieve the Contractor from sole responsibility for the adequacy of the method and the bars.

The reinforcing bars shall be secured firmly in their correct position so that no displacement will occur during concrete placing or as a result of vibration. Horizontal reinforcing bars shall be supported with precast concrete or steel saddles placed in such a manner that they shall be

adequate to maintain the bars at the correct level.

The intersecting points and laps of the reinforcing bars shall be securely tied with soft iron wire of not less than 0.9 mm in diameter. The minimum clear cover to main reinforcing bar shall generally be between five (5) and ten (10) cm as shown on the Drawings or as directed by the Engineer. Notwithstanding the minimum clear cover to reinforcement shown on the Drawings, the Engineer may as often as he deems necessary, vary the clear cover to reinforcement during the construction.

Reinforcing bars shall be lapped where necessary. The length of overlapping shall not be less than twenty five (25) times of the diameter of the larger bar or as directed by the Engineer. The location of laps in reinforcement shall be subject to the approval of the Engineer.

The Contractor shall be responsible for the accuracy of the cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to size, shape, length, splicing locations, position and amount after it has been placed. When a long period of time has elapsed after placing reinforcing bars, they shall be inspected again by the Engineer before placing concrete.

3.13.4 Anchor bars and joint bars

The anchor or joint bars shall be provided for the bridge structures as shown on the Drawings or elsewhere directed by the Engineer.

The Contractor shall furnish, cut and place all anchor bars or joint bars as indicated on the Drawings or otherwise required.

The cutting and placing of anchor or joint bars shall be in accordance with Sub-clause 3.13.3 hereinbefore or as directed by the Engineer.

3.13.5 Joint filler

The Contractor shall furnish and install the expansion joint filler at locations indicated on the Drawings or as directed by the Engineer. Expansion joint filler material shall be of the expanded polystyrene type satisfying the requirements of ASTM D2125, Type 1, Grade 15, or approved equivalent and shall be thick enough to cover all voids.

Requirements for Joint Filler

Physical Characteristic	Requirement	Code No.
Tensile strength	more than 20 kg/cm ²	JIS K 6301
Ultimate elongation	more than 100 %	-
Hardness	more than 50 HS	JIS K 6301 - 52
Water absorption	less than 0.5 %	JIS A 9511
Recovery	more than 90 %	ASTM D 544 - 48
Apparent density	more than 0.3 g/cm ³	-

Prior to installing the expansion joint filler, the Contractor shall submit the proposed material sample along with its test certificates, manufacturer's specifications and installation method of expansion joint filler he intends to use for approval of the Engineer.

The Contractor shall cut the joint filler to cover the required surface of the concrete at expansion joints and to fit around all openings.

Where placed against vertical surfaces the joint filler shall be held in place against the completed side of an expansion joint by an approved material applied to the face of each piece of joint filler for not less than forty (40) mm from each edge of the face. Splices or joints of the joint filler shall be made with cold applied cementing material so that mortar from the concrete will not seep through to the opposite concrete surface. The number of field joints shall be kept to a minimum by using factory produced joints wherever possible. The water tightness of the joints and structures for which joint filler has been provided shall be the Contractor's responsibility.

3.13.6 Waterstops

The Contractor shall furnish and install the waterstops as shown on the Drawings or as directed by the Engineer and as specified herein. The waterstops which have the following physical characteristics shall conform to the requirements of JIS K6773-74, Flexible Polyvinyl Chloride (PVC) Waterstops, or equivalent and shall be subject to the approval of the Engineer ;

Requirements for Waterstops

Physical Characteristic	Requirement
Specific gravity	1.40 or less
Tensile strength (kg/cm ²)	120 or more
Elongation (%)	350 or more
Hardness	65 or more

The waterstops shall be fabricated from a plastic compound, the basic resin of which shall be polyvinyl chloride. All waterstops shall be moulded or extruded and free in such a manner that any cross section will be dense, homogeneous and free from porosity and other imperfections. The waterstops shall be symmetrical in shape and the dimensions of both type shall be as follows:

Dimension (mm)	Type A (3-bulb type)
Width	200
Thickness	9
Allowance : width + 3 %, thickness + 10 %	

All waterstop shall be stored in a place as cool as practicable, so as to permit free circulation of air about it and in no case shall waterstop be stored in the open or exposed to the direct rays of the sun.

The number of joints in the waterstops shall be the minimum practicable and all joints and bends shall be made as shown on the Drawings or as approved by the Engineer. The number of straight field joints shall be kept to a minimum and all "Tee", "Cross" and "Ell" joints shall be factory produced or prepared at the Contractor's field shop to the satisfaction of the Engineer. The equipment used for making field joints in polyvinyl chloride waterstops shall be furnished by the Contractor and shall be as approved by the Engineer.

All joints shall be made with a temperature controlled apparatus as specified by the manufacturer and in such a manner as to ensure :

- that the material is not damaged by heat, searing or by the application of cementing materials;

- that the splices have a tensile strength not less than 80% of that required of the specified material;
- that the splice is watertight; and
- that the ribs and central bulb, where applicable, match up exactly and are continuous.

For the waterstop strips which are to be placed at contraction joints, close attention is required to see that they are properly embedded. The waterstops shall be installed with equal widths of the material embedded in the concrete on each side of the joint. The concrete shall be carefully placed and vibrated around the waterstops to ensure that the waterstops are not damaged and a complete bond is secured between the concrete and all embedded areas of the waterstops. After installation and before embedment in concrete, the waterstop shall be protected from the direct rays of the sun.

The Contractor shall replace or repair, at his expense, any waterstops torn, punctured or otherwise damaged before final acceptance of the work.

The Contractor shall provide all necessary supports and ties required for placing the waterstops and protect them from damage, deterioration or warping during the progress of work.

The water tightness of joints and structures for which waterstops are provided shall be the Contractor's responsibility. The Contractor shall supply all materials and labour and perform all the work necessary to rectify leaking joints and structures to the Engineer's directions and satisfaction.

3.14 Measurement and Payment

3.14.1 Concrete and mortar

Measurement, for payment, of concrete or mortar will be made on the basis of actual placed volume of concrete or mortar in cubic metres within the neat lines of the structures as indicated on the Drawings or as otherwise established by the Engineer.

Measurement of concrete against the sides of any excavation without the use of intervening forms shall be made only within the pay lines or designated lines of the structure. No deduction shall be made for rounded or beveled edges or space occupied by metal work, electrical conduits, nor for voids or embedded items which are less than 0.05 m² in cross section.

Payment shall be made for the number of cubic metres measured as provided above at the respective unit prices per cubic metre stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit prices for concrete or mortar shall constitute full compensation for the cost of all labour, tools, equipment, and materials, which are the cost of cement, water, preparation of joints, handling and incorporating the cement and admixtures into the work, transportation of aggregates from specified stockpile yard or elsewhere to the Site, including furnishing, loading, hauling, unloading, stockpiling, mixing, placing the concrete or mortar, placing in joints, treatment of joints, curing, testing as specified and all other items necessary to complete the works.

Payment will not be made for concrete required to be placed outside the designated lines beyond the excavation paylines due to over excavation or for any other reason, except as otherwise provided. No payment will be made for defective and wasted concrete or mortar. Any concrete which the Contractor places or uses for his own installations or on his own initiative, shall be at the expense of the Contractor.

3.14.2 Formwork

Measurement, for payment, of formwork for concrete will be made of the area in square meters of formed surfaces of concrete as shown on the Drawings or as directed by the Engineer. The measurement will include sloping surfaces steeper than 1 vertical to 2 horizontal, the formed surface of contraction joints and construction joints shown on the Drawings or directed by the Engineer and the formed surfaces of blockouts larger than 0.1 m² in cross-sectional area. The following surfaces will not be measured for payment for formwork :

- (a) Sloping surfaces not steeper than 1 vertical to 2 horizontal, whether formed or not.
- (b) Surfaces of materials, structures and installations which are required to remain in place after the concrete poured against them has hardened.
- (c) Formed surfaces of construction joints not shown on the Drawings.
- (d) Forms used to fill over-excavation.
- (e) Grooves and chamfers at joints and elsewhere.
- (f) Blockouts not larger than 0.1 m² in cross-sectional area.
- (g) Other surfaces as designated by the Engineer.

Payment for forms, and scaffolding where required, for concrete shall be made at the respective unit prices per square metre stated in the Bill of Quantities and duly certified by the Engineer in the

Bi-Monthly Statement of Account. The unit prices for formwork shall constitute full compensation for the cost of all labour, tools, equipment and materials required to perform the forming work including furnishing, transporting, fabricating, erecting, surveying, fixing, scaffolding work, dismembering, removing the form and all other items necessary to complete the works.

3.14.3 Reinforcing bars

Measurement, for payment, of reinforcing bars will be made on the basis of actual installed weight of steel bars in concrete for the Permanent Works in kilograms determined by the lengths and numbers of bars as shown on the Drawings or as directed by the Engineer, converted to weight for the size of bars listed by the use of unit weights per linear metre.

Steel in laps indicated on the Drawings or required by the Engineer shall be paid for at the unit price stated in the Bill of Quantities. No payment shall be made for the additional steel in laps and spacer or hanger bars which are authorized for the convenience of the Contractor.

Payment for reinforcement bars shall be made at the respective unit prices per kilogram stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit prices for reinforcing bars shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, bending, cutting, fabricating, cleaning, placing, supporting the bars and all other items necessary to complete the works.

3.14.4 Other miscellaneous items

(1) Expansion joint filler and bitumen coating

Measurement, for payment, of furnishing and installing expansion joint filler or bitumen coating will be made on the basis of actual installed or coated area in square metres determined by the dimensions as shown on the Drawings or as directed by the Engineer.

Payment shall be made for the number of square metres measured as provided above at the respective unit prices stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit prices for expansion joint filler or bitumen coating shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, fabricating, installing the expansion joint filler or coating and all other items necessary to complete the works.

