

D.8 MEASUREMENT AND PAYMENT

D.8.1 Grouting

- (1) Measurement and payment for the backfill grouting, in the water transbasin diversion tunnel and inlet structure will be made on the basis of volume in cubic meters of the grout materials actually injected into the gaps. Unit price tendered shall include all costs of furnishing labour, materials, construction equipment, grout supply systems and all operations required for connecting grout supply lines with injection pipes, washing holes, handling grout materials, mixing and injecting grout, re-drilling holes if they are choked by flowing out of grout, and all incidental works concerned with grouting, in accordance with the Specifications.

The specified quantity in the Bill of Quantity shall be the maximum limit which can be subject to payment. The part of actual quantity exceeding the above limit shall be deemed due to the Contractor's responsibility in making erroneously excessive excavation or his failure to construct the lining of sufficient thickness, and shall not be subject to payment.

The material of grout which has been wasted without rational reason or because of the Contractor's failure shall not be subject to measurement and payment.

- (2) Measurement and payment for contact grouting in periphery of tunnel plug will be made dividing into three items as follows:

- (a) Cement grout

Measurement for payment for cement grout will be made on the basis of actual injected weight of cement in kilograms as approved by the Supervision. The cement grout which has been wasted without rational reason or because of the Contractor's failure shall not be subject to measurement and payment.

Payment will be made for the number of kilograms measured as provided above at the unit price per kilogram tendered therefor in the Bill of Quantities, which unit price shall constitute full compensation for the cost of all labor, tools, equipment and materials including furnishing, transporting, handling, mixing and injecting cement grout and other items necessary to complete the works, except furnishing and installing the metal tubing and outlets for grouting system.

- (b) D. 40 mm steel pipes for contact grouting

Measurement for payment for furnishing and installing 40 mm diameter steel pipe for grout supply, return and vent pipe system for contact grouting will be made on the basis of the weight in kilograms of the steel pipes actually installed in the position in accordance with the Drawings or directed and approved by the Supervision in the plug concrete.

The unit price per kilogram tendered shall include full compensation for the cost of all labour, tools, equipment and materials including furnishing and installing D. 40 mm steel pipes with accessories necessary to complete the grouting system.

(c) D. 25 mm steel pipes for contact grouting

Measurement for payment for furnishing and placing 25 mm diameter steel pipe for risers for contract grouting will be made on the basis of the weight in kilograms of the steel pipes actually installed in the position in accordance with the Drawings or directed and approved by the Supervision in the plug concrete.

The unit price per kilogram tendered shall include full compensation for the cost of all labour, tools, equipment and materials including furnishing and installing D. 25 mm steel pipes with grout outlets and other items necessary to complete the grouting system.

D.8.2 Grout Pipes for Backfill Grouting

Measurement for payment for furnishing and placing 50 mm diameter steel pipe for backfill grouting for the water transbasin diversion tunnel and inlet structure will be made on the basis of the weight in kilograms of the steel pipes actually placed in the position directed in the concrete lining. The unit price per kilogram tendered shall include all costs of furnishing labour, materials and of all operations required for processing the pipes, placing and maintaining them in appropriate positions and all incidental works concerned, in accordance with the Specifications.

D.8.3 Drainage Holes

Measurement for payment for drilling the drainage holes in the water transbasin diversion tunnel and inlet structure shall be made on the basis of linear meter in the length of the drainage hole which has been drilled in accordance with the Specifications and/or the direction of the Supervision. The unit price per linear meter tendered therefor shall include all costs of furnishing labour, materials, construction equipment of all operations required for drilling through rock, shifting machines, washing of drill holes, and all incidental work concerned with drilling drainage holes without coring at the location and the angle as shown on the Drawings and in accordance with the Specifications.

CONSTRUCTION OF CIVIL WORKS

PACKAGE 1

DAULE-PERIPA-LA ESPERANZA TRANSBASIN

VOLUME III - GENERAL AND TECHNICAL SPECIFICATIONS

SECTION E

CONCRETE WORKS

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SECTION E CONCRETE WORKS

E.1 GENERAL

E.1.1 Contractor's Responsibility

All concrete work shall be performed as stipulated in these Specifications, and as shown on the Drawings or as directed by the Supervision. Such concrete work shall be carried out in the presence of the Supervision.

Not less than fifty-six (56) days prior to the installation by the Contractor of any construction 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, the Contractor shall submit flow charts, drawings, and written descriptions to allow the full and proper assessment of his plans for the production and placing of the concrete involved in the works under these Specifications.

Unless otherwise permitted, concrete for permanent structures shall be weighed, batched and mixed by using concrete plant with automatic weighing and batching system.

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

Where these Specifications require specific types of equipment to be used or specific procedures to be followed, such requirements are not to be construed as prohibiting use by the Contractor of alternative types of equipment or procedures if it can be demonstrated that equal results will be obtained by the use of such alternatives.

All proper precautions shall be taken by the Contractor to minimize discharge into the stream flows containing visible suspended matter. In locations where such discharge appears to the Supervision likely to take place, the Contractor shall construct, maintain and operate suitable settling ponds or other effective means that may be necessary to prevent such discharge.

Approval of plants and equipment or their operation, or of any construction procedure, shall not operate to waive or modify any provisions or requirement 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 all the equipment and instrument necessary for performing concrete tests. The Contractor shall operate and maintain the laboratory under

the control of the Supervision during the Contract period and shall employ sufficient number of qualified concrete experts and laboratory assistants to carry out the specified tests.

Unless otherwise provided in these Specifications, concrete shall be manufactured, transported, placed, cured, finished and tested by the Contractor in accordance with the instructions or manuals to be issued by the Supervision or other equivalent approved by the Supervision.

E.1.2 Technical Standards

Necessary tests and applicable standards will be as follows, but not be limited to:

- Sieve analysis of Aggregates JIS A 1102, ASTM-C 136-84
- Amount of Material Passing Standard Sieve 74 microns in Aggregates JIS A 1103, ASTM-C 117-69
- Unit Weight of Aggregate and Solid Content JIS A 1104, ASTM-C 29-69
JIS A 1116, ASTM-C 138
- Organic Impurities in Fine Aggregate JIS A 1105, ASTM-C 40-84
- Specific Gravity and Absorption of Coarse Aggregate JIS A 1109, ASTM-C 127-88
- Surface Moisture in Fine Aggregate JIS A 1111, ASTM-C 70-79
- Abrasion of Coarse Aggregate by Use of Los Angeles Machine JIS A 1121, ASTM-C 131-81
- Soundness of Aggregate by Use of the Sodium Sulfate JIS A 1122, ASTM-C 88-83
- Total Moisture Content and Surface Moisture of Aggregate by Drying JIS A 1125
- Soft Particles in Coarse Aggregate by Use of Scratch Tester JIS A 1126
- Bulk Specific Gravity and Absorption of Light Weight Fine and Coarse Aggregates JIS A 1134, ASTM-C 128-98
JIS A 1135, ASTM-C 127-88
- Clay Contained in Aggregate JIS A 1137
- Physical Testing Methods of Cement JIS A 5201
- Method for Chemical Analysis of Portland Cement JIS R 5202, ASTM-C 114-88
- Heat of Hydration of Cement JIS R 5203, ASTM-C 186-86
- Slump of Concrete JIS R 1101, ASTM-C 143-89a
- Compressive Strength of Concrete JIS A 1108, ASTM-C 39-86
- Washing Analysis of Fresh Concrete JIS A 1112

- Method of Sampling Fresh Concrete JIS A 1115, ASTM-C 172-82
- Air Content of Fresh Concrete by Pressure Method JIS A 1118, ASTM-C 231-89a
- Making and Curing Concrete Specimens JIS A 1132, ASTM-C 31-88
- Making Test Sample of Concrete in the Laboratory JIS A 1138, ASTM-C 192-88

E.1.3 Classification and Definition

Type of the concrete work is classified into two:

- (1) In Situ Concrete (or Concrete)
- (2) Precast Concrete

Unless otherwise designated, in situ concrete is defined as "Concrete" in these Technical Specifications.

The concrete class, which is classified in terms of size of aggregates, strength (kgf/cm², 28 days) and method of placement is defined as set out below:

Class of Concrete	Usage
A	Precast concrete pipe, blockout concrete, bridge slab and girder, and 2 nd stage concrete
B	Not applicable
C	Thin wall and slab, and inlet shaft (slab, beam and stair) for building works
D	Tunnel lining concrete, inlet structure and work adits (tunnel and shaft)
E	Retaining wall, box culvert, facing wall, bridge abutment wall, structural foundations, bottom slab of inlet channel, etc.
F	Drain ditch, catch basin, etc.
G	Backfill concrete, plug concrete, anchor block, etc.
H	Leveling concrete Shotcrete Cut slope and tunnel protection

E.2 CEMENT AND ADMIXTURES

E.2.1 Cement

Cement used in the work shall have quality equivalent to that of Portland cement, Ordinary Type as specified in JIS R 5210 or ASTM Designation C 150, Type I E, and/or as approved by the Supervision.

Prior to any cement being ordered, the Contractor shall inform the Supervision 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 on each batch sample taken immediately after its arrival at the store of his factory. Upon receipt thereof, such certificates shall be submitted to the Supervision.

Cement shall be furnished in moisture-resistant paper approved by the Supervision. Unless otherwise permitted, cement from not more than three factories shall be used in principle, and only the product of one factory shall be used in any particular section of the work.

The Contractor shall take samples and make tests of cement in principle for three and seven-day strength, for setting time and for soundness in store at the Site on each batch arrived, in accordance with Japan Industrial Standards or ASTM and shall supply the results to the Supervision expeditiously and in a systematic manner.

In addition to the above routine tests the Contractor shall conduct the check tests of the stored cement as directed by the Supervision when the Supervision deems necessary the tests. The check tests will be performed for the same items as specified for routine tests, unless specified by the Supervision.

No separate payment for routine and check tests on cement will be made and any and all costs incurred for the tests including cost of materials and labour, except furnishing and installing testing equipment, shall be deemed to be included in the unit prices tendered in the Bill of Quantities for the applicable items of concrete.

In arranging the storage facilities, the Contractor shall take into account all factors which might cause delays in the supply of cement such as the manufacturer's capacity, storage at his factory, time for transport between factories and the Site, holidays, weather conditions and breakdowns. However, the Contractor shall provide at the Site adequate handling and storage facilities for the capacity of not less than 4-weeks' supply of cement.

The Contractor shall provide adequate handling and storage facilities for the cement. Metal storage bins at the batching plant for cement shall be all weatherproof and shall be constructed so that there is no dead storage. If in the opinion of the Supervision, there is a possibility that any dead storage exists in any bin, that bin shall be emptied and cleaned out at least once every four months.

Cement delivered in bags shall be transported in a manner approve by the Supervision and shall be stored in completely all weatherproof warehouses with adequate provisions for

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

Cement shall be stored in a warehouse having a floor more than 30 cm above the ground surface, and in such a manner that the "first-in" shall be "first-out". Proper spacing shall be provided between piles of cement. Not more than 13 bags shall be permitted to be placed in one stack, or to a lesser number as directed by the Supervision when the storage period is expected to be longer than fifty-six (56) days. The maintenance and operation cost of the cement warehouse shall be included in the lump sum price tendered therefor in the Bill of Quantities.

No cement which has been stored at the Site for more than eighty-four (84) days shall be used in the work unless a test proves it to be satisfactory for use, and it is approved by the Supervision.

The Contractor shall take care to ensure that adequate stocks of cement are always available. He shall on the first day of each month inform the Supervision concerning the following data.

- (a) The stocks of cement on his hands at the Site as of the last day of the month.
- (b) The cement shipments received during the month.
- (c) The cement used in the authorized work during the month.
- (d) The cement wasted or lost during the month and the reasons therefor.
- (e) The other data as required by the Supervision.

E.2.2 Admixtures

(1) General

The Contractor shall furnish and use concrete admixtures so as to improve workability and finishability of concrete and mortar. Admixtures shall not be used unless otherwise approved by the Supervision. The Contractor shall notify the Supervision of the sources from which admixtures will be obtained and shall furnish technical information and samples for testing at least eighty-four (84) days in advance of the time when they are expected to be used. The information provided shall include:

- (a) The typical dosage and the detrimental effects of an excess or deficiency in the dosage.
- (b) The chemical names of the main active ingredients in the admixture.
- (c) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.
- (d) Whether or not the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage.

Additional admixtures may be specified or may be used on the written authority of the Supervision only in the manner and with the control specified by the Supervision.

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

The compatibility of admixtures shall be tested, when more than one is used, and shall be proven to the satisfaction of the Supervision and the satisfactory test result shall be submitted to the Supervision for approval before incorporating in the Works.

When more than one admixture is to be used, each admixture shall be batched in its own batcher and added to the mixing water separately before discharge into the mixer.

The amount of the agent used in each concrete mix and the section of the work where it may be used will be determined by the Supervision. Admixtures shall be added to the mix by the automatic dispensers approved by the Supervision.

The specified limits in respect of the maximum slump, slump loss during transit and the time allowed for concrete to remain in the mixer may be changed by the Supervision when approval of using the agent is given.

All costs incurred for the use of admixtures shall be included in the unit prices tendered in the Bill of Quantities for applicable items of concrete in which the admixtures are used.

(2) Air-entraining Admixture

An air-entraining admixture shall be used in all concrete unless otherwise directed. The admixture used shall conform to ASTM Designation C 260 or approved equivalent. The admixtures shall be of uniform consistency and quality within each container and from shipment to shipment. Any air entraining admixture which has been in storage at the Site for longer than six months shall not be used unless the check tests prove it to be satisfactory for use and it is approved by the Supervision.

The amount of air-entraining admixture used in each concrete mix shall be as shown in the following tabulation:

Maximum Size of Coarse Aggregate (mm)	Total Entrained Air (Percentage by Volume of Concrete)
20	5.0 ± 1
40	4.0 ± 1

The air-entraining admixture shall be batched as a solution with a solids content not exceeding 15% by weight, with a suitable, stable and consistent pH.

The admixture in solution shall be maintained at a uniform strength and shall be added to the batch in a portion of the mixing water. So far as the foregoing requirements of air content are met, the use of a water-reducing admixture which contains an air-entraining admixture will be allowed.

(3) Water Reducing Admixture

A water reducing admixture shall be added to the concrete mix in the amount approved and when directed by the Supervision. This admixture shall conform to the requirements of ASTM C494, Type A or approved equivalent.