(2) Waterstops

Measurement, for payment, of furnishing and placing the waterstops will be made on the basis of actual installed length of waterstops in place in linear metres determined by the locations, size and lengths as shown on the Drawings or as directed by the Engineer. In computing the quantities, no allowance shall be made for laps at splices, joints and intersections. Waterstops installed by the Contractor in construction joints in locations other than those shown on the Drawings or as directed by the Engineer will not be measured for payment.

Payment for furnishing and placing the waterstops shall be made for the number of linear metres measured as provided above at the respective unit prices stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit prices for waterstops shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, fabricating, installing, jointing the waterstops and all other items necessary to complete the works.

(3) Anchor bars and joint bars

Measurement, for payment, of anchor or joint bars will be made on the basis of actually set number as shown on the Drawings or directed by the Engineer.

Payment shall be made for the number of pieces measured as provided above at the respective unit prices per number stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit prices for anchor or joint bars shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, setting and all other items necessary to complete the works.

3.15 Gravel and Rubble Bedding

3.15.1 General

Gravel or rubble bedding shall be furnished underneath the levelling concrete for the foundation of concrete structures such as entrance and outlet aprons of the sluices to be built in the drainage channel.

Gravel or rubble bedding shall be made in accordance with the lines, grades and dimensions as

shown on the Drawings or as directed by the Engineer.

Materials to be used for gravel or rubble bedding shall be well graded, sound and hard. Size of the materials shall be combined as follows :

Maximum size : less than twenty (20) cm

Minimum size : more than ten (10) cm

The materials shall be natural angular stone selected from river deposits or quarry sites approved by the Engineer. The materials shall be placed and spread in layers with well graded blind materials and compacted by methods approved by the Engineer.

3.15.2 Measurement and payment

Measurement, for payment, of gravel or rubble bedding will be made on the basis of volume of gravel in cubic meters actually placed as shown on the Drawings or as directed by the Engineer.

Payment for gravel or rubble bedding shall be made at the unit price per cubic metre stated in the respective items of the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account.

The unit price for gravel or rubble bedding shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, subsequent mixing and placing the gravel or rubble stones and all other items necessary to complete the works.

3.16 Precast Concrete

3.16.1 General

This work shall consist of fabricating or procuring pre-fabricated concrete units such as precast concrete pipes, piles, beams, etc. and their installation at the Site, and the requirements of type, shape, size and grade in accordance with the Specifications and the Drawings or as directed by the Engineer.

If the Contractor decides to use such items, they can be either purchased from a reputable manufacturer or precast by the Contractor at the Site. If such items are purchased, they shall conform to the applicable standards, such as JIS A 5302-1975 for concrete pipe or equivalent

approved by the Engineer. If the Contractor decides to precast the items at the Site, the shall submit full details concerning such to the Engineer for approval at least forty five (45) days before commencing manufacture of the precast concrete units.

These details shall include the methods to be used in manufacturing the units such as type of prestress system, type of prestress wire or cable, size of aggregate, concrete mix, reinforcing steel, forming, placing, finishing, curing, handling, transport, storage, erection, etc. Upon receipt of such details, the Engineer will review them and if necessary will have the Contractor modify them until they are found to be satisfactory at which time they will be approved as specifications and incorporated herein. All precast concrete units manufactured by the Contractor shall comply with the approved specifications.

3.16.2 Manufacturing of precast concrete units

Precast concrete units shall be manufactured in the type 1 of concrete and to the sizes shown on the Drawings and the concrete shall comply in every respect with the provisions of these Specifications whether such precast concrete units are manufactured at the Site or are procured from approved manufacturers.

When casting concrete units, the concrete shall be placed continuously in the forms and compacted by vibrating, supplemented by spading and tamping, in a manner acceptable to the Engineer. The forms shall be overfilled and the surplus concrete shall be screeded-off.

Special care shall be exercised in tamping and vibrating the concrete so as not to displace the reinforcement. The concrete units shall be allowed to remain in their forms for three (3) days before being stripped, during which time the exposed face shall be covered with sacking or matting and kept constantly wet. In addition, sides of the forms shall be shielded from direct rays of the sun.

3.16.3 Curing of precast concrete units

After removal of the forms, the precast concrete units shall be kept moist continuously for a minimum period of eleven (11) days. After stripping, the concrete units shall be stacked for a period of not less than thirty (30) days before they are used for the work, unless otherwise permitted and approved by the Engineer. The precast concrete units shall be so stacked as to leave a free air space between each of these units. Each unit shall be clearly marked with the date of its casting.

3.16.4 Measurement and payment

Measurement, for payment, of the various items of precast concrete units will be made to the actual quantities of the respective works done in linear meters, square meters, cubic meters, numbers, pieces, tons or kilograms, etc. so measured as provided in the Bill of Quantities and duly certified by the Engineer.

Payment for the various items of precast concrete units shall be made at the unit prices per linear meter, square meter, cubic meter, number, piece, ton or kilogram and/or the lump sum price and to the actual volume of work so certified by the Engineer in the Bi-Monthly Statement of Account. The unit price of precast concrete units shall constitute full compensation for the cost of all labour, tools, equipment and materials including curing, stacking, furnishing, transporting, setting and installing at site and all other items necessary to complete the works.

4. PILING WORK

4.1 General

The Contractor shall supply all labour, materials, equipment and incidentals as necessary to furnish, install, drive and test piles of reinforced concrete, steel sheet and wooden piles as shown on the Drawings.

Piling work consists of furnishing and driving precast reinforced concrete piles for the foundation of sluiceways, parapet walls, and bridges; steel sheet piles for parapet walls, revetment works in drainage channels and for the foundation of concrete sluiceways; and wooden piles for wet rubble masonry and gabion, if any. The Work shall be completed in accordance with these Specifications and in reasonably close conformity with the lines, grades and dimensions shown on the Drawings or at the location and depth established by the Engineer. Types of concrete piles, steel sheet piles and wooden piles to be used are indicated on the Drawings or in these Specifications. Although number, penetration depth and length of piles shown on the Drawings are of estimate to give the required bearing value or required functions, the actual number, penetration depth and length of piles shall be finally confirmed by the Engineer through geotechnical investigation or test piling conducted by the Contractor.

The pile length and penetration depth established by the Engineer based on the results of test piling and/or geotechnical investigation shall supersede all other requirements precedingly set forth for the penetration of piles.

After the above parameters have been finalized, the Contractor shall submit to the Engineer for approval his detailed plans for pile manufacturing, pile driving equipment, pile driving method including pile arrangement, construction time schedule and quality control programme at least thirty (30) days prior to the commencement of pile manufacturing.

4.2 Handling and Pitching of Piles

The Contractor shall take all necessary precautions to prevent damage to piles and components when manufacturing, handling, transporting, storing, pitching or driving piles. Piles damaged by improper handling, transportation or storage shall be rejected and replaced by the Contractor at his own cost.

The Contractor shall employ an engineer qualified of and experienced in this type of work who shall establish required lines, levels and pitching. The Contractor shall be responsible for the correct locations of piles. Piles shall be located and staked out by the Contractor and the Contractor shall maintain all location staked 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 ensure that pile driving operations have not caused movement of the stakes.

During and after completion of piling, the pile head shall not be more than fifteen (15) cm off-centre in any one direction from its required position.

4.3 Pile Driving

4.3.1 Pile driving equipment

Before bringing any pile driving equipment to the Site, the Contractor shall submit to the Engineer for approval particulars of the equipment and driving methods which the Contractor proposes to use.

Piles may be driven with steam, air, vibration, gravity, or diesel hammers. When diesel hammers or any other types requiring calibration are used, they shall be calibrated with proper measures approved by the Engineer.

Any gravity hammer used for driving steel sheet piles shall weigh not less than the combined weight of the driving head and pile. The drop height shall be regulated so as to avoid injury to the pile and in no case shall exceed 4.5 m for steel piles. When gravity hammer is permitted for driving concrete piles, it shall have a weight not less than fifty (50) percent of the weight of the pile, and the drop of the hammer shall not exceed 2.4 m.

Pile hammers, steam, air, vibration or diesel hammers except gravity hammers, shall be approved by the Engineer, which develop sufficient energy to drive the piles at a penetration rate of not less than 3.2 mm per blow at the required bearing value. When steam, air or diesel hammers are used, the total energy developed by the hammer shall be not less than 1,000 m-kg per blow, except as specified below for concrete piles.

Steam, diesel, or air hammers used for driving concrete piles shall develop an energy per blow at each full stroke of the piston of not less than 625 m-kg per cubic metre of concrete pile driven. No

driving of piles shall be done within a distance of six (6) m from concrete structures which are less than four (4) days in age after placing.

Timber piles, at all stages during driving and until their incorporation in the super structure shall be adequately supported and restrained by means of leads, trestles, temporary supports or other guide arrangements to maintain their position and alignment and to prevent failure due to bending or buckling. The arrangements shall be such that damage to the pile, pile head and preservative treatment shall not occur.

Concrete and steel sheet piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or steel braces to insure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads, preferably, shall be of sufficient length to make the use of a follower unnecessary, and shall be so designated as to permit proper placing of battered piles.

4.3.2 Driving piles

In general, full-length piles shall be used. In exceptional circumstances, splicing of piles may be permitted. The method of splicing shall be as shown on the Drawings or as directed by the Engineer.

The driving of piles with followers shall be done only under written permission of the Engineer.

Concrete and wooden piles shall be driven as shown on the Drawings or as ordered by the Engineer. They shall be driven with an allowable variation of twenty (20) mm of pile length from the vertical or from the batter shown on the Drawings. The maximum allowable variation at the head of piles shall be seventy five (75) mm in any direction from the location shown on the Drawings or as directed by the Engineer. The inclination of piles shall be within \pm two (2) percent from the line designated on the Drawings.

The heads of all concrete and wooden piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design preferably having a rope or other suitable cushion next to the pile head and duly approved by the Engineer.

The head shall be shaped or chamfered to prevent splitting at its periphery.

For special types of piling, driving heads, mandrel, or other devices in accordance with the manufacturer's recommendation shall be provided so that the pile may be driven without injury.

Steel sheet piles shall be pitched and driven accurately in the position shown on the Drawings and to the required depths as directed by the Engineer. The piles shall be pitched inside a braced template and carefully aligned and positioned before driving. The piles shall then be driven to the required penetration in such a manner as to ensure that the verticality of the piles is maintained. In the event of any lean or tilt developing during driving, the Contractor shall take appropriate action to correct the condition during driving. Piles driven in excess of the tolerances specified herein or damaged during driving may be rejected, if in the opinion of the Engineer, the improperly aligned or damaged pile adversely affects the structure. The Contractor shall propose the corrective measures to be taken for approval by the Engineer. All corrective measures shall be at the Contractor's own expense. Rejected piles shall be extracted, redriven or replaced or cut-off at a level approved by the Engineer.

The maximum allowable variation at the head of piles shall be one hundred and twenty (120) mm in any direction from the location shown on the Drawings or as directed by the Engineer.

4.3.3 Defective piles

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing crushing and spalling of the wood, concrete or deformation of the steel. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, will not be permitted. Any pile damaged by reason of internal defects, or by improper driving or driven out of its proper location or driven below the elevation fixed on the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question :

- (1) The pile shall be withdrawn and replaced by new and if necessary, a longer pile.
- (2) A second pile shall be driven adjacent to the defective or low pile.
- (3) The pile shall be spliced or built up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

A concrete pile will be judged as defective if it has a visible crack or cracks extending around the

entire periphery of the pile or any defect which, in opinion of the Engineer, affects the strength or life of pile.

4.4 Precast Concrete Piles

4.4.1 Manufacturing, handling and storing

Type 1 concrete specified in Sub-clause 3.5.2 of Chapter 3, Concrete Work, of the Technical Specifications shall be used for all kinds of precast concrete piles. Dimensions of the piles, material and arrangement of reinforcing bars, etc. shall be as shown on the Drawings. All manufacturing works of the precast concrete piles, except those specified herein, shall be in accordance with the applicable provisions stipulated in Chapter 3, Concrete Work, of the Technical Specifications.

Forms shall be true to line and built of metal, plywood, or dressed lumber. Forms shall be watertight and shall not be removed for a period specified in Clause 3.12, Formwork, of the Technical Specifications.

Forms shall be rigid or supported rigidly not to be damaged or deformed during casting, compacting and curing of concrete. Forms shall be accessible for tamping and consolidation of the concrete.

Reinforcing bars shall be formed into a cage which shall be positioned accurately in forms and firmly fixed in centre of forms.

Steel shoe and steel cap shall be provided for each pile as shown on the Drawings or as directed by the Engineer.

Special care shall be taken to place concrete so as to produce satisfactory bond with the reinforcing bars and avoid the formation of stone pockets, honey-comb or other such defects.

To secure uniformity and remove surplus water, the concrete in each pile shall be placed continuously and shall be compacted by vibrating or by other means acceptable to the Engineer. The forms shall be overfilled, the surplus concrete screeded off, and the top surfaces finished to a uniform, even texture similar to that produced by the forms.

Immediately after the completion of concrete placing and finishing operation, the top surface of

piles shall be covered with wet cotton mats. The wet cotton mats shall remain in place until the side forms are removed. When the side forms are removed, the entire portion of piles shall be covered with wet cotton mats or other suitable means to keep the pile in wet condition throughout the curing period.

Test cylinders shall be made and tested to estimate the compressive strength of concrete piles casted.

Piles shall not be removed from the forms until eighty (80) percent of the design 28-day compressive strength is obtained, and they shall not be transported or driven until the design 28-day compressive strength is obtained.

During the curing period, piles shall remain in the original position on casting platforms, and shall not be moved or shifted in any manner. The method of storing and handling piles shall be such as not to fracture piles by impact or undue bending stress while being stored or handled. Unless otherwise specified, concrete piles shall be handled by means of a suitable bridle or sliding attached to pile. When concrete piles are lifted or moved, they shall be supported at the points shown on the Drawings or, if not so shown, they shall be supported at such points that will not cause any damage.

After the requirement of strength has been met with, piles may be moved for storing. The piles shall be stored on the adequate supports that will prevent undue stress in the piles as shown on the Drawings or as directed by the Engineer.

When the Contractor intends to use prestressed concrete piles, all raw materials for concrete and steel stipulated below shall be inspected by the Engineer and controlled through manufacture's laboratory.

Minimum compressive strength of concrete shall be 270 kg/cm^2 at both 28 days and driving. The steel materials should have the following requirements;

Prestrees steel breaking strength	15,460 kg/cm^2 for 7 mm dia.
Spiral steel	U-24 (dia. 4.20 and 5.58 mm)
Steel band	St 37, thickness = 2 mm
Steel joint plate	St 37, thickness = 19 mm
Tip plate	St 37, thickness = 3 mm

Production process which have been approved by the Engineer should be done in a factory. Each production lot of the prestressed concrete piles should be tested and the Factory Certificate should be issued for each production lot.

Before the Contractor purchases the prestressed concrete piles from the manufactures, the Contractor shall inform the Engineer in writing at least thirty (30) days before the commencement of the piling works the details of manufacturers and all the requirements of the prestressed concrete piles which the Contractor intends to purchase, for the Engineer's approval.

4.4.2 Recording of pile hammer blows

Number of hammer blows on concrete piles and penetration depth with each blow shall be recorded for confirmation of the bearing capacity of the strata. Unless otherwise directed by the Engineer, the Contractor shall provide suitable means of measuring, counting and recording of concrete piles under each hammer blow. For counting the number of blows, a digital counter or some other approved means of recording shall be provided. The elastic and plastic sets resulting from each blow may be recorded by using a fixed straight edge held against a sheet of paper affixed on the pile, and running a pencil along the straight edge at the moment of impact to record on the paper the elastic and plastic sets resulting from the blow. Based upon the pile driving records so made available, the Contractor shall calculate the bearing capacity of the strata encountered and report to the Engineer. The Engineer shall direct the Contractor either to terminate or to continue the pile driving till such time the desired bearing capacity is obtained.

4.4.3 Test piles

When required in the Specifications or by the Engineer, the Contractor shall drive the piles of designated length at locations ordered by the Engineer to ascertain the number and length of piles. These piles shall be of greater length than the length assumed in design in order to provide for any variation in soil conditions. The number of test piles will be decided by the Engineer, but this number shall not be less than one (1) and not more than three (3) for each foundation. The test loads on piles will be specified by the Engineer. The Contractor shall not manufacture or purchase the piles before the Engineer may approve the number and length of pile proposed on the result of test piles by the Contractor.

4.4.4 Static load test on test piles

Load test shall be made by the methods as directed by the Engineer. The Contractor shall submit

to the Engineer for his approval on the detailed procedures of the load test he intends to use. The load test apparatus shall be constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles.

Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor.

The apparatus shall have working capacity of three (3) times the design load directed by the Engineer for the pile being tested. Reference points for measuring pile settlement shall be sufficiently remote from the test pile to exclude all possibility of disturbance.

All pile load settlement shall be measured by adequate devices such as gauges, and shall be checked as and when ordered by the Engineer. Increments of deflection will be read just after each load increment is applied and at fifteen (15)-minute interval thereafter. The safe allowable load will be considered as fifty (50) percent of the load which, after forty eight (48) hours of continuous application, has caused not more than six and half (6.5) mm of permanent settlement, measured at the top of the pile.

A test load shall be twice the design load directed by the Engineer. The first increment of load to be applied to the test pile shall be the pile design load. The load on the pile shall be increased to twice the design load by applying additional loads in three (3) increments. A minimum period of two (2) hours shall intervene between the application of each increment except that no increment shall be added until a settlement of less than zero decimal one two (0.12) mm is observed for a fifteen (15)-minute interval under the previously applied increment.

If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by fifty (50) percent, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted. The full test load shall remain on the test pile not less than forty eight (48) hours. The full test load shall then be removed and the permanent settlement shall be read.

When requested by the Engineer, loading shall then continue beyond the double design load in ten (10)- ton increments until the pile fails or the capacity of the loading apparatus is reached, whichever is less. The pile may be considered to have failed when the total settlement under load exceeds two and half (2.5) cm or the permanent settlement exceeds six and half (6.5) mm.

After the completion of loading test, the load used shall be removed and the piles utilized in the

structure, if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilized similarly. If any pile, after serving its purpose as a test is found unsatisfactory for utilization in the structure, it shall be removed if so ordered by the Engineer or shall be cut-off below the ground line or footing, whichever is applicable.

The number and location of the piles to be submitted to load tests shall be decided by the Engineer, but this number shall be not less than one (1) and not more than three (3) for each foundation.

A report shall be prepared by the Contractor for the Engineer's decision on each load test, and this report shall be accompanied by the following documents :

- plan of the foundation;
- stratigraphy of the soil;
- calibrating curve of the gauges;
- graph of the test, having figures of the loads in (tons) and for ordinates the settlement in mm;
- table showing, as a function of the time (date and hour), the readings of the gauge in atmospheres, the loads in tons, the settlements and average of the settlements.

4.4.5 Extensions or build-ups

Extensions, splices or build-ups on concrete piles, when permitted or directed by the Engineer, shall be made as shown on the Drawings or in accordance with this Sub-clause.

After driving of the starter pile is completed and additional pile depth is required to be provided, pile cushion placed over the starter pile head shall be removed and steel cap shall be thoroughly examined for any damages to the pile head occurring during the course of its driving. If any damages are noticed, the same shall be repaired by welding or other approved means as directed by the Engineer. The surface of the steel cap shall then be thoroughly cleaned to receive the extension pile. The extension pile shall be provided with steel caps on its either end as shown on the Drawings. The cleaned surfaces of the two steel caps, i.e. the one at the head of the starter pile and the other at the lower end of the extension pile shall then be accurately aligned, matched and butt welded on all the four sides as shown on the Drawings or as directed by the Engineer. During the course of its welding, the extension pile shall be accurately held in position by securing it to a derrick or by any other approved means.