(4) Set Retarding Admixture

The sources, brand, and types of suitable set retarding admixtures shall be selected and submitted by the Contractor to the Supervision for his approval. The set retarding admixture will be compatible with the air-entraining admixture specified above and shall be batched and added to the concrete in the same manner as specified for the adding of the air-entraining admixture. The quantities of set retarding admixture to be used shall be in accordance with the instruction of the manufactures, as approve by the Supervision.

(5) Storage of Admixtures

Liquid or powdered admixtures for concrete shall be kept in completely water-proof stores with adequate provision for the prevention of water absorption. Storage shall be so arranged that the materials can be used in the order that the "first-in" shall be "first-out". 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.

E.3 AGGREGATE

E.3.1 General

Materials for the production of coarse and fine aggregates are to be obtained from the quarry site designated on the Drawings or other areas approved by the Supervision.

The prospective sources of sand and gravel materials for concrete aggregate are the Picoazá area, about 10 km west of Portoviejo. Crushed sand is produced in Picoazá and Cantera Basáltica Picoazá, using rod mill with a capacity of 30 ton/hr. There are four coarse aggregate quarries operated by three firms; the production capacity is more than 150 ton/hr. The rock is all basalt.

Even tests made by the Supervision on samples taken from the quarry site indicate that the quarried rock contains materials which, when processed, shall be suitable for coarse and fine aggregates, the quality of material available from the quarry site must be always assessed by the Contractor at his responsibility.

The Contractor have to pay for materials taken by him from the quarry site and used in the work covered by these Specifications. The Supervision's approval of the Contractor's use of the material at the quarry shall not be construed as constituting approval of all materials taken from the quarry, and the Contractor will be held responsible for the specified quality of all such materials used in the Works.

If material for aggregates is to be obtained from a source other than the quarry site, the Contractor shall submit for testing representative 50 kg samples of fine aggregate and of each size of coarse aggregate, proposed for use in the Works, at least 3 months before the materials are required for use. The cost of such tests shall be at the expense of the Contractor.

If an area other than the designated quarry site is used to obtain materials for the production of concrete aggregates, the Contractor shall clear vegetation, roots, brush, sod, clay, unsuitable sand and gravel, weathered and unsound rock and other objectionable matter from all of those portions of the surface from which materials for aggregates are to be obtained.

The areas from which the material for aggregates are to be obtained shall be located and operated so as not to detract from the usefulness of the deposits or any other property and so as to preserve, insofar as is practicable, the future usefulness or value of the deposits. Materials removed from the area and not used for the Works shall be disposed of as directed by the Supervision.

Processing of the raw materials will include such items as crushing, screening, washing, blending, etc. to produce fine and coarse aggregates meeting the requirements specified herein and shall be done in a manner approve by the Supervision. Water used for washing aggregates shall be free from objectionable quantities of suspended materials, organic matter, alkali matter, salts and other impurities.

After washing, fine aggregate must be stored in stock piles with a free draining base for at least 72 hours and shall be subsequently handled to ensure that sand delivered to the batch plant shall have a reasonably uniform and stable moisture content. Where the surface of the stockpiles from which sand is being delivered direct to the batch plant is substantially drier or wetter than the bulk of sand in the pile, handling shall be such as to exclude this surface sand from the batch plant.

Before procuring the construction plant for processing aggregates, the Contractor shall submit to the Supervision for approval a narrative description, flow diagram and drawings which sufficiently indicate layout, type and capacity of crushers, screening, washing, conveying and other aggregate processing and handling equipment. However, the Supervision's approval will not relieve the Contractor from his sole responsibility for the suitability of the proposed arrangement.

The cost of producing aggregates required under these Specifications shall be included in the unit prices tendered in the Bill of Quantities for the applicable items of concrete in which the aggregates are used. These unit prices shall also include all expenses of the Contractor in excavating, handling, processing, transporting and storing the materials. The Contractor

shall not be entitled to any additional compensation for materials wasted from the quarry or other approved areas, including crusher fines, excess materials of any of the sizes into which the aggregates are required to be separated by the Contractor, and materials which have been discarded by reason of exceeding the maximum sizes specified for use.

E.3.2 Fine Aggregate

The term fine aggregate is used to designate aggregate of which the maximum particle size is 5 mm. Fine aggregate for concrete, mortar and grout shall be furnished by the Contractor and shall be a manufactured type unless otherwise approved by the Supervision.

As provided in Paragraph E.7, the Supervision will make check tests of the fine aggregate, and the Contractor shall furnish and install facilities satisfactory to the Supervision for taking representative test samples. Tests will be done according to the requirements of Paragraph E.7.

Fine aggregate shall consist of hard, dense, durable, uncoated rock fragments of proper gradation and it shall be free from objectionable quantities of dirt, dust, silt, organic matter or other deleterious foreign materials. The moisture content of fine aggregate when delivered to the batching unit, shall not vary more than 1.0 percent within any one hour, and shall not vary more than 3.0 percent within the working time of one shift.

Fine aggregate shall substantially consist of particles having satisfactory shape. The particle having satisfactory shape is defined as a particle of which the maximum dimension is not greater by three (3) times than the minimum dimension.

Fine aggregate, as batched, shall be well graded and shall conform to the criterion shown below. However, this criterion may be varied if so directed by the Supervision, and in such case the Contractor shall not be entitled to additional allowance or cost.

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

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

<u>Item</u>	<u>Percentage by Weight</u>
Clay lumps	1.0
Material passing 0.088 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 0.088 mm sieve consists of rock dust free from clay or silt, this percentage may be increased to 5.0.

The sum of the percentages of all deleterious substances as delivered to the mixer shall not exceed 3% by weight, or 5% in the case of (*).

Fine aggregate may be rejected if it produces a colour darker than the standard in the colorimetric test for organic impurities specified in JIS A1105 or approved equivalent.

Loss of fine aggregate subjected to five cycles of the sodium sulphate soundness test shall not exceed 10 percent.

The grading of the fine aggregate shall be controlled so that at any time the fineness module of at least 9 out of 10 consecutive test samples of finished fine aggregate, when samples are taken hourly, will not vary more than 0.20 from the average fineness modulus of the 10 test samples. The fineness module of the fine aggregates shall range between 2.5 and 3.3.

Where fine aggregates from different sources are being used at the batching plant at the same time, they shall be so blended as to ensure uniform grading in successive batches.

E.3.3 Coarse Aggregate

The term coarse aggregate is used to designate aggregate in which the minimum nominal size is 5 mm and which is reasonably well graded from 5 mm to the largest size required in the work in which the material is being used. Coarse aggregate for concrete shall be furnished by the Contractor and shall consist of a manufactured type unless otherwise approved by the Supervision.

As provided in Paragraph E.7, the Supervision will make tests of the coarse aggregate, and the Contractor shall furnish and install facilities satisfactory to the Supervision for procuring representative test samples. Test will be done according to the requirements of Paragraph E.7.

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 mater or other deleterious material.

Grading of coarse aggregate (percentage by weight passing standard sieves) shall be as shown below. However, this may be varied if so directed by the Supervision, and in such case the Contractor shall be entitled to no additional allowance or payment.

Sieve Designation Mean Opening (mm)	Size of Coarse Aggregate (mm)	
	40 - 5	20 - 5
	Percent Passing by Weight (%)	
50	100	-
40	100 - 95	-
30	-	-
25	-	100
20	70 - 35	100 - 90
15	-	-
10	30 - 10	55 - 20
5	-	5 - 0 10 - 0
2.5	-	5 - 0

Further, the coarse aggregate in the concrete mix shall consist of the following proportion, unless otherwise directed by the Supervision.

Designation of Max. Size (mm)	Nominal Size (mm)		
	40 - 20	20 - 10	10 - 5
	Percent by weight (%)		
40	55 - 40	35 - 30	25 - 15
20	-	70 - 30	45 - 20

The amount of deleterious substance in coarse aggregate shall not exceed the limits prescribed in the following table:

Item	Percentage by Weight
- Clay lumps	0.25
- Soft particles	5.0
- Material passing 0.088 sieve	1.0 *
- Material floating on liquid having a specific gravity of 2.0	0.5

* If the material finer than 0.088 sieve consists of rock dust free from clay or silt, this percentage may be increased to 1.5.

The sum of the percentages of all deleterious substances in any size, as delivered to the mixer, shall not exceed 5% by weight.

Coarse aggregate may be rejected if:

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

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 material passing the undersize test sieve shall not exceed 2%, by weight, and all materials shall pass the oversize test sieves.

Designation of Aggregate Size (mm)	Size of Square Opening in Sieve	
	For Undersize Test	For Oversize Test
10	ASTM No. 5	11 mm
20	8 mm	22 mm
40	16 mm	44 mm

E.4 WATER

The water used in concrete, grout and mortar, for washing aggregates and for curing concrete shall be reasonably clean and free from objectionable quantities of silt, organic matter, alkali, salts, acids and other impurities. 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 Supervision. If so required by the Supervision, the water shall be tested in accordance with B.S. 3148 or approved equivalent by an approved testing authority. All costs involved in these tests shall be borne by the Contractor.

E.5 CONCRETE MIX

E.5.1 Composition

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

E.5.2 Mix Proportions and Classification of Concrete

The Contractor shall carry out the trial test to determine the concrete design mixes under the control of the Supervision at the laboratory so as to ensure that all concrete to be placed in the various structure of the works shall meet the requirement of the Specifications.

The data of mix proportions shall be prepared and proposed by the Contractor to produce the concrete having appropriate water-cement ratio, suitable workability, durability, low shrinkage and required design strength with the minimum cement content and amount of fine aggregate. The mix proportions selected by the Supervision from these data shall be further confirmed through the trial mixes to be executed by the Contractor in a manner as prescribed herein.

Based on the results obtained from the foregoing trial mixes the Supervision will notify the Contractor of the mix proportion for the concrete to be used in the various portion of the works. The mix proportions may be modified in the course of the works whenever the Supervision deems necessary for further improvement.

The Contractor shall furnish sample of cement used for the works in sufficient quantity required for such design of concrete mixes. The cost of sample of cement shall be deemed to be included in the appropriate unit prices for the concrete tendered in the Bill of Quantities.

The determination of the mix proportions by the Supervision 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 Supervision will permit the Contractor to produce and place concrete complying with the specified requirements.

The requirement of concrete mix and compressive strength shall be controlled based on compressive strength tests carried out by standard (15 cm in diameter by 30 cm in height) concrete test cylinder at the age of twenty eight (28) days in accordance with the applicable JIS standard or approved equivalent.

The Contractor shall use the specified class of concrete mix for the respective structures as indicated on the Drawings and stipulated in the Bill of Quantities or as directed by the Supervision.

The approximate concrete mix proportion to be used for the various classes of concrete defined in Subparagraph E.1.3. shall be as follows:

Class of Concrete	Max. Size of Aggregate (mm)	Compressive Strength at Age of 28 Days (kgf/cm ²)	Max. Water Cement Ratio (%)
A	20	250	40
B	40	210	50
C	20	210	50
D	40	210	50
E	40	180	50
F	20	210	50
G	40	140	55
H	20	140	55
Shotcrete	10	210	50

The Supervision shall reserve the rights to decide the cement contents of any one class or classes of concrete and the mix proportions, based on the trial mixes and from time to time during the course of the work. The Contractor shall not be entitled to any payment for extra cost of the concrete work incurred in any such change which the Supervision and/or the Contractor may make in the mix proportions.

In general, concrete shall be placed with a maximum 8 cm slump. Provided that, where deemed necessary by the Supervision, concrete with slump up to 14 cm may be permitted, e.g., where concrete is placed by pump.

The use of concrete pumps shall be limited to tunnel work and locations where other transportation and placement methods are not deemed practicable by the Supervision.

The determination of the mix proportions by the Supervision shall in no way 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 concrete mixed in the proportions determined by the Supervision will permit the Contractor to produce concrete complying with the specified requirements.

The Contractor shall notify the Supervision of any objection he has concerning the mix proportions and shall submit to the Supervision for approval his proposed alternative proportions which, if approved by the Supervision, shall be used for the manufacture of the concrete. The Contractor shall not be entitled to additional compensation on account of changes to the mix proportions.

The maximum size of coarse aggregate in concrete for any part of the work shall be the largest of the specified sizes, the use of which is practicable from the standpoint of satisfactory consolidation of the concrete by vibration, except where stated otherwise on the Drawings or directed by the Supervision.

E.5.3 Water Content and Slump

The amount of water used in the concrete shall be regulated by the Supervision 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. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Uniformity in concrete consistency from batch to batch shall be required.

Check slumps shall be taken after concrete has been deposited but before it has been consolidated. The Supervision may require a lesser slump whenever concrete of such lesser slump can be consolidated readily into place by means of the specified vibration. 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. The Supervision will determine the acceptable slump for each class of concrete, and the Contractor shall comply therewith.

E.6 TRIAL MIX

At least fifty-six (56) days prior to the start of permanent concrete work, the Contractor shall produce a trial mix for each class of concrete specified under the control of the Supervision, using the entire aggregates, batching and concrete mixing plants provided for the execution of the Works. Such trial mixes shall be continued until produced concrete complies with these Specifications.

No separate payment for the provisions specified in this Paragraph will be made, and all cost incidental to trial mixes, except furnishing and installing testing equipment, shall be included in the unit prices tendered in the Bill of Quantities for the applicable items of concrete.

E.7 TESTING OF CONCRETE AND CONCRETE MATERIALS

Except where otherwise stated, sampling and testing of concrete materials, fresh concrete and hardened concrete shall be conducted by the Contractor under the direction of the Supervision in accordance with the Japan Industrial Standards, or the ASTM, or approved equivalent. Check tests of concrete aggregates, fresh concrete, and hardened concrete will include, but will not be necessarily restricted to, those listed in Subparagraph E.1.2.

The Contractor shall execute routine tests of the concrete to determine the compressive strength, slump, air content and unit weight. The number and frequency of the tests of fresh concrete shall be as directed from time to time by the Supervision, provided that such tests shall be made at least twice for each class of concrete which is placed during the shift.

More frequent testing of fresh concrete will be required under certain circumstance, such as but not limited to times when the moisture content of fine aggregate is fluctuating, and the Contractor shall not be entitled to any additional compensation because of any additional sampling or testing of fresh concrete at any location directed by the Supervision. Results of

routine tests shall be submitted to the Supervision in the approved form and in such intervals as the Supervision may direct.

The Supervision will execute the check test of concrete material, fresh concrete and hardened concrete when he deems necessary. The Contractor shall fully assist the Supervision in such check tests.