4.4.6 Treatment of pile head

Pile heads of concrete piles for the tower part of sluiceways shall be embedded in concrete of raft of sluiceway structure whereas conduit part of the sluiceway shall be simply supported on the concrete pile head as shown on the Drawings.

For the pile heads to be embedded in concrete slab, pile shall be driven to such a depth that at least one thousand (1,000) mm of the pile length remains protruding above the levelling concrete surface as shown on the Drawings. After the driving is completed, all pile concrete one hundred (100) mm above the levelling concrete surface shall be cut-off, leaving reinforcing bars exposed. The exposed reinforcing bars shall then be bent and re-formed to mesh with sluiceway raft reinforcement as shown on the Drawings.

While cutting-off the concrete in the pile, care shall be taken not to damage the pile concrete below the cut-off level. Before placing concrete in the sluiceway raft, the chipped pile head shall be sufficiently moistened with water and smeared with a coat of neat cement mortar so as to ensure a proper bond with the pile and sluiceway concrete.

The piles which are not to be embedded in concrete, shall be driven to a depth which is the same as the top level of the levelling concrete surface. Raft of the conduit part of sluiceway shall be cast around and over the pile head in such a manner that no bond develops between the sluiceway concrete and the pile head.

4.4.7 Measurement and payment

Measurement and payment for prestressed concrete piling work shall be made on the basis of numbers for furnishing piles and on the basis of linear meters for driving piles separately.

(1) Measurement and payment for furnishing piles

Measurement, for payment, of furnishing prestressed concrete piles will be made on the basis of numbers of piles furnished in accordance with the pile length designated by the Engineer.

Payment shall be made at the unit price per number stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit price for furnishing piles shall include full compensation for furnishing piles and all materials required for placement, including all labour, tools, hauling equipment, handling, treatment and all other work incidental to

the construction of piles prior to driving.

(2) Measurement and payment for driving piles

Measurement, for payment, of driving prestressed concrete piles will be made on the piles driven and accepted all in accordance with the Drawings and the Specifications and indicated in the Bill of Quantities measured from the pile tip to the bottoms of the pile caps. No allowance shall be made for cut-offs. Any additional pile lengths that may be necessary to suit the Contractor's method of operation or for any other reason shall not be included in the measurements. Splicing of piles when allowed will not be measured or paid for directly but the cost thereof shall be considered as included in the unit price for piling.

Payment for prestressed concrete piling measured as provided above shall be made at the unit price per linear meter indicated in the Bill of Quantities, which unit price shall include the cost of all materials, labour and Construction Plant and Equipment, delivering, handling, storing and driving concrete piles and for other incidentals necessary to complete the work in accordance with the Drawings, Specifications or as directed by the Engineer.

When it is necessary to increase the length of prestressed concrete piles, whenever it has been directed by the Engineer prior to or after driving, the Contractor shall not be entitled to any additional allowance above the unit price per linear meter tendered in the Bill of Quantities, and the Contractor shall include such additional cost, if any, to his tender price.

Measurement and payment for precast reinforced concrete piling work shall be made on the basis of linear metres for furnishing piles and for driving piles separately.

(3) Measurement and payment for furnishing piles

Measurement, for payment, of furnishing precast reinforced concrete piles will be made to the total length of piles in linear metres furnished in accordance with the pile length designated by the Engineer. Extra length such as the length cast by the Contractor for his convenience or other than those designated by the Engineer shall not be paid for. The length of extensions or build-ups shall be paid for, only when the length shown on the Drawings or designated by the Engineer is not sufficient and when the extension of piles is required by the Engineer. In such a case, the cut-off portion shall be subject to payment. The length of piles which are withdrawn or replaced as defective piles defined in Sub-clause 4.3.3 shall not be paid for.

Payment shall be made for the number of linear metres measured as provided above at the unit price per linear metre stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account.

The unit price for furnishing piles shall include full compensation for furnishing piles and all material required for placement, including all material necessary for extensions and built-ups for completion of piles and for all labour, tools, hauling equipment, handling, treatment and all other work incidental to the construction of the piles prior to driving or construction of extensions and built-ups.

(4) Measurement and payment for driving piles

Measurement, for payment, of driving precast concrete piles will be made to the total penetrated length of only those piles forming part of the completed structures. Extra penetration length other than those designated by the Engineer shall not be paid for. The penetrated length of piles which have been withdrawn or replaced by other piles as defective piles in accordance with the provisions stipulated in Sub-clause 4.3.3 shall not be paid for.

Measurement and payment will be made separately for those concrete piles whose heads are treated for embedment in concrete raft and for those piles on whom the concrete raft is cast without any treatment of the pile head.

Payment shall be made for the number of linear metres measured as provided above at the unit price per linear metre stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account.

The unit price for driving piles whose heads are treated for embedment in concrete raft shall include full compensation for furnishing all labour, tools, materials, equipment and other necessary or incidental costs of handling, driving, cutting-off piles, treatment of pile heads including cleaning, bending, re-forming and meshing of reinforcing bars with raft reinforcement and all other incidental work required to complete the piling work in all respects.

The unit price for driving piles on whom the concrete raft is cast without any treatment of pile head shall include full compensation for furnishing all labour, tools, materials, equipment and other necessary or incidental costs of handling and driving and all other work required to complete the piling work in all respects.

(5) Measurement and payment for false work and defective piles

No separate payment shall be made for the furnishing or driving of false work piles. No payment shall be made for piles driven out of place, or for defective piles, or for piles which are damaged in handling or driving.

(6) Measurement and payment for test piles

Measurement, for payment, of furnishing and driving test piles will be made on the basis of the number of piles for testing completed and accepted by the Engineer. It shall not include test piles furnished and driven at the option of the Contractor, unless such test piles comply fully with the requirements specified herein and are accepted by the Engineer as a part of the completed structure.

Payment for furnishing and driving test piles shall be made for the numbers as provided above at the unit price per number stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit price so stated shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, loading, hauling, unloading, storing, handling, driving and cutting the test piles; furnishing, supplying and setting testing apparatus; the cost of recording, analysis and reporting of each load test; and all other incidental items necessary to complete the works in accordance with these Specifications or instructions by the Engineer.

4.5 Steel Sheet Piles

4.5.1 Material

Steel sheet piles shall be of the type and dimensions indicated on the Drawings or designated by the Engineer and of the material required below. The piles, when in place in the completed structure, shall be practically watertight at all the joints and coated with red lead paint conforming to JIS K 5622 or AASHTO M 71 or as directed by the Engineer. Materials employed in this piling work shall be new and free from rust, oil or any other harmful materials. They shall be clearly finished, free from cracks, surface flaws, laminations and all other defects.

Steel sheet piles shall be of U-shaped type conforming to the requirements of Class 1 (YSPF) of JIS A 5528, SNI 0052-87-A or equivalent standard.

4.5.2 Execution of work

Full length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted. The method of splicing shall be as shown on the Drawings or as approved by the Engineer. When the splicing of steel sheet piles is done by welding, the arc method shall be given preference. The Contractor shall provide suitable temporary bracing and guide structures to ensure that the piles are driven in the correct alignment. The sheet piles shall be driven to the prescribed depth and extended to the designated elevation as shown on the Drawings or as directed by the Engineer.

Pile driving equipment to be employed shall be subject to the approval of the Engineer. Suitable protection cap shall be employed, when necessary or required in the opinion of the Engineer, to prevent damages at the pile head. Generally, the driving operations shall be made in accordance with applicable provisions stipulated in Sub-clause 4.3.2 hereinbefore.

After driving is completed, piles shall be cut off, if necessary, at the elevations shown on the Drawings or as directed by the Engineer.

The method used in driving piles shall not subject them to excessive and undue abuse producing deformation of the steel.

Manipulation of piles to force them into proper position, if considered by the Engineer to be excessive, will not be permitted. Any pile damaged, driven out of interlock with adjacent piles or driven below the elevation shown on the Drawings or designated by the Engineer, shall be corrected by the method approved by the Engineer, or withdrawn and replaced by new piles at the Contractor's own expense.

Except vibration driving method, the Contractor shall take the following records under the supervision of the Engineer : tip depth of pile, number of blows per ten (10) cm for the last fifty (50) cm penetration, per fifty (50) cm earlier for the last two (2) m penetration and per one (1) m before the last two (2) m penetration, accumulated number of blows and drop height of ram.

4.5.3 Measurement and payment

Measurement and payment for steel sheet piling work shall be made on the basis of square metres for furnishing piles and for driving piles separately.

(1) Measurement and payment for furnishing piles

Measurement, for payment, of furnishing steel sheet piles will be made on the total area of piles in square metres furnished in accordance with the pile length designated by the Engineer.

Payment shall be made for the number of square metres measured as provided above at the unit price per square metre stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account.

The unit price for furnishing piles shall include full compensation for furnishing piles and all materials required for placement, including all labour, tools, hauling equipment, handling and all other work incidental to the construction of the piles prior to driving.

(2) Measurement and payment for driving piles

Measurement, for payment, of driving steel sheet pile will be made on the basis of the actually installed area of wall made by steel sheet piles in square metres to the designed lines, grades and dimensions as shown on the Drawings or as directed by the Engineer.

Payment shall be made for the number of square metres measured as provided above at the unit price per square metre stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit price so stated shall include full compensation for the cost of all labour, tools, equipment and materials including handling, driving and cutting the steel sheet piles and all other items necessary to complete the works. No payment shall be made for the material cut-off.

4.6 Wooden Piles

4.6.1 Material

Wooden piles shall be made from a tree planted in Indonesia and conforming to AASHTO M 168 Standard, SII 0404-80 or as directed by the Engineer.

The wooden piles shall be free from defects deleterious to their strength and durability, such as knots, rotten knots and cracks, etc. Well seasoned timber shall be used for piles. All branch knots shall be carefully trimmed. The pile tip shall be sawed in a conical shape and the tip angle shall be varied according to the ground conditions encountered at site. The pile head shall be cut at right

angles to the centre line of the pile. The pile head shall have a circular finish so that a steel ring can be set to prevent damages to the pile head during pile driving.

4.6.2 Extensions or build-ups

As far as possible, piles shall be provided in one piece unless otherwise approved by the Engineer. Where approved for extension or build-ups, the splice shall be capable of resisting safely any stresses which may develop during lifting, pitching or driving, and under the designed working load. The position and details of the splice shall be subject to the approval of the Engineer. Two (2) timber to be spliced shall be of the same cross-sectional dimensions and each cut at right angles to its axis to make contact over the whole of the cross-section when each length is co-axial. An approved jointing shall be used at the contact surface. The two (2) timber lengths shall be joined by a steel tube of round or rectangular section to fit the timbers closely. The tube shall be bolted, screwed or spiked to the timbers to keep the joined ends in close contact. All loosely jointed timbers shall be rejected and not paid for.

4.6.3 Measurement and payment

Measurement, for payment, of furnishing and driving wooden piles forming part of the completed structures will be made on the basis of total penetrated length of actually installed wooden piles in linear metres to the designated lines, grades and dimensions as shown on the Drawings or as directed by the Engineer.

Payment shall be made for the total penetrated length of wooden piles furnished, installed and forming part of the completed structures, by the Contractor and measured as provided above at the unit price per linear metre stated in the Bill of Quantities and duly certified by the Engineer in the Bi-Monthly Statement of Account. The unit price so stated shall include full compensation for the cost of all labour, tools, equipment and materials including furnishing, handling, storing, driving and cutting the wooden piles and all other items necessary to complete the works. No payment shall be made for extra length of wooden pile cut-off. The penetrated length of piles which have been withdrawn or replaced by other piles as defective piles in accordance with the provisions stipulated in Sub-clause 4.3.3 hereinbefore will not be paid for.

5. DRAINAGE STRUCTURAL WORKS

5.1 General

This Chapter covers the following works :

- 1) Slope protection
- 2) Foot protection
- 3) Sluiceway
- 4) Parapet wall
- 5) Drainage
- 6) Relocation of drainage pipe and canal

The Contractor shall furnish all materials, manpower and equipment required for completion of the above works until the time specified in the Contract Agreement and/or the issuance of Certificate of Satisfaction by the Engineer.

5.2 Slope Protection

5.2.1 General

Revetment for this Project is typified into two (2), that is, wet rubble masonry type and gabion type revetment, as shown on the Drawings. The wet rubble masonry type of revetment are further sub-typified into two (2) types, viz, Type I, and Type II.

All types of the revetments except gabion type are provided with weep holes.

The works covered under this Clause comprise of general work items required to be carried out in connection with excavation; filling/backfilling with approved granular material; piling of all kinds including timber, concrete and steel sheet piles; gravel bedding; levelling concrete; concrete slabs and concrete wall, if any; wet rubble masonry; PVC pipes and geo-textile for weep holes; gabion; etc. for every kind of slope protection work for this Project.

All work shall be done in strict conformity with the Drawings, applicable provisions in these Specifications and as directed by the Engineer.

5.2.2 Execution of work

Prior to construction of the revetment, the Contractor shall provide cofferings with suitable materials such as steel sheet piles, wooden piles with bamboo or wooden panels, sand bags, vinyl sheets, etc., surrounding the foundation of revetments, and sufficient number of dewatering pumps so as to enable to perform the foundation work in dry conditions in accordance with the requirements stipulated in Chapter 1, Temporary Works : Coffering Works, Care of Watr and Dewatering Works of these Technical Specifications. The Contractor shall take all suitable measures to drain out water either by pumping or gravity flow and digging temporary diversion trenches in addition to the cofferings.

(1) Concrete wall type revetment, if any

Sloped surface of the levee on which concrete revetment is to be constructed shall be formed and neatly finished to the lines and grades as shown on the Drawings. Foundation excavations for the wall shall be completed between joint to joint. Levelling concrete ten (10) cm thick shall then be placed in the foundations of the wall. The levelling concrete shall be of type 5.

Concrete wall with type 4 concrete shall be constructed on the levelling concrete placed in the foundations as shown on the Drawings or as directed by the Engineer.

If a depression is created on the slope of the levee during the above operations, the Contractor shall backfill it with approved materials as directed by the Engineer.

PVC pipes of fifty (50) mm in internal diameter with geo-textile packing at the earth side, as shown on the Drawings shall be provided at the specified spacing and of the required length as directed by the Engineer to serve as weep holes.

(2) Wet rubble masonry type revetment

Sloped surface of the levee on which wet rubble masonry revetment is to be constructed shall be formed and finished neatly to the lines and grades as shown on the Drawings. Wooden piles, ϕ 150 to 180 mm and three (3) m long, shall be driven at an interval of two (2) m. Gravel bedding twenty (20) cm thick shall be placed on the finished slope surface. Levelling concrete of ten (10) cm in thickness shall then be placed on the foundation excavated as shown on the Drawings. The levelling concrete shall be of type 5.

If a depression is created on the slope of levee, the Contractor shall backfill it with approved material. The backfilling shall be performed in such a way that the surface of the side slope is excavated in the shape of a step and all of dust and grass are removed. Approved material is then spread in horizontal layers with thickness not exceeding twenty (20) cm and sufficiently compacted by mechanical tamping to the satisfaction of the Engineer.

The rubble stone shall be placed over the foundation concrete by hand and voids between stones shall be filled completely with cement mortar. Thickness of a rubble layer shall vary as shown on the Drawings. Construction of the wet rubble masonry shall be done in accordance with the applicable provisions stipulated in Chapter 10, Miscellaneous Works.

Foundation concrete of type 4 at the foot of the rubble masonry revetment and partition wall concrete of type 4 shall be constructed as shown on the Drawings or as directed by the Engineer.

Contraction joints with rubber joint fillers of ten (10) mm in thickness shall be provided at an interval of ten (10) m in a longitudinal direction. PVC pipes, fifty (50) mm in internal diameter with required length of geo-textile packing at the earth side, shall be provided in the masonry as weep holes in every four (4) m² of surface area or as shown on the Drawings or as directed by the Engineer.

Foot of the wet rubble masonry type revetment shall be protected by gabion matters, 3.0 m x 1.5 m x 0.5 m, with cobble/rubble filling as shown on the Drawings.

(3) Gabion revetment

Sloped surface of earth levee on which gabion revetment is to be constructed shall be formed and finished neatly to the lines and grades as shown on the Drawings. All depressions created on the slope shall be backfilled by the Contractor in the approved manner or as directed by the Engineer.

Geo-textile of approved quality shall be laid over the finished slope as shown on the Drawings or as directed by the Engineer. Gabion, three hundred (300) cm long, one hundred and fifty (150) cm wide and fifty (50) cm thick shall then be laid over the geo-textile previously placed over the slope.

Construction of gabion shall be done in accordance with the applicable provisions stipulated in Chapter 10, Miscellaneous Works.

All earthwork, concrete work, piling work and miscellaneous work related to the construction of

the revetment shall be done in accordance with the applicable provisions in Chapter 2, Earthwork, Chapter 3, Concrete Work, Chapter 4, Piling Work and Chapter 10, Miscellaneous Works.

5.2.3 Measurement and payment

Measurement and payment for the construction of slope protection works of the revetments will be made under the separate work items stated in the Bill of Quantities.

5.3 Foot Protection

5.3.1 General

The works covered under this Clause consist of general items required in connection with filling up with rubble stones, driving of wooden piles to fix gabion and placing gabion at the foot of revetment in drainage channels. All works shall be done in strict conformity with the Drawings, applicable provisions in these Specifications and instructions given by the Engineer.

5.3.2 Execution of work

Wooden piles of fifteen (15) cm in diameter shall be driven at the bottom of wet rubble masonry type revetment into the required depth and at spacing shown on the Drawings or as directed by the Engineer. Then, the foot of the revetment shall be covered by the rubble stones and gabion mattress to the elevation as shown on the Drawings. The gabion without rubble stone shall be set in the proper position. The empty gabion shall be filled with rubble stone and fixed with steel wire net cover in accordance with provisions stipulated in Chapter 10, Miscellaneous Works.

5.3.3 Measurement and payment

Measurement and payment for the foot protection works will be made under the separate work items stated in the Bill of Quantities.

5.4 Sluiceway

5.4.1 General

The works covered under this Clause consist of the general items in connection with demolishing existing structure; concrete piling in the foundation of sluiceways; steel sheet piling for cut-off

walls of sluiceways; constructing sluiceways and revetments; backfilling with selected material; manufacturing and installing gates including guide frames and hoists, miscellaneous metal work and wooden stoplogs, etc. for sluiceways to be newly constructed, extended or modified.

All works shall be done before the commencement of embankment of the levee and in strict conformity with the Drawings, applicable provisions in these Specifications or instructions given by the Engineer.

5.4.2 Execution of work

Prior to the commencement of sluiceway construction, the Contractor shall confirm their locations, alignments, lines and elevations as shown on the Drawings by using the nearest BPM, CP and bench marks of sluiceways, only referring to X and Y coordinates. After confirming the above works, the Contractor shall provide coffering for the area to be occupied by the sluiceways in accordance with the provisions stipulated in Chapter 1, Temporary Works : Coffering Works, Care of Water and Dewatering Works, of these Technical Specifications.

After the completion of foundation excavation for sluiceways, concrete piling and steel sheet piling, if any, shall be made to the lines and elevations as shown on the Drawings according to the provisions stipulated in Chapter 4, Piling Works, of these Technical Specifications.

Levelling concrete of type 5 shall be placed under the sluiceways. Concrete type of main body of sluiceways shall be of type 4, except in blockouts which shall be of type 3. Concreting in the sluiceways shall be made in conformity with the applicable provisions stipulated in Chapter 3, Concrete Works, of these Technical Specifications.

Inlet and outlet channels with wet rubble masonry shall be constructed at both ends of sluiceways in conformity with the requirements stipulated in Clause 5.2 hereinbefore.