The compressive strength of the concrete shall be determined by tests of 15 cm diameter by 30 cm high cylinders. In sampling fresh concrete, when the concrete contains aggregate larger than 40 mm, it will be necessary to remove such oversize material from the concrete to be used for slump tests or test specimens. Oversize material shall be removed by wet screening through a screen. The screened concrete shall be re-mixed with a shovel into a uniform mass before making slump tests and test specimens.

The Contractor shall provide such equipment, facilities, material and labour as may be necessary for producing, handling and waste disposal of respective test samples for the tests stipulated in these Specifications.

Samples will be required of all concrete ingredients and plastic concrete at the crushing plant, batching/mixing plant and at the forms where concrete is being placed. The batching/mixing plant shall be equipped with sampling devices and facilities approved by the Supervision for obtaining samples of water, cement, aggregates, admixtures and plastic concrete. Such sampling devices will be used frequently and should be designed to ensure that representative samples of appropriate size of the required material are obtained with the minimum disruption of the Contractor's production of aggregates and concrete. The Contractor shall bear any and all costs associated with the provision of such sampling facilities, labour and samples and shall not be entitled to any additional compensation for any delays or costs incurred in the provision of these samples.

No separate payment for samples of materials to be tested will be made; however, the costs for maintaining and operating a field laboratory, and for the testing of concrete and concrete materials shall be included in the lump sum price tendered therefor in the Bill of Quantities.

E.8 BATCHING

The Contractor shall install, maintain and operate batching equipment as required to determine and control within the specified limits of accuracy, the prescribed amounts of the various materials including water, cement, admixtures, fine aggregate and each individual size of coarse aggregate used for concrete.

The amount of water, cement, fine aggregate and each individual size of coarse aggregate shall be determined by weighing. The amount of the air-entraining admixture shall be determined by volumetric measurement in an approved positive displacement type dispenser, or by weighing in approved equipment, mounted so that no vibration of the equipment is possible under all conditions of batch plant operation.

The batch bins will be constructed so as to be self-cleaning during draw-down and the bins shall be drawn down until they are practically empty at least three times per week. Materials shall be deposited in the batch bins directly over the discharge gates. The coarse aggregate shall be deposited in the batch bins through effective rock ladders when the distance through which the aggregate would fall is greater than 1.5 m.

Equipment for conveying batched materials from the batchers or hoppers into the mixer shall be so constructed, maintained and operated so that there will be no spillage or contamination of the batched materials or overlap of batches. Equipment that fails to conform to this requirement shall be effectively modified or replaced to the satisfaction of the Supervision.

The construction and accuracy of the weighing and measuring equipment will be such that the equipment will maintain accuracy within 0.4% of the scale capacity. The equipment will be capable of ready adjustment for compensating for the varying weight of any moisture contained in the aggregates and for effecting changes in concrete mix proportions.

Batching equipment shall be maintained and operated so that the combined inaccuracy (error) in feeding and measuring the materials will not exceed 1.0% for water or air-entraining admixture and 3% for cement and each size of aggregate. Cement and water will be weighed in individual containers and the weight of each will be indicated on separate scales.

The Contractor shall, using standard test weights and any other necessary auxiliary equipment for checking the operating performance of each scale or other measuring device, make periodic tests over the ranges of measurements involved in the batching operations. The tests shall be made in the presence of the Supervision and shall be adequate to prove the accuracy of the measuring devices. Unless otherwise directed, tests of equipment in operation shall be made at least once every month. The Contractor shall make such adjustments, repairs, or replacements as may be necessary to meet the specified requirements for accuracy of measurement.

The operating mechanism in the water batching devices shall be so maintained that leakage will not occur when the valves are closed. After discharge no portion of the prescribed amount of mix water shall be retained in the water batcher.

Batching equipment shall be maintained and operated in such a manner that any noticeable increase of dust in the plant during the measuring and discharging of each batch of material is prevented.

The weighing hoppers will be so constructed that convenient removal of overweight material, in excess of the prescribed tolerances, will be practicable.

Aggregates shall not be batched for concrete or mortar when free water is dripping from the aggregates or when the aggregates are contaminated by dust.

E.9 MIXING

The concrete ingredients shall be mixed thoroughly in the Contractor's batch mixers until sufficient uniformity throughout the mixed batch is obtained for concrete samples taken from the start and the end of the mixer discharge to satisfy the following requirements:

- (a) The slumps of the two samples shall not differ by more than 25 mm.
- (b) The air content of the two samples shall not differ by more than 1.0%.
- (c) The unit weight of air-free mortar of the two samples shall not differ by more than 1.0% from the average weight of the two samples.
- (d) The unit weight of coarse aggregate of the two samples, each of which is 50 liters in volume, shall not differ by more than 8% from the average weight of the two samples.

Hand-mixing shall not be used for concrete to be used in permanent structures, and when used for temporary structures, it shall be strictly subject to the approval of the Supervision.

Unless otherwise directed or allowed by the Supervision, the mixing of each batch shall continue not less than nor more than 3 times of the following numbers of minutes, after all ingredients except the full amount of water and admixtures are in the mixer:

Capacity of Mixer (cubic meters)	Time of Mixing (minutes)
3 to 2	2.5
2 to 1.5	2
1.5 or less	1.5

The specific time of mixing shall be determined by the Supervision after performing the mixer efficiency test based on comparison of the samples taken from the start and the end of the mixer discharge as stated at the beginning of this Paragraph.

The minimum mixing periods specified are conditional on the materials being fed into the mixer in a manner which will facilitate efficient mixing and on operation of the mixer at its designed speed.

The Supervision reserves the right to vary the mixing time or to limit the batch size when the charging and mixing operations fail to produce a concrete batch that conforms to the foregoing requirements with respect to adequacy of mixing. The concrete, as discharged from the mixer, shall be uniform in composition and consistency within batches and from batch to batch except where changes in composition or consistency are required.

Water shall be added before, during and after the mixer-charging operations. Excessive overmixing requiring addition of water to preserve the required concrete consistency will not

be permitted. Concrete which has been retained in any mixer for more than 1.0 hour after charging the mixer shall be wasted.

Any mixer that at any time does not meet the requirements of this Paragraph shall be repaired promptly and effectively or shall be replaced. Mixers shall be loaded to their rated capacity or to such batch sizes as determined in accordance with the provisions of this Paragraph except when mixing mortar or concrete for the concluding phase of concrete placement. Mixers shall not be loaded in excess of their rated capacity unless specifically authorized by the Supervision, but in no case shall mixers be over-loaded by more than 10% of their rated capacity. Each mixer shall be equipped with a mechanically operated timing and signalling device which will indicate and ensure the completion of the required mixing period and will count the batches.

E.10 PLACING OF CONCRETE

E.10.1 General

No concrete shall be placed until all formwork, 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 Supervision.

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

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 Supervision. No special payment or allowance will be made for this.

E.10.2 Preparation for Placing

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, loose rock fragments, or other perishable materials by the use of high-velocity air-water jet or other effective means approved by the Supervision.

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

The surface of the rock foundation shall be moistened thoroughly before placing concrete, and standing water shall be removed.

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

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

E.10.3 Temperature of Concrete during Placing

Temperature of concrete when it is being placed shall be not more than 32°C. Whenever it is necessary to maintain the temperature of the concrete below 32°C as it is placed, the Contractor shall employ effective means, such as pre-cooling of aggregates, refrigerating the mixing water, placing at night or a combination of these or other methods approved by the Supervision.

The Contractor shall not be entitled to any additional compensation on account of the requirements of this Subparagraph.

If the concrete is placed when the weather is such that the temperature of concrete would exceed 32°C, as determined by the Supervision, the Contractor shall use water-reducing admixture, set-retarding type, to mitigate unfavorable effects on concrete caused by the high temperature.

E.10.4 Equipment for Transporting and Placing Concrete

The methods and equipment used for transporting and placing concrete and the time that elapses during transportation shall be that concrete will not cause appreciable segregation of coarse aggregate, a slump loss in excess of 25 mm, or a loss in air content before consolidation of more than 1% 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:

(1) Agitator Truck

The agitating speed of the drum shall be between 2 and 4 revolutions per minute. The volume of mixed concrete in the drum shall not exceed the manufacturer's rating nor exceed 70 percent of the gross volume of the drum. Upon approval of the Supervision, 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 1.0 hour. During this interval, the mixture shall be agitated continuously at the above-mentioned speed.

(2) Non-agitator Truck

Bodies of non-agitator trucks shall be smooth and watertight. Covers shall be provided when needed for protection against rainfall and sunshine. 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 2.5 cm in slump. Placing of concrete shall be completed within 1.0 hour after feeding mixing water into the cement and aggregates.

(3) Chutes

Transportation of concrete by the use of chutes will not be permitted in principle unless approved by the Supervision. 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 not less than 1.5 m in height to avoid segregation of falling concrete. Chutes shall be protected from direct rays of the sun and rainfall.

(4) Concrete Pump or Placer

Delivery pipes shall be so installed as to permit easy removal. Before starting the pump or placer operation, about one cubic meter 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 as possible. Air boosters shall not be used except in conditions where the outlet of the pipe is completely embedded at least 2 m in fresh concrete.

(5) Belt Conveyers

Transporting concrete by belt conveyers will not be permitted unless approved by the Supervision. If authorized, belt conveyers 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 conveyer to limit the drop of the concrete being placed to a maximum of 1.5 m.

Full details consisting of manufacturer's catalogs, drawings, manuals, etc. for each type of the above described items of equipment shall be submitted to the Supervision. 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 Supervision at least 30 days prior to their being used.

E.10.5 Placing

The Contractor shall keep the Supervision advised as to the time when the placing of concrete is to be performed. Placing of concrete shall be performed only in the presence of the Supervision.

Any concrete which has become so stiff that proper placing cannot be assured unless retempered, or of which the slump has been reduced by 2.5 cm or more, as determined by the Supervision, shall be wasted to places designated by the Supervision at the Contractor's expense.

Insofar 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 falling concrete shall not exceed 1.5 m.

All formed concrete, except lining concrete for underground structures, shall be placed in horizontal layers, the thickness of which shall not exceed 40 cm. The Supervision reserves the right to require lesser depths of layers where concrete in 40 cm layers cannot be placed in accordance with the requirements of these Specifications. The height of one lift of concrete placing shall be as designated on the Drawings or as directed by the Supervision.

Unless otherwise authorized by the Supervision, lining concrete for underground structures shall be placed by concrete pump or placer into the forms without high velocity discharge. Concrete shall be forced into all irregularities in the rock surfaces so that no voids are left. Where the invert concrete is placed separately from the sidewalls and arch concrete, and without inside form, pneumatic placing equipment shall not be used unless an approved type of discharge box which prevents segregation is provided.

Before starting concrete placing, mortar shall be fed through the pipe of the concrete pump or placer as specified in Item (4) of Subparagraph E.10.4. When filling the arch crown in underground structures, the end of the pipe of the concrete pump shall be kept buried at least 2 meters in fresh concrete. Placing equipment shall be operated by experienced persons only.

Cold joints shall be avoided where practicable in placing concrete in tunnels. 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 and as such shall comply with the stipulations of Sub-paragraph E.21.1.

In placing unformed concrete on slopes so steep as to make internal vibration of the concrete impracticable without forming, the concrete shall be placed ahead of an unvibrated slip-form screed extending approximately 80 cm back from its leading edge. Concrete ahead of the

slip-form screed shall be consolidated by internal vibrators so as to ensure complete filling under the slip-form. Vibrators used shall conform to the requirements of Subparagraph E.10.6.

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

- (a) Placing of concrete shall be delayed not less than one hour nor more than three 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 the concrete placed before the delay. When consolidating concrete placed after the delay, the vibrating unit shall penetrate and revibrate the concrete placed before the delay.
- (b) The last 60 cm or more 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.
- (c) 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.
- (d) 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 over the unit prices tendered in the Bill of Quantities for concrete by reason of any limitations in the placing of concrete required under the provisions of this Paragraph.

E.10.6 Consolidation

Each layer of concrete shall be immediately 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.

Concrete shall be consolidated in principle with electrical or pneumatic power-driven, internal-type vibrators, operating at a speed of at least 7,000 revolutions per minute when immersed in concrete. The vibrating head shall be inserted in concrete vertically and at least 5 cm into the underlying layer. Where it is difficult to use internal vibrators, concrete may be consolidated with the external-type form vibrators as described hereinunder or compacted with a handplunger as directed by the Supervision.

Consolidation of concrete in parts of structures exposed to view shall be by immersion-type vibrators supplemented where directed by the Supervision, by approved heavy-duty form vibrators. Form vibrators shall be firmly attached to the form during operation but the vibrator shall be capable of being quickly removed and re-attached to other positions on the forms and shall operate at speeds of at least 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 surfaces of the forms shall be avoided.

E.11 CURING OF CONCRETE

Although attention to curing requirements is important at all times, it is especially so in hot or dry weather because of the greater danger of crazing or cracking, and the Contractor shall therefore strictly follow the requirements listed herein.

The Contractor shall protect all concrete against damage or harmful effects due to sudden drying, loading, shock or vibration until it has hardened sufficiently to prevent damage. Where possible, the exposed finished surface of concrete will be protected from the direct rays of the sun for at least the first 3 days after placement, in principle, or otherwise by means approved by the Supervision.

All concrete shall be cured by water curing or by membrane curing in accordance with the requirements specified herein except that precast concrete may be steam cured using a method approved by the Supervision. 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 requirements for water curing and membrane curing are stipulated as follows:

(a) Water Curing

Concrete cured with water shall be kept wet for at least 14 days immediately following placement of the concrete, or until covered with fresh concrete, by covering with water-saturated material or by a system of perforated pipes, mechanical sprinklers or porous hose,

or by any method approved by the Supervision which will keep all surfaces continuously (not periodically) wet, provided that water used for curing shall meet the requirements of Paragraph B.4. Water curing shall be handled so as to prevent the formation of unsightly stains on concrete surfaces which will be permanently exposed.

(b) Membrane Curing

Membrane curing shall be by application of an approved type of white pigmented curing compound which forms a water retaining membrane on the surfaces of the concrete, provided that on concrete surfaces which will be permanently exposed to view an approved grey pigmented curing compound may be required. Curing compound will be used on surfaces for which F3 finish is required. Curing compound shall be applied to the concrete surfaces by spraying on one coat to provide a continuous uniform membrane over all areas, with a maximum coverage per litre as directed by the Supervision according to the roughness of the surface to be covered. If necessary to adequately cover the surface, as determined by the Supervision, a second coat of curing compound shall be applied. Mortar encrustations and fins on surfaces for which F3 finish is specified shall be removed from formed surfaces prior to application of the curing compound.