The existing drainage facilities shall also be extended and/or modified at places where the levee construction will be heightened therewith. The extension and/or modification works shall be carried out as shown on the Drawings or as directed by the Engineer. The Works shall be carried out without disturbing the present function of the drainage facilities. Interruptions to the functioning of the existing facilities shall be kept to the minimum while carrying out the extension, modification and/or joining works. The Contractor shall furnish his plans for execution of the works for approval of the Engineer prior to the commencement of any of his activities for the works.

The extension and/or modification works shall be carried out in accordance with the provision of Chapter 2, Earthwork, Chapter 3, Concrete Work, and Chapter 4, Piling Work, of these Technical Specifications.

The existing sluiceway facilities on the abandoned levee, if any, shall be demolished or left as they are when directed by the Engineer. In case the new levee is to be constructed on the land side of abandoned old levee, the levee and the existing sluiceway facilities shall be demolished. However, this demolishing shall be done only after the completion of new levee and new sluiceway facilities and when directed by the Engineer to do so.

Drainage channels, drain ditches and cross drains shall be constructed in conformity with the applicable provisions stipulated in Chapter 2, Earth Work, and Chapter 3, Concrete Work, of these Technical Specifications.

Manufacturing and installing the gates including guide frames and hoists, steel ladders, wooden stoplogs, steel access bridge, etc., shall be made in conformity with the requirements stipulated in Chapter 8, Gates and Related Hydromechanical Equipment, Chapter 9, Other Metal Work, and Chapter 10, Miscellaneous Works, of these Technical Specifications.

5.4.3 Measurement and payment

Measurement and payment for the construction of sluiceways will be made under the separate work items stated in the Bill of Quantities.

5.5 Parapet Wall

5.5.1 Classification

The reinforced concrete parapet wall for the drainage channel is classified into the following two types for this Project :

- Reverse T-type reinforced concrete wall with the height of wall ranging from 1.0 m to 1.5 m
- L-type reinforced concrete wall with the height of wall ranging from 1.81 m to 1.85 m.

5.5.2 Execution of work

Reinforced concrete for the parapet wall shall be watertight. All reinforced concrete for the footing shall be placed over a ten (10) cm thick layer of levelling concrete of type 5.

All earthwork required for excavation and backfill, concrete work and piling work shall be made in accordance with Chapter 2, Earth Work, Chapter 3, Concrete Work and Chapter 4, Piling Work, respectively of these Technical Specifications.

Before carrying out any excavation, the Contractor shall take all necessary precautions for the diversion and care of water in accordance with Chapter 1, Temporary Works : Coffering Works, Care of Water and Dewatering Works, of these Technical Specifications.

5.5.3 Measurement and payment

Measurement and payment of the parapet wall will be made under the separate work items stated in the Bill of Quantities.

5.6 Drainage

5.6.1 General

The work under this Clause consist of the construction of drains with concrete pipes, steel pipes, plastic pipes, drain ditches and drain pits as a part of the various permanent structures.

The Contractor shall furnish all materials required for drainage. The pipe to be used for drains shall be subject to the approval of the Engineer.

Care shall be taken to avoid clogging drains during the progress of the work, and if should any drain become clogged or obstructed from any cause before final acceptance of the Work, it shall be cleaned out in a manner approved by the Engineer or replaced by and at the expense of the Contractor. No pipe which has been damaged shall be used for the Work.

5.6.2 Drains with concrete pipe, if any

The Contractor shall construct drains with reinforced or plain concrete pipes in the location as shown on the Drawings or as directed by the Engineer.

All concrete pipes to be used for drains shall be subject to the approval of the Engineer and shall be constructed with closed joints as shown on the Drawings or as directed by the Engineer.

The items of the Bill of Quantities for cross drains with concrete pipe shall be constructed in the following manner;

Pipe Description	Construction Sequence
600, 800 and 1000 millimeter-diameter reinforced concrete with collar joints, in cross drain for access road.	Excavated trench, place rubble bedding, cover with random backfill and compaction.

Measurement, for payment, of drains constructed with concrete pipes will be made to the length along the centerline from end to end of the pipe in place, and no allowance will be made for joints.

Payment shall be made at the unit price per linear meter tendered therefor in the Bill of Quantities, which unit price shall include the cost of furnishing and installing concrete pipe with jointing, rubble stone and sand bedding, random backfill, compaction and other works required. Provided, that payment for trench excavation shall be made separately under the appropriate items in the Bill of Quantities.

5.6.3 Drains with steel pipe

All steel pipe to be used for drains shall be subject to the Engineer's approval for their quality and thickness and shall be furnished and installed as shown on the Drawings or as directed by the Engineer.

Pipe shall be placed to the prescribed lines and grades. Joints of pipe shall be connected with appropriate couplings or connectors to provide watertight connections or as approved by the Engineer. Drains with steel pipe shall be constructed in the following manner;

Pipe Description	Construction Sequence
75 or 100-millimeter-diameter steel pipes, with screen plates and head plates, for draining slab in bridge	Install in concrete, weld head plates and screen plates.

Measurement, for payment, of steel pipe of 75 or 100-mm-diameter with or without screen plates and head plates for draining the deck slab in the bridge will be made at the number of set of the pipe with accessories installed.

Payment shall be made at the unit price per number tendered thereof in the Bill of Quantities, which unit price shall include all the cost to complete the work.

5.6.4. Drains with plastic (PVC) pipe, if any

Plastic pipe to be used for drains shall be furnished and installed to the prescribed line and grades as shown on the Drawings or as approved by the Engineer. Drains with plastic pipe shall be constructed in the following manner,

Pipe Descriptions	Construction Sequence
50-millimeter-diameter plastic pipe, for weep holes in concrete walls and wet rubble masonry wall.	Pipe shall be set into the slope surface at least 5 cm deep before placing concrete and embedded in concrete wall or wet rubble masonry.

Measurement, for payment, of drains with plastic pipe will be made for the length of pipes in linear meter in place.

Payment for drains with plastic pipe shall be made at the unit prices per linear meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all works and materials required.

5.6.5 Drain ditches and drain pits, if any

The Contractor shall perform excavation, fill or backfill, and concrete work to construct drain ditches and drain pits to the lines, grades and dimensions as shown on the Drawings or as directed by the Engineer.

Drain ditches and drain pits will be made of reinforced concrete or non-reinforced concrete as shown on the Drawings and the materials used shall conform to the requirements of Chapter 3, Concrete Work.

Measurement, for payment, of drain ditches will be made for the length in linear meters for the ditches constructed as shown on the Drawing or as directed by the Engineer. Payment will be made at the unit prices tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all work and concrete, formwork, reinforcements and other materials required. Provided, that payment for trench excavation will be made separately under the appropriate items of the Bill of Quantities.

Measurement, for payment, of drain pits will be made for the number of each pit actually constructed. Payment shall be made at the unit prices per each drain pit tendered in the Bill of Quantities, which unit prices shall include the cost of all work, materials, excavation, backfilling and disposal of excavated material required.

5.7 Relocation of Drain Ditches and Pipes, if any

5.7.1 General

The existing drain ditches and pipes shall be relocated at places where the levee construction intersects therewith. The relocation works including cutting, extension and joining of ditches and pipes shall be carried out as shown on the Drawings or as directed by the Engineer.

The relocation works shall be carried out without disturbing the present hydraulic conditions of such ditches and pipes. Interruptions to the functioning of existing works shall be kept to the minimum while carrying out cutting, extension and joining works. The Contractor shall furnish his plans for execution of the work for approval of the Engineer prior to the commencement of any of his activities for relocation works.

The relocation work shall be carried out in accordance with the provision of Chapter 2, Earthwork and Chapter 3, Concrete Work, of these Technical Specifications.

5.7.2 Measurement and payment

Measurement and payment for the relocation of drain ditches and pipes shall be made under separate work items stated in the Bill of Quantities.

6. CONCRETE BRIDGE WORK

6.1 General

The work specified in this Chapter consists of concrete structures including foundation, piers, abutments, revetments, piling, etc., and all other structural portion of the concrete bridge to be constructed in reasonably close conformity with the lines, grades and dimensions shown on the Drawings or established by the Engineer.

All road and pedestrian bridges shall be constructed of a simple supported slab type with precast concrete main girders by means of pre-tension method or in situ concrete slab. After the installation of all main girders on the substructure at the Site, filling concrete of type 2 shall be placed into the spaces between the adjacent girders and transverse tendons shall be tensioned at the stress specified by the Engineer.

All concrete bridge works except those specified herein shall be carried out in accordance with the applicable provisions stipulated in Chapter 3, Concrete Work, of these Technical Specifications.

The works include any incidental work called for in these Specifications and on the Drawings. The works will also include the detailed designs and drawings to be prepared by the Contractor and their subsequent approval by the Engineer in accordance with Clause G3.2, Drawings to be Furnished by the Contractor, of Vol. III, Part I - General Specifications.

6.2 Drawings

Based on the Contract Drawings, these Technical Specifications and site investigations to be carried out by the Contractor, the Contractor shall review the Contract Drawings, and prepare detailed drawings for any portion of the structures not indicated on the Contract Drawings.

Design of temporary structures necessary for the work shall also be completed by the Contractor.

The Contractor shall submit copies of the detailed construction drawings to the Engineer for approval at least thirty (30) days prior to the commencement of work. Any work done prior to the approval of the construction drawings shall be at the Contractor's risk. When material must be ordered in advance specific approval of the Engineer of such an action shall be obtained by the Contractor prior to placing the order. Construction drawings for concrete structures shall give full

dimensions and sizes of all component parts of the structure and details of all miscellaneous work such as bolts, railings, ramps, drains, etc., associated with the bridge work.

The Contractor shall expressly understand that the Engineer's approval of the construction and working drawings submitted by the Contractor shall not relieve the Contractor from any of his responsibility for the correctness and accuracy of the whole or any part of the structure.

6.3 Materials

6.3.1 General

Unless otherwise specified, materials shall meet the requirements of the following standards of their latest editions. The Contractor shall, if required, furnish complete certified mill test reports showing chemical analysis and physical tests for each heap of steel and for all members. The Engineer may accept materials with characteristics which he considers equal or higher in grade/class to those required.