When curing compound is to be used on unformed concrete surfaces, application of the compound shall commence immediately after the finishing operations are completed.

When curing compound is to be used on formed concrete surfaces, the surface shall be moistened with a light spray of water immediately after the forms are removed, and shall be kept wet until the surfaces will not absorb more moisture. As soon as the surface film of moisture disappears but while the surface still has a damp appearance, the curing compound shall be applied. There must be ample coverage with the compound at edges, corners and rough spots of formed surfaces. After application of the curing compound has been completed and the coating is dry to the touch, any required repair of concrete surfaces shall be performed. Each repair, after being finished, shall be moistened and coated with curing compound in accordance with the foregoing requirements.

Equipment for applying curing compound and the method of application shall be approved by the Supervision.

Traffic and other operations by the Contractor shall be such as to avoid damage to coatings of curing compound for a period of not less than 28 days after application of the curing compound. Where it is impossible because of construction operations to avoid traffic over surface coated with curing compound, the membrane shall be protected by a covering of sand not less than 25 mm in thickness or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. Before final acceptance of the work, the Contractor shall remove all sand covering in a manner acceptable to the Supervision. Any sealing membrane that is damaged or which peels from concrete surfaces within 28 days after application, shall be repaired without delay and in a manner satisfactory to the Supervision.

The proposed type of curing compound shall be made available for sampling and testing by the Supervision at least twenty-eight (28) days prior to use. Unless sampling and testing are waived by the Supervision, curing compound shall not be used until it has been tested and approved. The Contractor shall provide, at the Contractor's expense, such facilities and assistance as may be necessary for testing the curing compound. Instructions supplied by the manufacturer shall be followed when storing, mixing and applying the curing compound.

In addition to spray membrane curing, sheet plastic may also be used, especially in curing slabs and structural shapes. In such cases, as soon as the concrete has hardened sufficiently to prevent damage, the surface is to be sprayed lightly with water and then completely covered with a white, 0.10 to 0.15 mm (4- to 6-mil), plastic sheet. The sheet shall be airtight, non-staining and vaporproof to effectively prevent loss of moisture by evaporation. Care must be exercised in obtaining and airtight membrane by lapping and sealing all edges. This type of membrane shall be maintained for a minimum of 14 days.

All construction joints shall be kept continuously moist by water curing, regardless of time, until they are covered with concrete, provided that if it becomes necessary to delay the placement of new concrete upon or against a construction joint for an extended period, moist curing of the surface of the joint may be discontinued at the expiration of the regular prescribed curing period, but if the moist curing is so discontinued, it shall be resumed not later than 48 hours prior to the placement of new concrete against the joint.

Where chipped openings in concrete are not made until after the expiration of the regularly prescribed curing period, the surface of the openings shall be kept continuously moist for at least 4 hours immediately prior to filling.

The cost of furnishing and applying all materials used for curing concrete shall be included in the unit prices tendered in the Bill of Quantities for the applicable items of concrete construction.

E.12 MEASUREMENT AND PAYMENT FOR CONCRETE

Measurement, for payment, of each class of concrete required to be placed directly upon or against surfaces of excavation will be made on the basis of the neat lines of open excavation and the B-lines of underground excavation as specified in Sub-paragraph C.13.2.

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. The Supervision reserves the right to designate the classes of concrete or mix proportions of mortar which are to be placed beyond the designated lines.

Measurement, for payment, of each class of all other concrete will be made on the basis of the actual volume of concrete within the neat lines and grades of the structures, as shown on the Drawings unless otherwise prescribed in these Specifications.

No measurement for payment will be made for processing and transportation of aggregates, foundation preparations, construction joint treatment including the mortar applied before placing concrete, repair, architectural features, etc., for curing or for hot weather concreting.

In measuring concrete for payment, the volume of all openings, recesses, ducts, embedded pipes, woodwork, and metalwork, each of which is larger than 0.05 square meters in cross section, will be deducted.

Unless otherwise specified, payment for each class of concrete in the various parts of the work will be made at the unit prices per cubic meter of the volume tendered therefor in the Bill of Quantities.

The unit prices shall include: (a) the cost of all equipment, labor, all materials, water from the water supply system and handling of water for concrete mixing, and cleaning; (b) the cost of producing aggregates such as quarrying if any, transportation, crushing, screening, washing, storing and mixing of aggregates; (c) the cost of bathing, mixing, transportation, placing, compaction, surface finishing, curing, cooling, protection, and repairing of concrete; (d) the cost of treatment of construction joints; and (e) the cost of testing works; except formwork, reinforcing bars, joint filler and waterstops for which separate payment will be made as provided in Paragraphs E.13, E.14, E.24 and E.22, respectively.

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 expenses of the Contractor.

No separate measurement and payment will be made for the use of admixtures. All costs incidental to the use of admixtures shall be included in the unit prices tendered therefor in the Bill of Quantities for the respective applicable items of concrete in which the admixtures are used.

E.13 FORMWORK AND FINISHES

E.13.1 General

Forms shall be used, whenever necessary or particularly directed by the Supervision, to confine concrete and shape it to required lines. Where required, forms will be supported by scaffolding. The Contractor shall determine, considering cost efficiency and safety, whether the type of forms and any necessary scaffolding shall be made of steel or lumber and shall submit his design drawings for such to the Supervision for approval prior to manufacturing the forms.

The forms and any required scaffolding shall have sufficient strength and rigidity to hold the concrete and to withstand the pressure resulting from placement and vibration without deflection from the prescribed lines. The surfaces of all forms to be in contact with the concrete shall be clean, rigid, and sufficiently tight to prevent loss of mortar.

Edges at intersections of concrete surfaces that will be exposed permanently to view, and other edges of concrete surfaces designated by the Supervision, shall be beveled or rounded not less than 2 cm by the use of molding strips.

Formwork is classified only in terms of the concrete finish required, as shown on the Drawings and specified in Sub-paragraph E.13.6.

Forms for concrete surfaces for which finish F3 is specified shall not be constructed continuously from lift to lift but shall be removed after concrete in a lift has hardened, and reset for the next lift. Form tie holes shall be located in a regular pattern approved by the Supervision before the formwork is constructed. The reset forms shall overlap the hardened concrete in the lift previously placed by not more than 30 mm and shall be tightened snugly against the hardened concrete so that, when the concrete placement is resumed, the forms will not spread and allow offsets or loss of mortar at construction joints. Additional bolts or form ties shall be used as necessary to hold the reset forms tight against the hardened concrete. All joints and grooves shall be straight and true.

Before starting fabrication of formwork required to form concrete surfaces for which finishes other than F1 are specified, the Contractor shall submit for approval his proposed methods of constructing forms to obtain the type of surface finish specified.

E.13.2 Material for Forms

All material used in the forms, whether steel or lumber, shall be subject to the review and/or approval by the Supervision. Lumber shall be sound and straight, free from warp, decay and loose knots, and be dressed smooth and uniform in width and thickness prior to fabrication of formwork.

Forms to be used in water passages and for concrete which will ultimately be exposed to view shall be faced with either plywood 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. Insofar 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 discoloration 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 with the applicable requirements of these Specifications pertaining to finish of formed surfaces.

Where finishes F2, F3 and F4 are specified the sheathing or lining shall be placed so that the joint marks on the concrete surfaces are generally horizontal, and vertical, and continuous and the form sheathing material used for such surfaces shall be restricted to major feature of the work.

Form sheathing and lining shall conform to the following requirements; unless otherwise authorized by the Supervision.

Required Finish of Formed Surface	Timber Sheathing or Lining	Steel Sheathing or Lining *
F1	Any type and grade approved by the Supervision	Steel sheathing permitted Steel lining permitted
F2	Any type approved by the Supervision, shiplap or ply-wood sheathing and lining	Steel sheathing permitted. Steel lining permitted if approved by the Supervision
F3	Plywood sheathing or lining	Steel sheathing and sliding form permitted
F4	Plywood sheathing or lining coated with plastic or epoxy	Steel sheathing not permitted. Steel lining permitted

* Steel sheathing denotes steel sheets not supported by a backing of timber boards. Steel lining denotes thin steel sheets supported by a backing of timber boards.

E.13.3 Installation of Forms

Forms shall be installed 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 Supervision.

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 between the forms. The surface of the forms shall be oiled with a refined mineral oil of a type approved by the Supervision. The form oil shall be applied before the reinforcement 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 Supervision.

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 a serviceable condition and shall be thoroughly cleaned before being reused. Forms for exterior faces of 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.

E.13.4 Internal Ties

Embedded ties for holding forms shall remain embedded, and except where F1 finish is permitted, shall terminate not less than twice of diameters or twice of the minimum dimension of the tie or 5 mm, whichever is the greater, in from the formed faces of the concrete. Where F1 finish is permitted, ties may be cut off flush with the formed surfaces except where ties are fastened to reinforcement.

Wire ties passing through the forms shall not be used unless authorized by the Supervision. The ties shall be constructed so that removal of the ends or end fasteners can be accomplished without causing appreciable spalling at the faces of the concrete. Recesses resulting from removal of the ends of form ties shall be filled in accordance with the provisions of Sub-paragraph E.13.7.

E.13.5 Removal of Forms

Forms shall not be removed until the concrete has hardened and is of sufficient strength to carry its own weight safely, together with any construction load likely to be imposed upon it. Forms shall be removed only with the approval of the Supervision.

Except as otherwise provided herein, forms shall be removed as soon as the concrete has hardened sufficiently without any damage of concrete by careful form removal in order to facilitate satisfactory progress with the specified curing and to enable the earliest practicable repair of any surface imperfections; however, it must be ascertained in advance that the strength of the concrete is such that removal of forms shall not be the reason for the concrete to collapse or fail.

Forms on upper sloping faces of concrete, such as forms on the water sides of warped transitions, shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging or collapse. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and be followed immediately by the specified curing.

In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening.

Upon the approval of the Supervision, forms on concrete surfaces close to excavated rock surfaces may be left in place, provided that the distance between the concrete surface and the rock is less than 50 cm and that the forms are not exposed to view after the completion of the Works.

Forms shall be removed with care so as to avoid injury to the concrete, and any concrete so damaged shall be repaired in accordance with the provisions of Sub-paragraph 5.13.7.

E.13.6 Finishes and Finishing

(1) General

Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings, as specified in Paragraph E.16 are defined as tolerances and are to be distinguished from irregularities in finish as described herein. The classes of finish and the requirements for finishing of concrete surfaces shall be as shown on the Drawings, or as hereinafter specified. In the event that finishes are not definitely specified herein or on the Drawings, the finishes to be used shall be those specified for similar adjacent surfaces, as determined by the Supervision.

Finishes of concrete surfaces shall be performed only by skilled workmen. The Contractor shall keep the Supervision being advised as to when finishing of concrete will be performed. Unless inspection is waived by the Supervision in each specific case, finishing of concrete shall be performed only in the presence of the Supervision. Concrete surfaces will be tested by the Supervision where necessary to determine whether surface irregularities are within the limits hereinafter specified.

Surface irregularities are classified as abrupt or gradual. Offsets caused by displaced or misplaced from sheathing or lining or form sections, or by loose knots or otherwise defective forms will be considered as abrupt irregularities, and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities, and will be tested by use of a template consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 1.5 m for testing of formed surfaces, and 3 m for testing of unformed surfaces.

(2) Formed Surfaces

The classes of finish for formed concrete surfaces are classified into four and are designated by use of symbols F1, F2, F3 and F4. Bag rubbing or sandblasting will not be required on formed surfaces. Nor will grinding be required on formed surfaces, other than that necessary for the repair of surface imperfections. Unless otherwise specified or indicated on the Drawings, the classes of finish shall apply as follows:

(a) Class F1

The surface of Class F1 formwork shall be formed by plane segments. This is a rough finish which is generally intended for unexposed surface without special treatment.

(b) Class F2

The surface of Class F2 formwork shall be formed by plane segments and curved surface. This is required for structural surface permanently exposed to view. If

wooden boards are used for this formwork they shall be planed boards of uniform thickness and width. The edges and inside shall in all cases be planed. These boards shall have square edges, and uniformly arranged with nail and knot holes filled flush with putty or other approved substance. Other materials for this Class shall be subject to approval of the Supervision.

(c) Class F3

The surface of Class F3 formwork shall be formed by plane segments and curved surfaces. This finish is required for surfaces of water passages, such as open channel lining concrete and concrete facing wall in inlet channel. The surfaces will be permanently exposed to public view and where an attractive appearance is paramount. It shall be free from boardmarks or surface pitting and the formwork shall be faced with plywood, steel plates or equivalent materials in as large sheets as possible and arranged uniform pattern.

Joints in the facing shall coincide with architectural features or changes in direction on the surface and shall be either vertical or horizontal unless otherwise approved or shown on the Drawings.

(d) Class F4

The surfaces of Class F4 formwork shall be formed by using a steel sliding form and required for eliminating destructive effects of water action in the tunnel.

(3) Unformed Surface

The classes of finish for unformed concrete surfaces are classified into three and are designated by the symbols U1, U2 and U3. Interior surfaces shall be sloped for drainage where shown on the Drawings or directed by the Supervision. Unless the use of other slopes or level surfaces is indicated on the Drawings or directed by the Supervision, surfaces which will be exposed to the weather and which are nominally level shall be sloped approximately 1 vertical to 50 horizontal for drainage. Unless otherwise specified or indicated on the Drawings, the classes of finish for unformed surfaces shall apply as follows:

(a) Class U1

Finish U1 is a screeded finish to be applied to unformed surfaces that will be covered by fill material or by concrete. Finish U1 is also used as the first stage of Finishes U2 and U3. Finishing operations shall consist of sufficient leveling and screeding to produce even and uniform surfaces.

(b) Class U2

Finish U2 is a floated finish to be applied to unformed surfaces which will be generally exposed to view. Finish U2 is also used as the second stage of Finish U3. Floating

shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture.

(c) Class U3

Finish U3 is a troweled finish to be applied to the unformed surfaces of waterways which will be permanently exposed to public view and where an attractive appearance is paramount. When the floated finish has hardened sufficiently to prevent an excess of fine material from being drawn to the surface, steel troweling shall be started. Steel troweling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. If Finish U3 is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface, so as to permit effective trowelling. Sprinkling of the surfaces with dry cement or any other material during finishing operations for drying off the concrete to facilitate trowelling or for any other purpose will not be permitted.