6.3.2 Steel materials

- | | | |
|------|--|------------------------------|
| (1) | Rolled steel for general structures | JIS G 3101 |
| (2) | Rolled steel for welded structures | JIS G 3106 |
| (3) | High strength bolt sets (set of high strength hexagonal bolt, hexagonal nut and plain washers for frictional grip joint) | JIS B 1186 |
| (4) | Set of hexagonal bolt, hexagonal nut and plain washers | JIS B 1180 and
JIS B 1181 |
| (5) | Electrodes | |
| | (a) Covered electrodes for mild steel | JIS Z 3211 |
| | (b) Covered electrodes for high tensile strength steel | JIS Z 3212 |
| (6) | Wires and fluxes for arc welding | |
| | (a) Steel wires and fluxes for submerged arc welding | JIS Z 3311 |
| | (b) Steel wires for CO ₂ gas shielded arc welding | JIS Z 3312 |
| (7) | Gray iron casting | JIS G 5501 |
| (8) | Steel bar for concrete reinforcement | JIS G 3112 |
| (9) | Welded stud shear connector (JSS : Japanese Steel Structures Association Standards) | JSS 8-1977 |
| (10) | Carbon steel pipes for ordinary piping | JIS G 3452 |
| (11) | Others : Pertinent and applicable JIS Clause shall be adopted. | |

6.3.3 Materials other than steel materials

- (1) Paint
 - (a) Etching primer JIS K 5633
(type - 2)
 - (b) Red-lead ready mixed paint JIS K 5622
(type - 1)
 - (c) Ready mixed phthalic acid resin paint JIS K 5516
(type - 2)

- (2) Elastomeric bearing pads JIS K 6386
C08, C10 and
JIS G 4305

- (3) Others : Pertinent and applicable JIS Clause shall be adopted.

6.3.4 Concrete materials

Concrete materials shall be in accordance with the requirements of Chapter 3, Concrete Work, of these Technical Specifications.

6.4 Construction of Sub-structure and Superstructure

6.4.1 General

Works under this Clause consist of all works such as, but not limited to, care of water and coffering of foundations, dewatering, excavation, piling work, construction of bridge piers and abutments including their foundations and backfilling of foundation trenches, etc., construction of composite girder and slab including stagings, scaffolding and their removals, RC - box girder and slab, sidewalk, furnishing and installing bearings, railings for the sidewalks, construction of approach slab, approach road, asphalt treated pavement and all other works required for completion, commissioning and maintenance of the Works as specified in the Contract, these Technical Specifications or as directed by the Engineer.

6.4.2 Storage of material

Structural material, either plain or fabricated, shall be stored at the bridge shop yard above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be protected as far as practicable from corrosion and bending.

Proper measures shall be taken so as to prevent materials from mixing with other materials of different class/grade during fabrication.

6.4.3 Concrete supply facility

The Contractor shall provide appropriate arrangements for the continuous and uninterrupted supply of concrete to the works. Contractor shall provide adequate stocks of cement, coarse and fine aggregates, water, concrete mixing, carrying and placing facilities so as to meet the requirements of the site.

6.4.4 Form work

Form work shall be made in conformity with Clause 3.12 of Chapter 3, Concrete Work, of these Technical Specifications.

All staging and scaffolding required to support the forms shall be designed and constructed to provide necessary rigidity to support the load without appreciable deflection or deformation. All materials used in the construction of the stagings and scaffolding shall be approved by the Engineer, or conform to the relevant SII or JIS standard.

Detailed design, drawings and deformation calculations for staging and scaffolding shall be submitted to the Engineer for his approval, but in no case shall the Contractor be relieved of his responsibility for the results obtained by use of these plans and proposals. The time when formwork should be started is to be decided by the Contractor on his responsibility, and the forms shall be removed after the concrete strength has reached 270 kg/cm^2 for beam and slab.

6.4.5 Placing of reinforcement

Reinforcing bars shall be in conformity with Clause 3.13 of Chapter 3, Concrete Work, of these Technical Specifications. Before placing, reinforcing bars shall be examined by the Engineer and any smearing of the reinforcing bars with mud, oil, rust, etc. shall be removed.

Re-bar to re-bar shall be bound rigidly with binding wire and reinforcing bar placing in the form or above leveling concrete shall be positioned accurately with spacer bars and hanger bars duly approved by the Engineer.

6.4.6 Placing of concrete

Concrete shall be placed in the foundations of piers and abutments after dewatering of the same. The Contractor shall provide adequate arrangements for coffering, care of water and dewatering of the foundation pits and trenches for the bridge piers and abutments in accordance with the requirements of Chapter 1, Temporary Works : Coffering Works, Care of Water and Dewatering Works, of these Technical Specifications.

All excavations shall be adequately protected, if necessary by strutting, shoring or any other approved means.

Concrete shall be placed within one (1) hour after addition of water to the cement and aggregates. At the construction joints any laitance or loose part of concrete of the old concrete surface shall be removed completely. Just before placing the concrete, construction joints shall be adequately moistened. While placing the concrete, special care shall be taken to produce satisfactory bond with the reinforcement and to avoid formation of honey comb or other such defects in the concrete.

All other requirements of mixing, placing, vibrating, testing and curing concrete, etc. shall be in accordance with the provisions stipulated in Chapter 3, Concrete Work, of these Technical Specifications.

6.4.7 Elastomeric (rubber) bearing pads

The Contractor shall furnish and install all elastomeric bearing pads for bearing the bridge superstructures in accordance with the requirements shown on the Drawings, Specifications or as directed by the Engineer.

Details of necessary accessories are shown on the Drawings and included anchor bars and caps, reinforcement, etc.

Bearing pads shall conform to the following requirements;

Bearing stress	: 15-50 kg/cm ²
Compression strain	: 15% max.
Horizontal deformation	: 50% max.

The elastomeric bearing pads shall be approved non-laminated pads cast in moulds under pressure and heat. Elastomeric pads shall be bonded to stainless steel plates at the top and bottom surface. The variation in thickness of elastomeric bearing pads, measured any two points shall not exceed 0.8 mm. the pads shall be installed within twelve (12) months of the date of manufacture.

The Contractor shall submit to the Engineer for approval sixty (60) days before use details of the proposed method of manufacture and test specimens of the elastomeric bearing pads. Pads shall have the following physical properties :

Hardness, ASTM D1415, I.R.H.D.	70 + 5 or 60 + 5 or 50 + 5 as directed
Tensile strength, ASTM D412, minimum	140 kg/cm ²
Elongation at break, minimum percent	300 for 70 hardness 400 for 60 hardness 500 for 50 hardness
Tear test, ASTM D624-Die "C", minimum	45 kg/cm ²
Compression set, ASTM D395, 24 + 0 hrs at 70o C - Method B,-2 under constant deflection, maximum percent	25
Low temperature stiffness, ASTM D1053, at -40o C,	maximum 700 kg/cm ²
Oven aged, 14 days at 70o C, ASTM D573	
Hardness, point change, maximum	0 to + 15
Tensile strength, % change, maximum	± 15
Elongation at break, % change, maximum	-40

Ozone resistance, ASTM D1149
1 p.p.m. ozone in air by volume,
100 hours, 20% strain at 40 +10 C

no crack

The Contractor shall store the elastomeric bearing pads in a manner which will prevent deterioration, as approved by the Engineer.

Bearings shall be rectangular bearing pad set over shoe seat mortar of total thickness twelve (12) mm sandwiched with three (3) plates of stainless steel (SUS 304 or better) each of one (1) mm thickness and shall be placed in the direction as prescribed on the Drawings or as directed by the Engineer.

When they are set on thin pads or cement mortar, the mortar shall be cured and allowed to develop sufficient strength before the beams are erected.

The bearing pads shall be maintained in their correct position during the placing of the beams. After the beams has been completed, each bearing and the area around it shall be left clean.

(1) Anchor bars

Anchor bars shall be set rigidly and immovably at the prescribed position designated on the Drawings or as directed by the Engineer.

The part of the anchor bar which juts out from the bridge seat shall be protected from concrete or other matter adhering to it during the placement of concrete in the bridge seat by sealing with vinyl tape or other suitable means. Before concreting of the end cross beam, anchor bar shall be swept up to strip-off sealing tape and spiral steel bar and anchor cap shall be set up as directed by the Engineer. The anchor cap shall be of approved quality. The space between the anchor shall be filled up with corrosion proofing material of approved quality.

(2) Box out of anchor bar

Material for box out for anchor bar shall be spiral steel pipe of grade SR 235 or other approved quality. Diameter of the spiral steel pipe shall be equal to diameter of anchor bar plus ten (10) cm and its length shall be equal to built-in length of the anchor bar plus ten (10) cm. The spiral steel pipe shall be set rigidly and immovably at the prescribed position designated on the Drawings or as directed by the Engineer.

The top end of the spiral steel pipe shall be covered with a cap to prevent any objectionable material dropping into it.

The styrol foam which substitutes for the form at the junction of old and new RC beam to maintain the expansion gap and is also spread over the circumference of elastomeric bearing pad and anchor bars as shown on the Drawings, shall be removed completely after concrete has hardened.

(3) Shoe seat

As mentioned under Sub-clause 6.4.7 (1) hereinabove, elastomeric bearing pads shall be set over shoe seat mortar.

After completion of the portion of the bridge seat concrete and before hardening of the concrete, surplus concrete shall be scooped-out to the dimensions shown on the Drawings or as directed by the Engineer. Shoe seat mortar shall be placed as shown on the Drawings after allowing for setting and curing of the concrete. Shoe seat reinforcement shall be welded in the form of a grating and placed in position as shown on the Drawings before pouring the mortar.

6.4.8 Expansion details

Bridge superstructure shall be constructed in accordance with the Drawings, these Technical Specifications or as directed by the Engineer leaving adequate space for expansion of the structural members of the superstructure.

The work shall consist of the supply and installation of the expansion joint of steel plate reinforced with steel angle or beams.

Steel plate to be used for bridge expansion joint shall conform to the requirements of SII 0876 or JIS G 3101 and angles to the requirements of SII 0163 or JIS G 3192.