No separate payment shall be made for the work under this Item (3). The cost therefor shall be included in the appropriate unit prices for concrete work tendered in the Bill of Quantities.

(4) Allowable Surface Irregularities

The surface irregularities of finished concrete surfaces shall not exceed the following allowable irregularities:

Type of Finish		Allowable Irregularities	
Formed Surface	Unformed Surface	Abrupt	Gradual *
Class F1	Class U1	10 mm	25 mm
Class F2	Class U2	6 mm	15 mm
Class F3	Class U3	3 mm	6 mm
Class F4	-	2 mm	4 mm

* Measured on a straight or curved length of 2.0 m.

E.13.7 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 his own expense. Irregularities of alignment due to inaccurate finishing of surfaces, 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 Supervision.

Repair of concrete shall be performed by skilled workmen. The Contractor shall keep the Supervision advised as to the time when repair of concrete is to be performed. Unless inspection is waived by the Supervision, in each specific case the repair of concrete shall be performed only in the presence of the Supervision.

The Contractor shall correct all imperfections on the concrete surfaces as necessary to produce surfaces that conform to the requirements specified in Subparagraph E.13.6 and Paragraph E.16. Unless otherwise approved by the Supervision, repair of imperfections in concrete shall be completed within 24 hours after removal of forms, or in the case of unformed concrete within 24 hours after the placing of the concrete, except that if epoxy resin repairs are required the repair shall not be made until 28 days after the concrete has been placed. Fins and encrustations shall be neatly removed from surfaces for which F3 and F4 finish are specified, and encrustations shall be removed from surfaces for which U2 and U3 finishes are specified.

Where bulges and abrupt irregularities protrude outside the limits specified in Paragraph E.16 on formed surfaces for which finishes other than F1 are required, the protrusions shall be reduced by bushhammering and grinding so that the surfaces are within the specified limits.

Concrete damaged by any cause, honeycombed, fractured or otherwise defective, and concrete which must be 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 hereinafter specified. The filling of recesses in surfaces designated to receive finish F1 will be required only where such recesses are deeper than 25 mm in walls having less than 30 cm thick. The filling of recesses will not be required if finished walls have thicknesses of 30 cm or more after placement.

All porous and fractured concrete and surface of concrete, to which repair is required to bring it to prescribed lines, shall be removed by the Contractor by chipping openings into concrete to bare the reinforcement. The extent and dimensions of the chipped openings shall be as directed by the Supervision. The chipped openings shall be sharp-edged and keyed and shall be filled to the required lines by dry-pack mortar or concrete as directed by the Supervision. Where concrete is used for filling, the chipped openings shall be not less than 8 cm in depth.

Dry-pack mortar of a mixture approved by the Supervision shall be used for filling holes having at least one surface dimension not greater than the hole depth, for narrow slots cut for repair of cracks, and for tie-rod fastener recesses as specified. Dry-pack mortar shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.

Mortar filling, placed under impact by use of a mortar gun, shall be used for repairing defects which are too wide for dry-pack filling and too shallow for concrete filling and are not deeper than the far side of the reinforcement that is nearest the surface.

Mortar for patching shall consist by volume of one part of cement, two parts of regular concrete sand, and just enough water so that after thorough mixing of the ingredients the mortar will barely hold together when compacted by squeezing with the hand. The mortar shall be fresh when placed and any mortar that is not used within two hours after preparation shall be wasted. In no time prior to mortar application, the surface to which the mortar is to be bonded shall be dampened, then scrubbed with a small quantity of mortar using a wire brush.

Where chipped openings are more than 3 cm deep, the mortar shall be applied in layers not more than 2 cm thick to avoid sagging. After each layer, except the last, is placed, it shall be thoroughly roughened by scratching with a trowel to provide an effective bond with the succeeding layers. The last or finishing layer shall be smoothed with a trowel to form a continuous surface with the surrounding concrete. The addition of a small quantity of water to the finished surface of the patch to aid in securing a smooth finish will be permitted, but other than this no additional water shall be used. All patches on exposed surfaces shall be neat and smooth and as near as possible of the same color as the adjoining concrete. All patches shall be thoroughly bonded to the surfaces of the chipped opening and shall be sound and free from shrinkage and cracks.

Concrete filling instead of mortar filling, shall be used for holes extending entirely through concrete sections; i.e., for holes which are greater in area than 1,000 cm² and deeper than 10 cm and for holes in reinforced concrete which are greater in area than 500 cm² and which extend beyond the reinforcement that is nearest the surface. The class of concrete shall be as directed by the Supervision.

In repairing damaged or defective concrete at important locations, the Contractor shall use epoxy resin bonding agent if directed by the Supervision. All imperfections and air holes to be repaired with epoxy resin shall be chipped back to sound concrete and the edges of the holes trimmed square for a minimum depth of 3 mm. The following requirements shall be complied with for performing repairs with epoxy resin although they may be varied depending on the Supervision's analysis of the situation:

- (a) In no time prior to carrying out a repair, the surface of the concrete in the hole shall be freed of all contaminants by sandblasting, etching with a 5% solution of hydrochloric acid or other approved method. If acid etching is the approved method, immediately after the foaming ceases, the hole shall be thoroughly flushed with clean and fresh water to remove the acid and clean the area. The surface of the hole shall be mopped dry and where necessary, effective means taken to exclude all surface water. The surface of the hole and the concrete immediately surrounding it shall be dried and heated, using lamps, an oxy-acetylene flame fitted with a descaling tip, heaters, dry oil-free compressed air or other suitable means approved by the Supervision. The heating and drying shall be carried out in such a manner as to prevent damage to the concrete and until the hole is free from surface moisture and the temperature of approximately 20°C has been obtained and maintained over the area for a period of 30 minutes.

- (b) When prepared in accordance with the preceding paragraph, the surface of the hole shall be painted with one or more coats of an approved unfilled epoxy resin prepared and cured in accordance with the manufacturer's instructions. The approved epoxy resin with approved filler prepared in accordance with the manufacturer's instructions shall be applied to a clean surface of the unfilled epoxy resin, steel trowelled to smooth surface and allowed to cure as directed by the Supervision. It is anticipated that curing at 20°C for a period of 24 hours will be required. During that time the area shall be kept dry.
- (c) Unused epoxy resin, either filled or unfilled, shall be wasted when it loses its plastic condition. Excess or spilled resin shall be cleaned up while in a plastic state.
- (d) If it is necessary to use for forming to mould the filled resin mixture, either the material used for the forms shall be incompatible with the resin or the form shall be coated with a special release agent.
- (e) The finished surface of the epoxy resin shall conform to the requirements of Paragraph E.16. Any grinding required shall be performed using a silicon carbide or other suitable abrasive, and preferably under water.

Except for materials used for repairs with epoxy resin, all materials used in the repair of concrete shall conform to the requirements of these Specifications and any directions by the Supervision. All fillings shall be bonded tightly to the surfaces of the holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been cured and have dried.

All patches and repairs shall be kept continuously damp for a period not less than 7 days and kept out of the direct rays of the sun for at least 3 days following completion of the patch or repair. The applicable parts of Paragraph E.11 shall be complied with.

The cost of all materials, labour and equipment required in the repair of concrete shall be borne entirely by the Contractor.

E.13.8 Measurement and Payment for 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. 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 Supervision 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) Forms used in construction joints of lining concrete of adit and tunnel except those specified on the Drawings,
- (h) Other surfaces as designated by the Supervision.

Payment for forms, and scaffolding where required, for concrete will be made at the applicable unit prices per square meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all labor, equipment and material required to perform the forming work including fabrication, placing, scaffolding work, removing, cleaning, repairing and similar items.

E.14 REINFORCING BARS

E.14.1 General

The Contractor shall furnish and install all reinforcing bars required for completion of the Work.

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 fifty-six (56) days before the scheduled placement of concrete around the reinforcement.

The delivery schedule is to be based on the Contractor's detailed construction program, including amendments if any, as reviewed by the Supervision.

Except where otherwise stated, the reinforcing bars shall be deformed steel bars, shall be made by an approved manufacturer, and shall comply with JIS G 3112-75 or ASTM A 15-66 or approved equivalent.

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 Supervision before the fabrication and placing of reinforcing bars.

Construction details for the reinforcement and bar bending schedules shall be prepared by the Contractor and submitted to the Supervision for approval. Such details shall be based on data furnished in the Drawings.

The Specifications for wire mesh reinforcement for shotcrete (pneumatically applied mortar) are listed in Paragraph E.17.

E.14.2 Fabrication and Placing

Reinforcing bars shall be placed where shown on the Drawings or where directed by the Supervision. 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.

Before the reinforcing bars are placed, the surfaces of the bars and the surfaces of any bar supports shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease, or other foreign substances, which, in the opinion of the Supervision are objectionable. If necessary, as determined by the Supervision, exposed and previously placed bars shall be cleared of rust and debris before being covered by concrete.

Unless otherwise shown, reinforcing bars shall be accurately placed and secured in position so that there will be a clear distance of at least 25 mm between the bars and any adjacent embedded metalwork and so that the bars will not be displaced during the placing of the concrete.

Chairs, hangers, spacers and other satisfactory metal or concrete supports may be furnished and used by the Contractor for supporting the reinforcing bars and for maintaining required distances from the surfaces of forms or foundations. Concrete supports, where used, shall conform to the concrete requirements of these Specifications. Steel spacers which are liable to cause rust staining of finished surfaces shall not be used.

Bars shall be tied at all intersections, and splicing tied at several points, by using annealed iron wire more than 0.9 mm in diameter or suitable clips.

Joints or splices in reinforcing bars shall be made at the positions shown on the Drawings. Except where the use of approved screwed couplings is required by the Drawings, reinforcement bars shall be lapped at all approved splices.

Welding for joints or splices in reinforcing bars shall only be performed with the approval of the Supervision, and shall be in accordance with ASTM A 185 or approved equivalent. No separate payment will be made for such welding.

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 Supervision before placing concrete.

E.14.3 Measurement and Payment

Measurement, for payment, of furnishing, cutting, bending and placing of reinforcing bars will be made for the weight of bars embedded in concrete in accordance with the Drawings or as directed by the Supervision.

Payment for furnishing, cutting, bending and placing reinforcement bars will be made at the unit prices per metric ton tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all labor, equipment and materials required to perform the work described in this Paragraph. Such unit prices shall also include the cost of attaching wire ties and metal, concrete or other supports, cleaning, securing and maintaining in position all reinforcing bars, and the cost of screwed couplings where these are used.

The unit prices for joint dowels shall also include the cost of bituminous coating.

E.15 BLOCKOUTS IN CONCRETE

E.15.1 General

Blockouts in concrete shall be constructed, as shown on the Drawings or as directed by the Supervision, 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 Class A concrete or mortar as directed by the Supervision after the installation is completed.

Before concrete or mortar is placed in the blockouts, the 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-paragraph E.10.2 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 Supervision, it shall be kept moist for at least 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 Supervision, concrete placed in blockouts shall contain an approved expander or shall be delayed between mixing and placing to reduce subsequent shrinkage.

E.15.2 Measurement and Payment

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 corresponding 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 Supervision and in accordance with the provisions of Paragraph E.12.

Payment for blockout concrete will be made in accordance with the provisions of Paragraph E.12 at the unit prices per cubic meter tendered in the Bill of Quantities.

E.16 CONSTRUCTION TOLERANCES

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 Sub-paragraph E.13.6.

This Paragraph establishes tolerances that are consistent with construction practices, 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 in this Paragraph, provided that the Supervision may reduce the tolerances set forth herein if such tolerances impair the structural action or operational function of a structure.

Where tolerances are not stated in the Specifications or Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this Paragraph. Notations on the Drawings or as may be included elsewhere in these Specifications, of specific tolerances in connection with any dimensions, shall be considered as supplemental to the tolerances specified in this Paragraph.

The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits and shall ensure that the work is completed within the tolerances specified herein. Concrete work that exceeds these tolerance limits shall be remedied or removed and replaced by and at the expense of the Contractor.

(a) Construction Tolerances for Concrete Construction

Variation from the plumb, from specified batter, or from the curved surface in the lines and surface of columns, piers, walls, arch sections, vertical joint grooves and other conspicuous lines:

12 mm in 3 m

18 mm in 6 m

30 mm in 12 m.

(In buried construction, double the tolerance.)

Variation from the level or from the grades indicated on the Drawings in floors, inverts, ceilings, beam soffits, horizontal joint grooves and other conspicuous lines:

6 mm in 3 m

12 mm in 10 m or more.

(In buried construction, double the tolerance.)

Variation of the linear structure lines from established portion in plan:

12 mm in 6 m

18 mm in 12 m or more.

Variation in locations of sleeves, and size and locations of floor openings and wall openings:

6 mm.

Variation in cross-sectional dimensions of columns, beams and in the thickness of slabs and walls:

Minus 6 mm

Plus 12 mm.

Variation from the plumb and the level in sills and side walls for gates and trashrack grooves:

3 mm in 3 m.

Variation in a flight of stairs:

3 mm in rise

6 mm in tread.

Variation in consecutive steps:

2 mm in rise

3 mm in tread.

(b) Construction Tolerances for Concrete in Tunnel Lining

Departure from established alignment or from established grades but parallel to it:

12 mm.

Variation in thickness of linings at any point:

Minimum 0 mm

Maximum No limit but within the reason as determined by the Supervision.

Variation from inside dimensions:

0.5 %.

(c) Construction Tolerances for Placing Reinforcing Bars

Variation of protective covering:

6 mm with 50 mm cover less

9 mm with 51 - 60 mm cover

12 mm with more than 60 mm cover.

Variation from specified spacing (any one bar):

25 mm.

(d) Construction Tolerances for Placing Embedded Metalwork

Minus 6 mm.

Plus 6 mm.

(e) Tolerance for 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.

E.17 SHOTCRETE

E.17.1 General

These Specifications apply to all work in which shotcrete will be used, such as for strengthening rock surfaces, slope protection, special support in tunnel construction and for various kinds of relatively thin linings.

Shotcrete shall be such a pneumatically applied mortar or concrete that mixture of Portland cement, aggregates, water and additives, if applicable, is shot into or over places by means of compressed air through a spray nozzle. If this shotcrete is properly proportioned, mixed, placed and cured, it forms a very hard, high-strength concrete.

Prior to commencement of the works, the Contractor shall submit details of the work method, construction equipment to be used, proposed mix design, proposed gradation of fine and coarse aggregates, and work schedule for the approval of the Supervision.

Depending on the condition of the area being treated, any one of the following types of treatment may be directed.

- (a) Shotcrete without steel mesh reinforcement, if any.
- (b) Shotcrete with steel mesh reinforcement for slope protection.
- (c) Shotcrete with steel mesh reinforcement for tunnel support.

Shotcrete work shall be done by skilled spraying crew as approved by the Supervision.

E.17.2 Materials

The basic types of materials to be used for the shotcrete shall be as specified hereafter but these may be changed or varied as determined by the Supervision.

(1) Cement, Admixtures and Water

Cement, admixtures and water for shotcrete shall conform to the requirements of Paragraphs E.2 and E.4.

(2) Fine Aggregate

Fine aggregate used in shotcrete shall be well graded, complying with the requirements of Sub-paragraph E.3.2, and the moisture content shall be 3 to 5 percent. The maximum size of aggregate shall be 5 mm and the fineness modulus shall range between 2.5 and 3.3.

(3) Coarse Aggregate

Coarse aggregate used in shotcrete shall comply with the requirement of Sub-paragraph E.3.3. The maximum size of aggregate shall be 10 mm and grading of coarse aggregate shall be as shown below. However, this may be varied if so direct by the Supervision, and in such case the Contractor shall be entitled to no additional allowance or payment.

Sieve Designation Mean Opening (mm)	Standard Percentage by Weight Passing Individual Sieve
15	100
10	40 - 80
5	0 - 15
2.5	0 - 5

(4) Steel Mesh Reinforcement

Steel mesh reinforcement to be used in shotcrete for slope protection as well as for tunnel support shall be as shown on the Drawings or as directed by the Supervision, and shall consist of 3.2 mm iron wire which shall comply with JIS G 3532-62 or approved equivalent, and shall have a chain wire mesh opening of 100 mm by 100 mm or approved by the Supervision. The steel mesh reinforcement to be used in the tunnels shall be fixed to the

rock bolts to be installed around the sides and roof of tunnels which are carried out in the underground excavation prescribed in the Specifications listed in Paragraph C.15.

Steel mesh reinforcement shall be fastened with nails, staples or other types of surface anchors so that it fits firmly and soundly to the surface. The mesh may be fastened either directly to the rock surface or to the initial layer or layers of mortar. Depending on the character of the rock being treated, the Supervision may direct the use of rock anchors for fastening steel mesh reinforcement in addition to surface anchors.

Surface anchors are defined as any device used for fastening the steel mesh reinforcement which do not penetrate the rock to a depth greater than 30 cm and include nails, staples, and embedded wire ties.

Rock anchor for steel mesh reinforcement shall consist of 16 mm diameter ungrouted bolts 1 m long, fitted with and approved expansion type anchor at one end and with a 100 mm x 100 mm x 6 mm thick bearing plate, washers and nut at the other end. The rock anchors shall be threaded for at least 125 mm at the free end.

(5) Pipe for Weep Holes

Polyvinyl chloride (PVC) pipe, 50 mm in diameter, meeting the requirements of JIS K 6741 or approved equivalent shall be used for weep holes.

E.17.3 Mixing Proportion and Quality Control

The Contractor shall propose the required mixing proportion for shotcrete of cement, aggregate, water and suitable additives in each type for the approval of the Supervision. The Contractor shall make every effort to ensure the compressive strength more than 210 kgf/cm² after age of 28 days. Final mixing proportion and minimum compressive strength will be determined on the basis of test results upon approval of the Supervision.

For the purpose of approving mix design, the Contractor shall prepare not less than 3 test panels for each mix for testing by the Supervision initially at least twenty-eight (28) days before any shotcrete is started in the Works, before approval of an additive is given, when the use of new equipment is proposed, and subsequently, whenever in the opinion of the Supervision, shotcrete is being produced which does not meet these Specifications.

For approximately every 1,000 m² for each important shotcrete section, one test consisting 3 panels shall be performed.

If the test results are unsatisfactory, the test is to be repeated at the Contractor's expense on a sample taken from the in-place shotcrete. At the request, specimens shall be drilled, chiselled or otherwise removed from the finished tunnel or other lining and brought to the site laboratory.

Sets of 3 panels for mix design approval and for routine quality control shall consist of one shot downward onto a horizontal surface.

All panels shall have a minimum thickness of 8 cm. Panels shall be made in the presence of the Supervision. The panels shall be left undisturbed at the point of placement until the final set has taken place.

The Supervision will determine the compressive strength of the shotcrete by testing 8 cm cubes sawn from the test panels immediately before testing. Ends shall be capped in accordance with ASTM Designation C 192 or approved equivalent.

Cube test results will be statistically analyzed in accordance with the recommendations of ACI 214. Test results shall be consistent with the average 28 days compressive strength required to limit the probability of tests falling below the specified crushing strength to one out of every 5 tests with a coefficient of variation of 15 percent for tests for mix design approval and 20 percent for tests for quality control. The average of any 6 consecutive tests shall not be less than the specified crushing strength.

The aggregate and cement with or without the water shall be thoroughly mixed to the satisfaction of the Supervision in an approved mixer and then promptly placed in an approved pneumatic placing machine and deposited in the layers specified so as to avoid partial setting of the cement. Mixed aggregate and cement not placed within 30 minutes after mixing shall be discarded and payment will not be made for such discarded aggregate and cement. Mixing of mortar ingredients by hand will be allowed only in special cases approved by the Supervision. All proportions and mixing operations shall be subject to the approval of the Supervision.

Use of admixtures in the mix shall be subject to the direction and approval of the Supervision.

E.17.4 Preparation for Spraying

Not less than forty-two (42) days prior to placing any shotcrete, the Contractor shall submit drawings for approval by the Supervision showing his proposed plant arrangement together with a general description of the equipment he plans to use and the method of operation.

Wherever shotcrete is required, the Contractor shall clean and prepare the rock surface to receive the mortar. Loose or shattered rock, rock debris, earth or other loose material shall be removed from the surfaces to the satisfaction of the Supervision. Material in clay seams shall be cut back to a depth as directed by the Supervision to provide a key for shotcrete. After the loose material has been removed the rock shall be washed with a jet water and high pressure air or by other approved means.

The wire mesh, where required or as directed by the Supervision, shall be securely fixed to designated positions with anchor pins in rock to avoid movement due to spraying operation. Anchor pins are defined as any device used for fastening the steel mesh reinforcement and include nails, staples, and embedded wire ties. The cost of all surface anchors shall be included in the unit price tendered in the Bill of Quantities for furnishing and installing steel mesh reinforcement for shotcrete.

Each anchor pin shall be driven into rock so that one end projects from the rock surface to fix the wire mesh as directed. The wire mesh shall be placed at a position at least 3 cm from the surface.

50 mm diameter PVC plastic pipes for weep holes shall be installed securely in accordance with the applicable provisions in Paragraph F.4.

E.17.5 Placing and Curing

For shotcrete application the nozzle shall be held normal to and about 90 cm from the surface to be coated. The nozzle shall be so moved to place a layer in uniform thickness.

The Contractor shall employ only skilled nozzlemen and before being permitted to perform any production and application of shotcrete. Each nozzleman shall furnish evidence to the satisfaction of the Supervision that he has had adequate previous experience on shotcrete work, and can apply the mortar to the required standard.

Air and water shall be provided in sufficient volume and under such pressure as may be necessary for the best operating conditions. In applying the mortar or concrete, the discharge nozzle shall be held so that the stream of material shall impinge as nearly as possible perpendicular to the surface being coated. The velocity of discharge from the nozzle, the distance of the nozzle from the surface and the amount of water used in the mix shall be regulated so as to produce a dense coating with minimum rebound of the material and no sloughing.

Any obstructions such as service lines shall be removed to enable direct application of shotcrete to the surfaces. Rebounding material shall not be used again but shall be removed from the work and disposed of by the Contractor. The Contractor shall provide adequate ventilation facilities and take such other measures as are necessary for the safety of his workmen, including provision of face protection for nozzlemen.

Areas of shotcrete which are pitted, scattered or otherwise defective shall be removed and repaired within 7 days of the Supervision informing the Contractor that such repairs are required.

The mortar shall be applied in such a manner as to ensure that cavities resulting from cutting back of clay seams are completely backfilled with pneumatically applied mortar. Where steel mesh reinforcement is used, the mortar shall cover the reinforcement to a depth of at least 25 mm.

The total thickness of shotcrete for the first layer shall be not less than 5 cm and the mortar shall be applied in layers not more than 2.5 cm thick. There shall be an interval of 30 minutes to 1 hour between applications of the second layer to prevent sloughing, but before the previously placed shotcrete has set completely. Before placing succeeding layers, the surface of previously applied shotcrete shall be cleared of dust, loose sand and other perishable materials, and surface water shall be removed by pressure-air jet after sufficient moistening.

The water pressure shall be greater by at least 1 kilogram per square centimeter than the air pressure and shall be uniform. The maximum, minimum, and average air pressures and water pressures shall be as follows:

	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>
Air pressure (kgf/cm ²)	5.9	2.5	3.5
Water pressure (kgf/cm ²)	9.0	3.5	5.0

The surface of the final layer of shotcrete shall be kept wet for at least 7 days in the case that ordinary Portland cement is used.

During the application of shotcrete any water flowing over or seeping through the rock surface to which the shotcrete is to be applied shall be diverted by the use of panning, pipes, felt strips or other approved means. Where directed by the Supervision, holes shall be formed in the coating or permanent outlets consisting of pipes shall be embedded in the coating to relieve water pressure on the coating.

The application of shotcrete shall not be construed as relieving the Contractor of his responsibility to maintain all portions of the works in a safe condition.

E.17.6 Measurement and Payment

(1) Measurement, for payment, of shotcrete with steel mesh reinforcement constructed to exposed surface in open-cut excavation will be made only of the square meter of shotcrete area with steel mesh reinforcement actually placed as shown on the Drawings or as approved by the Supervision. Payment for shotcrete with steel mesh reinforcement will be made at the respective unit prices per square meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all labor, materials and equipment and also include the cost of installing and fastening mesh, nails, staples, surface and rock anchors, and drilling holes, etc., but will exclude the cost of furnishing and placing P.V.C. drain pipes which are separate pay items.

(2) Measurement and payment for shotcrete to be made in the tunnels will be made dividing into two as follows;

(a) Shotcrete in tunnels

Measurement, for payment, of shotcrete in tunnels will be made on the basis of volume in cubic meters of shotcrete actually placed in accordance with the Drawings or as directed and approved by the Supervision.

Payment for shotcrete will be made at the respective unit prices per cubic meter tendered therefor in the Bill of Quantities, which the unit prices shall include the cost of all labor, equipment and materials, except steel wire mesh, rock bolts, nails, staples and P.V.C. drain pipes, and also include the cost of all works required by applicable provisions stipulated in this Paragraph.

(b) Steel wire mesh in tunnels

Measurement, for payment, of steel wire mesh for shotcrete in tunnels will be made only of the square meter of steel wire mesh area actually placed as shown on the Drawings or as directed and approved by the Supervision.

Payment for steel wire mesh will be made at the respective unit prices per square meter tendered therefor in the Bill of Quantities, which the unit prices shall include the cost of all labor, equipment and materials, including nails and staples, but excluding rock bolts and P.V.C. drain pipes, and also include the cost of all works required by applicable provisions stipulated in this Paragraph.

No separate measurement and payment will be made for admixtures used for shotcrete. All costs incidental to the admixtures used in conformity with the Specifications shall be included in the unit prices tendered therefor in the Bill of Quantities for the respective applicable items of shotcrete.

E.18 CONCRETE LINING FOR TUNNELS AND ADITS

E.18.1 General

Except as otherwise specified, all spaces outside the minimum specified thickness of the concrete lining placed against the excavated rock surface shall be filled completely and solidly with lining concrete. The Contractor shall ensure that the concrete is forced into all irregularities in the rock surface.

Where closely placed lagging or other types of close supports are used, all voids outside the "B" lines shall be filled with concrete or other materials approved by the Supervision prior to placing backfill grouting. The cost of filling the voids outside the "B" lines with such materials shall be at the expense of the Contractor. Details pertaining to backfill grouting are provided in Section D.

If an appreciable quantity of water flows from the rock against which the lining concrete is to be placed, it shall be excluded from the space to be filled with the concrete by caulking or diverting by pipes, pans or other means, and drained off until the concrete has been placed and set sufficiently to be unaffected by any action of water through percolation, hydrostatic pressure or abrasion. Cost for removal of water shall be included in the unit price of underground excavation tendered therefor in the Bill of Quantities, which the unit price shall include the cost of labour, materials and equipment, and all items incidental to such work.

In no time before the concrete is placed, the Contractor shall confirm that all surfaces of the foundation and all forms are completely conditioned for placing concrete as required by these Specifications.

Unless otherwise approved by the Supervision, lining concrete for the tunnels shall be placed by the specific type of equipment prescribed in Sub-paragraph E.10.5. Where the concrete is placed for the arch crown, side walls and invert arch separately, the Contractor

shall prepare a sequence of placing, applicable drawings and written descriptions to allow the full and proper assessment of his plans for the placing of the concrete and mortar involved in the work under these Specifications. These will be submitted for approval of the Supervision at least forty-two (42) days before the first concrete is placed.

E.18.2 Measurement and Payment

Measurement and payment for the concrete, formwork and reinforcing bars in tunnels and adits will be made as prescribed in Paragraph E.12 and Sub-paragraphs E.13.8 and E.14.3, respectively.

Cost for removal of water required for concrete placement shall be included in the unit price of underground excavation tendered therefor in the Bill of Quantities, which the unit price shall include all costs of labour, materials and equipment, and all items incidental to such work.

E.19 CONCRETE FOR INCASEMENT OF STEEL PIPES

E.19.1 General

The specified area in which steel pipes are to be incased with concrete shall be filled completely and solidly with the stipulated class of concrete as shown on the Drawings or as directed by the Supervision. The Contractor shall ensure that all surfaces of foundation upon and against which the concrete is to be placed are cleaned as prescribed in Paragraph E.10 and that the concrete is forced into all irregularities in the surface of the rock or previously placed concrete. The concrete work in this Section shall comply with the Specifications of preceding Paragraph E.1 to E.12.

Before concrete is placed, the outside surface of the steel pipes shall be cleaned by removing all loose rust, scales or other objectionable materials and shall be maintained clean until the concrete is placed. Field welding of any joint of the steel pipes shall be completed and approved by the Supervision before the steel pipes are incased with the concrete. All temporary supports, struts and debris shall be removed from around the steel pipes prior to the concrete being placed.