The expansion joint of steel plate will be fabricated in the factory or fabricating yard in the Site. The size of the lap of the expansion joints shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with the Drawings or arrangements approved by the Engineer.

The position of expansion joint and all anchor bolts cast into concrete shall be accurately

determined from the template or other materials. During the placing and hardening of concrete or mortar under expansion joint components, relative movement shall be prevented between them and support to which they are being fixed.

Angle steel for the edge protection shall be fixed at the prescribed locations rigidly and immovably as shown on the Drawings or as directed by the Engineer. The intervening space between the parapet wall and superstructure and girder to girder shall be packed with elastic material and backup material of approved quality as shown on the Drawings or as directed by the Engineer.

6.4.9 Pile length and treatment of pile head

All piling work, in general, shall be carried out in accordance with the requirements stipulated in Chapter 4 , Piling Work, of these Technical Specifications.

(1) Pile length

Bridge piers and abutments shall have pile foundations made of a group of prestressed concrete piles. Piles shall be circular in section with diameter of 350 and 400 mm and from 7 m to 18 m in length. However, final penetration depth and length of all piles shall be determined based upon the results of geotechnical investigations and test piling at site. Pile length and penetration depth so determined shall supersede all other requirements precedently set forth on the Drawings and these Technical Specifications.

(2) Pile head treatment

Pile heads shall be embedded in concrete footings as shown on the Drawings or as directed by the Engineer.

After driving is completed, the concrete at the top of the pile shall be cut-off leaving reinforcing bars exposed for the length required as shown on the Drawings or as directed by the Engineer.

The cut-off length shall be sufficient to permit the removal of all damaged portion of concrete in the pile. Exposed reinforcing bars shall be embedded in pier or abutment foundation raft as shown on the Drawings or as directed by the Engineer.

6.4.10 Handrailing

This work shall consist of furnishing, fabricating and erecting steel pipes fixed with steel or concrete posts for the bridges, all as indicate on the Drawings and as required by these Specifications.

Steel pipe of seventy five (75) mm in diameter shall conform to the requirements of SII 0585. Concrete post, type 2, shall conform to the requirements of Chapter 3. Formwork and reinforcement bars shall conform to the requirements of Clauses 3.12 and 3.13, respectively.

Steel pipe railing shall be fabricated and erected as indicated on the Drawings and rails shall be parallel to the grade of the bridge. Post shall be set truly vertical unless otherwise instructed by the Engineer. Concrete post shall be carefully constructed true to the line and grade as shown on the Drawings.

No construction shall be commenced before inspected and approved by the Engineer, and before all concrete support and falsework or staging of superstructure have been removed.

6.4.11 Asphalt wearing surface course

This work shall consist of the construction for one (1) layer of asphalt wearing surface course of minimum indicated thickness on an approved bridge deck in accordance with these Specifications and in conformity with lines, grade, thickness and typical cross-sections shown on the Drawings unless otherwise directed by the Engineer.

Material and construction requirements shall conform to Clauses 7.8 and 7.9 respectively.

6.4.12 Sidewalks and drains

The works under this Clause shall consist of construction of sidewalk covered with bituminous surface course including drains fixed with steel pipe of 100 mm in diameter in conformity with lines, grades, thickness and typical cross section shown on the Drawings.

Concrete, type 4 shall be used for base concrete of sidewalk and conform to Chapter 3. Aggregates stuffed into the sidewalks shall be the same material of the base course and conform to Sub-clause 7.7.2.

Bituminous surface shall conform to Clauses 7.8 and 7.9, respectively. Steel pipe of 75 mm or 100 mm in diameter shall conform to the requirements of Sub-clause 5.6.3. Steel channel and angle, if required, shall conform to the requirements of SII 0233.

The sidewalk made in concrete shall be mounted and covered with bituminous surface course as shown on the Drawings and in accordance with Chapters 3 and 7, respectively. Drain pipes cast into concrete shall be accurately set at the position shown on the Drawings before placing concrete. Channel or angle steel and edge steel for sidewalk shall be anchored into concrete rigidly.

6.4.13 Backfilling

Foundation pits and trenches shall be backfilled with excavated soil. Where soil parameters such as angle of internal friction and unit weight of soil determined from geotechnical investigations at site are at variance with the design parameters, the Contractor shall check and confirm the safety of backfill or change the design as instructed by the Engineer.

6.4.14 Revetment works

Revetment works for bridges shall be made in accordance with the requirements stipulated in Chapter 5, Drainage Structural Work, of these Technical Specifications.

6.4.15 Temporary bridge

For temporary bridges across to the drainage channels, the Contractor shall, before starting work on the bridge, construct a substitute temporary bridge and approach roads which would be of the class similar to the existing bridge. The Contractor shall furnish for approval to the Engineer, at least thirty (30) days prior to the start of construction activities, his plans for the substitute bridge including necessary diversion of approach roads, protection works, etc. Approval of the Contractor's plans for the substitute bridge, however shall not relieve the Contractor of his responsibility for the safety and appropriateness of the substitute temporary bridge including its maintenance till such time the new bridge is opened to the traffic or till the time indicated in the Contract.

6.4.16 Timbering

Timbering for construction of bridge shall be designed, constructed and maintained by the

Contractor for the loads which will come upon it. The Contractor shall prepare and submit to the Engineer for approval his plans for timbering and for making changes in the existing structure necessary for maintaining the traffic.

If bearing capacity of ground over which the timbering is set up is not enough for the loads which will come upon it, the Contractor shall submit to the Engineer for approval his alternative plans.

However, it must be expressly understood by the Contractor that approval of his plans by the Engineer would not relieve the Contractor from any of his responsibility for the safety of timbering and maintenance of traffic.

During concrete placing, the Contractor shall post checkmen inside of the timbering who shall inspect the camber, sinking, etc. of the timbering and report to the Engineer.

6.4.17 Drain pipe

Drain pipe shall be fixed with steel plate supporter as shown on the Drawings or as directed by the Engineer.

Steel plate supporter shall be fastened with drift bolt or other suitable means to the main girder and duly approved by the Engineer.

6.4.18 Name plates

The Contractor shall furnish and install name plates of such form, dimensions, material and design as shown on the Drawings or as directed by the Engineer. Unless otherwise provided, the Contract Price for the superstructure shall include the cost of such name plates.

No permanent plates or markers other than those shown on the plans or approved by the Engineer will be permitted on any structure.

6.4.19 Protection against scouring

The Contractor shall inspect the condition of the existing bridges and their foundations, channel bed conditions, water levels, free boards, etc. and report to the Engineer.

Where the conditions are found to be at considerable variance from the design conditions, the

Contractor shall submit to the Engineer for approval his detailed plans for any additional protection works envisaged by him.

6.5 Measurement and Payment

6.5.1 General

Measurement, for payment, for the various items of work executed for the construction of concrete bridges will be made to the actual quantities of the respective works done in linear meters, square meters, cubic meters, numbers, pieces, ton or kilogram, etc. so measured as provided in the Bill of Quantities and duly certified by the Engineer.

Payment for the concrete bridge works shall be made at the unit price per linear meter, square meter, cubic meter, number, piece, ton or kilogram and/or the lump sum price and to the actual volume of work so certified by the Engineer in the Bi-Monthly Statement of Account.

6.5.2 Concrete works, types 1 and 2 for superstructure

Measurement, for payment, of concrete works of rectangular beams and slabs will be made as provided for in Sub-clause 3.14.1 for concrete, Sub-clause 3.14.2 for formworks and Sub-clause 3.14.3 for reinforcing bars, at the unit prices entered therefor in the Bill of Quantities.

The unit prices for the respective works shall include full compensation for furnishing all materials, labour and equipment, scaffolding placing in position, concreting and completing all necessary works for the beams and slabs in accordance with the Drawings, these Specifications or as directed by the Engineer.

Staging, scaffolding and other related temporary works, whenever included as pay item in the Bill of Quantity, shall be paid for at the unit prices in accordance with the following provisions : this work shall include furnishing, installing, maintaining and removal of any and all stagings and scaffoldings, necessary for acceptable completion of the concrete works.

6.5.3 Expansion joint of steel plate

Measurement, for payment, of expansion joint of steel plate will be made in the actual length measured in term of the linear meters of the expansion joints completed in place in accordance with the Drawings or as directed by the Engineer.

Payment for the expansion joint of steel plate shall be made at the unit price per linear meter stated in the Bill of Quantities, which the unit price shall constitute full compensation for all chipping for formation of construction joint with existing concrete and for all labour, equipment, furnishing of materials including reinforcement bars, concrete, fabricating, transporting, painting, setting expansion joints and for other incidental items of the work.

6.5.4 Elastomeric bearing pads

Measurement, for payment, of furnishing and installing elastomeric bearing pads will be made in the actual length measured in term of the linear meters of the pads in place as shown on the Drawings or as directed by the Engineer.

Payment for the bearing pads shall be made at the unit price per linear meter tendered therefor in the Bill Quantities, which the unit price shall constitute full compensation for furnishing, fabricating, transporting, and placing all materials including all labour, tools, equipment and incidentals necessary to complete the work, all in accordance with the Drawings and Specifications or as directed by the Engineer.

6.5.5 Handrailing (Guard pipes)

Measurement, for payment, of the handrail (guard pipe) will be made in actual length measure in terms of the linear meters of the handrail (guard pipe) completed in place in accordance with the Drawings or as directed by the Engineer.

Payment for the handrail (guard pipe) shall be made at the unit price per linear meter tendered therefor in the Bill of Quantities, which the unit price shall constitute full compensation for furnishing materials, equipment, tools and labour , and forming, concreting and other incidental works, all in accordance with the Drawings and Specifications or as directed by the Engineer.

6.5.6 Asphalt wearing surface course

Measurement and payment for the asphalt wearing surface course for the bridge will be made in accordance with the provisions stipulated in Sub-clauses 7.8.4 and 7.9.4, respectively.

6.5.7 Drain pipe

Measurement and payment of the drain pipe for the bridge will be made in accordance with the provisions stipulated in Sub-clause 5.6.3.