All sections of the steel pipes to be incased with the concrete shall be supported and anchored with steel or concrete cradles or supports as shown on the Drawings or as approved by the Supervision. Site welding of supports or anchors to the outside of the steel pipes shall not be allowed. Temporary internal stiffeners for the pipes and conduits shall not be removed for at least 24 hours after the concrete is placed, unless otherwise approved by the Supervision.

E.19.2 Measurement and Payment

Measurement and payment for the concrete, formwork and reinforcing bars used for incasement of the steel pipes will be made as prescribed in Paragraphs E.12, E.13 and E.14, respectively, at the unit prices tendered therefor in the Bill of Quantities, which unit

prices shall include the costs of all necessary labor, materials and equipment to perform the work.

E.20 PRECAST CONCRETE FOR FLUMES, DUCTS, PIPES, CURBS, BLOCKS, ETC.

E.20.1 General

The Contractor may use precast concrete for certain items such as flumes, pipes, lined drain ditches, ducts, curbs, blocks, etc. If the Contractor decides to use such items, they can be either purchased from a reputable manufacturer or can be precasted by the Contractor at the Site. If such items are purchased they shall conform to the applicable Japanese Industrial Standards, such as JIS A 5302-1975 or approved equivalent for concrete pipe. If the Contractor decides to precast the items at the Site, he shall submit full details concerning such to the Supervision for approval at least forty-two (42) days before commencing manufacture of the precast concrete units.

These details shall include size of aggregate, concrete mix, reinforcing steel, forming, placing, finishing, curing, handling, transport, storage, erection, etc. Upon receipt of such details, the Supervision will review them and, if necessary, will let 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.

E.20.2 Measurement and Payment

- (1) Measurement and payment for precast concrete pipes, flumes and ducts will not be made separately, but the cost shall be included in the corresponding work items, such as installation of drainage flumes and pipes, cable duct, etc., as stipulated in Section F, Drainage and other Sections, if any.
- (2) Measurement, for payment, of precast concrete curbs, edging blocks, troughs and covers shall be made on the basis of volume of precast concrete in cubic meters actually made as shown on the Drawings or as directed by the Supervision.

Payment for precast concrete curbs, edging blocks, troughs and covers will be made at the unit price per cubic meter tendered in the Bill of Quantities. The unit price shall include the costs of all labor, cement, aggregates, reinforcing bars, admixtures, all necessary materials, equipment, installation and other necessary work to complete the work.

E.21 CONSTRUCTION AND CONTRACTION JOINTS

E.21.1 Construction Joints

Concrete surfaces, upon or against which concrete is to be placed and to which new concrete is to adhere, which have become so rigid that new concrete can be incorporated integrally with that previously placed, are defined as construction joints.

Joints shown on the Drawings with full lines or broken lines as compulsory construction joints shall not be altered and no concrete shall be placed against the joint for at least 3 days for sections up to 90 cm in thickness and for 7 days where the thickness exceeds 90 cm, unless otherwise approved by the Supervision. The placement sequence at compulsory construction joints shown on the Drawings shall not be varied unless so directed by the Supervision.

Upon approval of the Supervision, the Contractor may vary the locations of other type of construction joints having no-compulsory locations, 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 Supervision at the Contractor's expense.

In addition to those construction joints shown on the Drawings, the Contractor shall prepare his own drawings showing the locations of construction joints which 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 joints. If approved by the Supervision, all necessary work related thereto shall be made at no extra cost to the CRM.

Construction joints shall be approximately horizontal or vertical unless otherwise shown on the Drawings or prescribed by the Supervision 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 surfaces which will be exposed to view shall be made straight and level or plumb.

The surfaces of construction joint 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 materials. 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.

E.21.2 Contraction Joints

Contraction joints shall be located and constructed as shown on the Drawings or as directed by the Supervision. 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 first placed at contraction joints shall be cleaned and then coated with a curing compound to break the bond before concrete on the other side of the joint is placed.

E.21.3 Measurement and Payment

Measurement and payment for construction joints and contraction joints will not be made.

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

The cost of contraction joints shall be include in the unit prices per cubic meter tendered in the Bill of Quantities for the corresponding concrete which require such joints, except that payment for formwork, waterstops, bituminous coating and joint fillers as required, will be made as provided in Sub-paragraph E.13.8 and Paragraphs E.22, E.25 and E.24, respectively.

E.22 WATERSTOP

E.22.1 General

Waterstops, Type B (200 mm wide) shall be furnished by the Contractor and shall be placed at such positions as shown on the Drawings or as directed by the Supervision. Waterstops shall be of a plastic material meeting the requirements of JIS K 6773 or approved equivalent as shown on the Drawings and shall be subject to the approval of the Supervision.

For the waterstop strips which are to be placed at contraction joints, close attention is required to ensure that they are properly embedded without any damage. Particular care should be exercised to obtain thorough filling of concrete under the strip. In pouring concrete under the waterstop at these critical points, the concrete should be well vibrated so that it will flow in a direction nearly parallel to the joint. Also, the waterstop should be vibrated if it is sufficiently heavy to withstand the vibration without distortion or displacement.

E.22.2 Waterstop Joints

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

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

- (a) that the material is not damaged by heat, searing or by the application of cementing materials;
- (b) that the splices have a tensile strength not less than 80% of that required of the specified material;
- (c) that the splice is watertight; and
- (d) that the ribs and central bulb, where applicable, match up exactly and are continuous.

E.22.3 Storage and Installation

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

The Contractor shall provide suitable supports and protection during the progress of work to protect the waterstop from damage, deterioration, or warping.

The waterstop shall be installed with equal widths of the material embedded in the concrete on each side on the joint. The concrete shall be carefully placed and vibrated around the waterstop to ensure a complete bond between the concrete and all embedded areas of the waterstop. After installation and before embedment in concrete, the waterstop shall be protected from the direct rays of the sun.

The waterstops shall be of sufficient stiffness so that they remain in their correct position during concreting. The type shall suit the particular location in the structure in which the waterstop is to be placed and the pattern shall be such that concrete can be placed all around it with complete consolidation and no voids or crevices. Waterstops used in each location, shall include at least one nailing strip so located that the efficiency of the seal is not impaired, and shall have a minimum thickness of 5 mm and shall be as approved by the Supervision. The width of the seal shall be within a tolerance of 12 mm of the nominal width exclusive of the nailing strip.

E.22.4 Measurement and Payment

Measurement, for payment, of furnishing and placing the waterstops will be made of the length of the waterstops in place with no allowance 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 Supervision will not be measured for payment.

Payment for furnishing and placing the waterstops will be made at the applicable unit prices per linear meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of furnishing all materials, labor and equipment necessary to perform the work.

E.23 ELASTOMERIC BEARING PADS FOR BRIDGE

E.23.1 General

The Contractor shall furnish and install all elastomeric bearing pads for bearing the bridge as shown on the Drawings and elsewhere directed by the Supervision. The materials to be used for and the method to be applied to the elastomeric bearing pads shall conform to the Specifications in this Paragraph.

E.23.2 Elastomeric Bearing Pads

The elastomeric bearing pads, which are subject to approval of the Supervision, shall be non-laminated pads cast in moulds under pressure and heat. Stainless steel plates shall be bonded to elastomeric pads 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 12 months of the date of manufacture.

The Contractor shall submit to the Supervision for approval fifty-six (56) 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 D 1415, I.R.H.D.	70 ± 5 or 60 ± 5 or 50 ± 5 as directed
Tensile strength, ASTM D 412, minimum	140 kgf/cm ²
Elongation at break, minimum per cent	300 for 70 hardness 400 for 60 hardness 500 for 50 hardness
Tear Test, ASTM D 624-Die "C", minimum	45 kgf/cm ²
Compression Set, ASTM D 395, 24 + 0 hrs at 70°C - Method B, -2, under constant deflection, maximum per cent	25 %
Low Temperature Stiffness, ASTM D 1053, at -40°C, maximum	700 kgf/cm ²

Over aged, 14 days at 70°C, ASTM D 573

- | | |
|--|-----------|
| - Hardness, point change, maximum | 0 to ± 15 |
| - Tensile Strength, % change, maximum | ± 15 |
| - Elongation at break, % change, maximum | -40 |

Ozone Resistance, ASTM D 1149 1 p.p.m. ozone in air by volume, 100 hours, 20% strain at 40 ± 1°C	no crack
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The Contractor shall store the elastomeric bearing pads in a manner which will prevent deterioration, as approved by the Supervision.

E.23.3 Measurement and Payment

Measurement, for payment, of furnishing and installing elastomeric bearing pads will be made of the number of the pads and plates in place as shown on the Drawings or directed by the Supervision.

Payment for furnishing and installing elastomeric bearing pads will be made at the unit price per number tendered therefor in the Bill of Quantities, which unit price shall include the cost of all labor, materials and equipment required by these Specifications.

E.24 JOINT FILLER AND SEALER, IF ANY

E.24.1 Joint Filler

The Contractor shall place an elastic joint filler where shown on the Drawings or where directed by the Supervision. The elastic joint filler material shall be of the expanded polystyrene type satisfying the requirements of ASTM D 2125, Class 1, Grade 15 or approved equivalent and shall be thick enough to cover all voids. The Contractor shall cut and fabricate the joint filler to fit around all openings as shown on the Drawings or as directed by the Supervision.

E.24.2 Joint Sealer, if any

Joint sealer shall be used in the concrete structural joints elsewhere as shown on the Drawings or as directed by the Supervision, for establishing water-tightness of the joints.

The material of joint sealer shall be of polysulphide, epoxy or equivalent approved by the Supervision, to be injected in the joint. The composition of the sealer shall be durable and watertight against contraction and expansion of the joint space, chemical variations and loads encountered upon, during and after completion of the work.

The Contractor shall propose the material, structural design and procedure for the construction of joint sealer at least eighty four (84) days prior to beginning of the work for approval of the Supervision.

Sealing work in the joint shall be performed only by skilled workman. Unless inspection is waived by the Supervision in each specific case, the work shall be performed only in the presence of the Supervision, but shall not be made until 28 days after the concrete has been placed.

E.24.3 Measurement and Payment

- (1) Measurement, for payment, of furnishing and installation joint filler will be made for the area of joint filler actually placed.

Payment for furnishing and installing joint filler will be made at the unit prices per square meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all labour, equipment and materials required.

- (2) Measurement, for payment, of joint sealer if used will be made on the basis for the length along the center line of the sealer actually constructed in accordance with the Specifications.

Payment of joint sealer will be made at the unit price per linear meter of the sealer tendered therefor in the Bill of Quantities.

E.25 BITUMINOUS COATING FOR CONTRACTION JOINT

E.25.1 General

Contraction joints as indicated on the Drawings or elsewhere as directed by the Supervision shall be provided by the Contractor. The joint material shall consist of a layer of bituminous coating or other approved material on the face of the first concrete.

E.25.2 Measurement and Payment

Measurement for payment of bituminous or other joint material shall be made on the basis of actual coated or installed area in square meters determined by the dimensions as shown on the Drawings or directed by the Supervision.

Payment shall be made for the number of square meters measured as provided above at the unit price per square meter tendered therefor in the Bill of Quantities, which unit price for joint material shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, fabricating, coating or installing the joint material and other items necessary to complete the works.

E.26 DOWEL BARS

E.26.1 General

The Contractor shall furnish and install dowel bars in contraction and expansion joints in concrete structures at locations as shown on the Drawings or as directed or approved by the Supervision.

Dowel bars shall consist of plain or deformed reinforcement bars of high yield steel complying with the requirements stipulated in Sub-paragraph E.14.1. They shall be free of oil, paint other than bond-breaking compound, dirt, loose rust and scale.

Dowel bars shall be of sizes as shown on the Drawings and directed by the Supervision, and shall be straight, free from burred edges, or other irregularities and shall have their sliding ends sawn or, if approved, sheared.

Bond-breaking compound for dowel bars shall consist of 66 % of 200 pen bitumen blended hot with 14 % light creosote oil and, when cold, brought to the consistency of paint by the addition of 20 % solvent naphtha or other approved compound.

E.26.2 Installation of Dowel Bars

Dowel bars shall be provided as shown on the Drawings parallel to the finished surface and to the longitudinal axis. The half of each dowel bar projecting away from the concrete operation shall be coated with a thin film of bond-breaking compound and provided with a closely fitted sleeve 100 mm long of waterproofed cardboard or other approved material. The end of the sleeve will be packed with a disc of joint filler or pad of cotton waste to a depth of 25 mm.

The assembly of joint filler and dowel bars shall be so supported as to remain rigidly in the correct position while placing and compacting the concrete.

Misalignment of dowel bars shall not exceed 6 mm per 300 mm in length of dowel bar.

E.26.3 Measurement and Payment

Measurement, for payment, for furnishing and installing dowel bars shall be made on the basis of weight in metric tons of bars installed as shown on the Drawings or directed by the Supervision.

Payment for furnishing and installing dowel bars will be made at the appropriate unit price per metric ton tendered therefor in the Bill of Quantities, which unit price shall include the cost of all labour, materials and equipment required for transporting, cutting, placing, and supporting bars, bar treatment, and all other items incidental to the work.

E.27 ANCHOR BARS

E.27.1 General

Wherever shown on the Drawings or directed by the Supervision, the Contractor shall drill holes into rock formation to receive bars for anchoring concrete structures or parts thereof to the formation. The dimensions of anchor bar and the locations, diameters, and depths of the drilled holes shall be as shown on the Drawings or as directed by the Supervision.

E.27.2 Drilling Holes and Placing Bars

The diameter of each anchor bar hole shall be not less than 1.5 times the diameter of the anchor bar specified for that hole. The depth of each hole shall be as shown on the Drawings or as determined by the Supervision depending upon the nature of formation.

Anchor bars shall be cleaned thoroughly before being placed. The holes shall also be cleaned thoroughly and shall be completely and compactly filled with grout or mortar. The anchor bar shall be forced into place before the grout or mortar takes its final set and, where practicable, shall be vibrated or rapped until the entire surface of the embedded portion of bar is in contact with the grout. Special care shall be taken to ensure against any movement of the bar grouted in place, until the grout has completely set.

E.27.3 Measurement and Payment

Measurement, for payment, of grouted anchor bars will be made on the basis of length of bars actually placed and grouted into the holes drilled through the rock formation or concrete surface.

Payment for grouted anchor bars will be made at the respective unit prices per linear meter of bar placed and grouted tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all labour, materials and equipment required for drilling holes, furnishing and installing bars, grouting and anchoring, and all other items incidental to the work.

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DAULE-PERIPA~LA ESPERANZA TRANSBASIN

VOLUME III - GENERAL AND TECHNICAL SPECIFICATIONS

SECTION F

DRAINAGE

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SECTION F DRAINAGE

F.1 GENERAL

The work under the items for drainage in the Bill of Quantities consists 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 Supervision.

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 Supervision or replaced by and at the expense of the Contractor. No pipe which has been damaged shall be used for the Work.

F.2 DRAINS WITH CONCRETE PIPE

F.2.1 General

The Contractor shall construct drains with in situ concrete or reinforced precast concrete pipes in the location as shown on the Drawings or as directed by the Supervision. The precast concrete shall be produced as stipulated in Paragraph E.20.

All precast concrete pipe drains shall be sealed with approved material and constructed with open joints or closed joints as shown on the Drawings or as approved by the Supervision.

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

<u>Pipe Descriptions</u>	<u>Construction Sequence</u>
150-millimeter-diameter precast perforated concrete pipe with open joint, if any.	Place gravel filter bedding on covering sheets in excavated trench; install pipes; place gravel covering; cover the sheets.
600-, 800- and 1,000 millimeter-diameter precast reinforced concrete pipes with collar joints.	Excavate trench; place sand bedding; cover with random backfill and Compaction.

The gravel filter material shall consist of screened natural gravel or crushed rock, lean and well graded from 20 to 50 mm in size.

F.2.2 Measurement and Payment

Measurement, for payment, of drains constructed with concrete pipes shall be made of the length along the centerline from end to end of the pipe in place, and no allowance will be made for joints. Payment will be made at the respective unit prices per linear meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of furnishing and installing concrete pipes with jointing and other works required. Provided that payment for trench excavation, gravel filter material, covering sheets if any, random backfill with compaction and concrete works will be made separately under the appropriate items in the Bill of Quantities.

F.3 DRAINS WITH STEEL PIPE

F.3.1 General

All steel pipe to be used for drains shall be furnished and installed as shown on the Drawings or as approved by the Supervision.

Pipe shall be placed to the prescribed lines and grade. Joints of pipe shall be connected with appropriate couplings or connectors to provide watertight connections or as approved by the Supervision.

F.3.2 Measurement and Payment

Measurement, for payment, of drains with steel pipe will be made for the length of pipes installed. Payment will be made at the unit price per linear meter tendered therefor in the Bill of Quantities, which unit price shall include the cost of all works and materials required. Provided, that payment for trench excavation, random backfill with compaction and concrete works will be made separately under the appropriate items in the Bill of Quantities.

F.4 DRAINS WITH PLASTIC (PVC) PIPE

F.4.1 General

All plastic pipe to be used for drains shall be furnished and installed as shown on the Drawings or as approved by the Supervision.

Drains with plastic pipe shall be constructed in the following manner:

Pipe Descriptions

50-and 75-millimeter-diameter plastic pipes, for weep holes in concrete facing, walls of inlet and outlet, and shotcrete.

Construction Sequence

Pipe shall be wrapped with PVC sheet and holes shall be drilled into the rock at least 5 cm deep after placing surrounding concrete, through the pipe opening.

Pipe Descriptions

Construction Sequence

100-and 150-millimeter-diameter plastic pipes.

Embedded in concrete or excavated trench and backfill with compaction.

200-millimeter-diameter perforated plastic pipes.

Place gravel filter bedding in excavated trench; install pipes; place gravel covering; cover with random backfill and compaction.

The pipe shall be placed to the prescribed lines and grades.

F.4.2 Measurement and Payment

Measurement, for payment, of drains with plastic pipe will be made for the length of pipes in place. Payment for drains with plastic pipe will be made at the respective 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, except earth works including gravel filter material and concrete works.

F.5 DRAIN DITCHES AND DRAIN PITS

F.5.1 General

The Contractor shall perform trench 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.

Drain ditches and drain pits will be made of reinforced concrete or non-reinforced concrete as shown on the Drawings. The precast concrete frames stipulated in Paragraph E.20 may be used for the reinforced concrete ditches upon approval of the Supervision.

F.5.2 Measurement and Payment

Measurement, for payment, of drain ditches and drain pits will be made on the basis of the actual volume in cubic meters of the concrete placed as stipulated in Paragraph E.12. Payment for drain ditches and drain pits will be made at the respective unit prices per cubic meter tendered therefor in the Bill of Quantities, which unit prices shall include the cost of all labor, equipment and materials as stipulated in Paragraph E.12. Provided, that payment for trench excavation, gravel bedding and backfill will be made separately under the appropriate items of the Bill of Quantities.

F.6 COBBLED DITCH, IF ANY

F.6.1 General

Cobbled ditches, if any, for the permanent access roads shall consist of wet cobble or rubble masonry and shall be constructed to the lines, dimensions and at the location shown on the

Drawings or as directed by the Supervision. Cobbles or rubbles to be used for the ditch shall be of selected, hard and block, not less than 15 centimeters in length and not less than 180 square centimeters in area. Cobbles or rubbles shall be carefully arranged in relation to one another so as to have a pleasing appearance with a minimum of voids or empty spaces to be filled with mortar.

Mortar shall consist of three parts of clean fine aggregate to one part of Portland cement (ordinary type) by volume. The cement, fine aggregate, and water shall conform to the requirements specified in Sub-paragraph E.2.1 and E.3.2 and Paragraph E.4.

The wet cobble or rubble masonry work shall be performed by experienced masons, duly qualified in their trade. The rock shall be laid carefully so that the exposed faces form an uniform surface and are true to the dimensions, lines and levels shown on the Drawings or as directed by the Supervision. Prior to setting, the cobbles or rubbles shall be wetted sufficiently to take up its surface absorption.

F.6.2 Measurement and Payment

Measurement, for payment, of the cobbled ditches will be made on the basis of the volume in cubic meter of the ditches actually constructed at the location and to the lines and dimensions. Payment for the cobbled ditches will be made at the unit price per cubic meter of the ditches tendered therefor in the Bill of Quantities, which unit price shall include the costs of all labor, materials and equipment required to perform the work specified in this Paragraph.

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VOLUME III - GENERAL AND TECHNICAL SPECIFICATIONS

SECTION G

ROAD WORKS

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SECTION G ROAD WORKS

G.1 GENERAL

The Contractor shall carry out, as shown on the Drawings and/or as directed by the Supervision, the construction and maintenance of permanent and temporary access roads as specified herein. In addition, the Contractor shall be responsible for designing, constructing and maintaining his various temporary construction roads as outlined in Paragraph G.15.

Items of work pertaining to road work such as control and removal of water, excavation and backfill, embankment, drainage, concrete work, improved subgrade and graded crushed stone subbase, and surface courses, guard railing, etc. shall comply with the stipulations of this Section as well as the other applicable Section of these Specifications.

Unless otherwise specified in this Section, the Contractor shall construct the access roads in conformity with the applicable provisions of the Ecuadorian standards such as " Manual de Diseño de Carreteras, Ministerio de Obras Públicas y Comunicaciones " (Main Road Standard) and " Manual de Diseño de Caminos Vecinales, MOP-1984, Ministerio de Obras Públicas y Comunicaciones " (Second Road Standard).

G.2 ROAD DESIGN STANDARDS

The Conguillo access road (permanent), the Membrillo outlet access road (temporary) and the El Guasmo access road (temporary) shall conform to the following standards:

- (1) The total roadway width is six (6) m for permanent roads and four (4) m for temporary roads.
- (2) The grade along the centerline of the roads shall not exceed ten (10) percent.
- (3) The minimum radius of curvature shall be fifteen (15) m.

The horizontal and vertical alignments, are shown on the Drawings indicating the locations of the points of intersection of tangents and grades lines.

The Contractor shall stake out the alignment of access roads and secure the Supervision's approval of the stake-out before proceeding with construction. If, in the opinion of the Supervision, any modification of the line or grade is advisable, either before or after stake-out, the Supervision will issue detailed instructions to the Contractor for such modification and the Contractor shall revise the stake-out for further approval. These requirements shall be met without additional payment.

Provisions for drainage shall include the construction of drainage ditches, cross drains and culverts in accordance with the provisions of Paragraph G.5 herein and Section F.

Sufficient templates and straightedges shall be furnished by the Contractor for use in checking the finished surface of the graded crushed stone subbase. These templates and straightedges shall be submitted to the Supervision for his approval and shall be maintained by the Contractor at all times in a condition to produce the correct cross-sectional profile. These templates and straightedges shall be checked at intervals and, if necessary, repaired or adjusted as directed by the Supervision. The furnishing and maintenance of the templates and straightedges will not be paid for directly, but all costs therefor shall be included in the applicable unit prices tendered in the Bill of Quantities for road construction.

The gradation, moisture control, density, placing and compaction for the embankment, improved subgrade and graded crushed stone subbase shall be as stipulated herein; however, the Supervision reserves the right to adjust these requirements as he deems best, and in such case no change will be allowed in the unit prices for such work as tendered in the Bill of Quantities.

G.3 CONTROL AND REMOVAL OF WATER

G.3.1 General

Control and removal of water during construction of the permanent and temporary access roads shall be accomplished in accordance with the stipulations of Section B of these Specifications.

G.3.2 Measurement and Payment

No separate payment will be made for control and removal of water during excavation and embankment work. All costs incurred from the works for control and removal of water shall be deemed to be included in the unit prices or lump sum prices for the corresponding items in the Bill of Quantities.

G.4 CLEARING AND STRIPPING

G.4.1 General

The ground over which the road is to be built, to a width of one (1) m outside the tops of all cut sections and one (1) m outside the toes of the roadway embankments as the case may be, and the ground along the lines of the drain ditches shall be cleared of trees, brush, rubbish and other objectionable matter as required. The ground surface under the roadway embankment shall be cleared of all stumps, roots, and non-perishable objects except for those which will be a minimum of one (1) m below subgrade or slope of the embankment. All cleared material shall be disposed of in the same general manner as provided for in Sub-paragraph C.2.1 of Section C, or as ordered by the Supervision.

All the surfaces which are to be stripped will be directed by the Supervision. This work shall comply with the stipulations of Sub-paragraph C.2.2 of Section C.

G.4.2 Measurement and Payment

Measurement and payment of the clearing and stripping works will be made according to the provisions stipulated in Sub-paragraph C.2.3.

G.5 DRAINAGE AND CONCRETE WORK

G.5.1 General

All drainage work for the permanent and temporary access roads such as drain ditches and catch basins, concrete pipe culverts and cross drains including related concrete headwalls, side walls and aprons, P.V.C. drain pipe, etc. shall be constructed as shown on the Drawings. The detailed specifications which pertain to drainage ditches, catch basins, pipe culverts and cross drain's head walls, etc. for the permanent access roads shall comply with the provisions in Section F, Drainage and Section E, Concrete Works. The stipulations in these Sections shall be fully applied, where applicable.

The Contractor shall construct ditches and culverts as shown on the Drawings. In order to keep water away from the embankment, improved subgrade and graded crushed stone subbase during construction, the Contractor shall at all times ensure adequate drainage by scheduling ditch and culvert construction work so that the drainage is operative before work is begun on the embankment and surfacing. He shall clean and trim all such drainage ditches from time to time so that there may be a free flow of water throughout the whole Contract period. Damage to the work due to unfavorable drainage or through failure to provide adequate drainage will result in an order by the Supervision to repair the damage at the Contractor's expense.

The Contractor shall construct retaining walls along the access roads using a rubble concrete as shown on the Drawings or as directed by the Supervision. The rubble concrete shall composed of concrete, class E, and hard and durable rubbles/boulders of which the maximum size is 300 mm. The rubble stones and boulders shall be placed by hand one by one into the concrete during placing and well embedded and compacted individually.

G.5.2 Measurement and Payment

Measurement and payment for the drainage and concrete work including rubble concrete for retaining walls in the permanent and temporary access roads shall be made at the respective unit prices tendered therefor in the Bill of Quantities, in accordance with the corresponding work items in Section E, Concrete Works and Section F, Drainage, hereof.

G.6 EXCAVATION

G.6.1 General

All classes of materials (common, weathered rock and rock) encountered in the road excavation shall be excavated to the grades and lines shown on the Drawings or as directed by the Supervision. The detailed specifications which pertain to excavation for the

permanent and temporary access roads, including measurement and payment thereof, are stipulated in Section C, Earth Works. The stipulations in Section C shall be fully applied, where applicable.

If the subgrade line is to be excavated in common including weathered rock, it shall be formed to the correct transverse and longitudinal profiles as required but at a grade higher than the final grade in order to allow for the effect of compaction. The material shall be compacted with approved rollers, and prior to compaction the moisture content shall be adjusted by watering with sprinkler trucks or other approved methods, or by drying out, as may be required in order to attain the specified compaction. If the nature of the common and weathered rock material is such as to make it impossible to obtain the required compaction, the unsuitable material shall be removed and paid for at the unit price per cubic meter of common including weathered rock excavation as tendered therefor in the Bill of Quantities.

When the subgrade line is to be excavated in rock, the rock shall be excavated neatly to the correct transverse and longitudinal profiles and checked by straightedges. There shall be no payment for excavation in rock below the grade level. The Contractor shall remove all loose rock and if necessary bring the grade up to the correct level by the addition of approved granular material compacted by rolling. No rock shall project more than four (4) cm above the grade level.

Suitable material excavated within the limits of the access roads shall, unless provision is expressly made to the contrary by the Supervision, be used in the most effective manner of the formation of the roadway embankment as for the improved subgrade material. The excavated material which is surplus to these requirements shall be disposed of in accordance with the provisions of Paragraph C.17.

G.6.2 Measurement and Payment

Measurement, for payment, of common including weathered rock material, and rock material removed from the excavation for the permanent and temporary access roads will be made to the lines and grades shown on the Drawings or as directed by the Supervision and such measurement shall be based on the original ground surface before excavation and the actually excavated surface as approved by the Supervision, in accordance with the provisions of Sub-paragraph C.5.5 of Section C. The class of the excavated material will be determined based solely on the Supervision's analysis and judgement.

Payment for each class of material excavated for the access road will be made at the unit prices per cubic meter tendered therefor in the Bill of Quantities, in accordance with the provisions of Sub-paragraph C.5.5 of Section C. Provided that the payment for open-cut excavation for the structures to be constructed in the access roads will be made as an open-cut excavation, all classes of materials.