

9.13 PROTECTION AND CURING

9.13.1 General

The Contractor shall protect all concrete against injury or harmful effect due to sudden drying, loading, shock or vibration until it has hardened sufficiently to prevent damage. Exposed surfaces of all concrete shall be protected from the direct rays of the sun for the first 3 days after placing, if not cured by membrane curing. All such protection shall be made effective as soon as practicable after placing of unformed concrete or after removal of forms from formed concrete. Concrete shall be cured either by water curing or by membrane curing.

9.13.2 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. The concrete shall be kept wet by covering with water-saturated material or by any other method which will keep all surfaces to be cured continuously, not periodically, wet. Water used for curing shall meet the requirements of this Specification for water used in concrete, but with the additional requirement that the water shall not contain any chemical or other substances that will cause staining of concrete surfaces.

9.13.3 Membrane Curing

- a. Membrane curing shall be application of a pigmented curing compound of the surface membrane type. The pigmented curing compound shall be subject to the approval of the Engineer.
- b. The curing compound shall be applied to formed surfaces immediately after the forms are removed and to unformed surfaces immediately after finishing work is completed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surfaces. The surfaces shall be thoroughly moistened with water and the curing compound applied as soon as free water disappears. Special care shall be taken to ensure ample coverage with the compound at edges, corners and rough spots of formed surfaces. Equipment applying curing compound and the method of application shall be subject to the approval of the Engineer.
- c. Curing compound shall not be permitted to be used on construction joints unless these surfaces are to be wet sand blasted prior to placing concrete on or against it.
- d. 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 surfaces 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. The Contractor shall remove all sand covering after completion of the curing period. Any sealing membrane that is damaged or that peels from concrete surfaces within 28 days after application, shall be repaired without delay.

- e. At least 30 days before using compounds, the Contractor shall submit for approval details of the proposed compounds. Such details shall be accompanied by test certificates to show that the compound will give a satisfactory result for the proposed application.

9.14 CONCRETE TESTS

9.14.1 General

The tests of concrete materials shall be carried out by the Contractor in the Contractor's laboratory using equipment provided by the Contractor as specified in Clause 1.6.3. The tests of concrete placed during the Works shall be made by the Contractor in his laboratory. The cost of all such tests and all charges incidental thereto shall be borne by the Contractor.

9.14.2 Scope of Tests

Sampling and testing concrete materials, plastic concrete and hardened concrete shall include, but not necessarily restricted to, those listed in Table 9.14.a.

TABLE 9.14.a – TESTING PLASTIC AND HARDENED CONCRETE

Test	Sampling/Testing Frequency
Sampling	See note a below
Compressive strength	See note a below
Slump	See note b below
Air content	See note c below
Unit weight	See note a below

- a. Sampling, compression testing and unit weight determination.

During manufacturing and placing of concrete, not less than four (4) samples in each day of placing, and not less than one (1) random sample for each one hundred (100) cubic meters or fraction thereof of continuously placed concrete shall be taken. Compression test cylinders of 15 cm in diameter and 30 cm in length shall be moulded from each sample, cured and tested in accordance with ASTM C 172, C 192 and C 39, and JIS A 1108 at 7 days and at 28 days. The test results shall be progressively analysed and statistically evaluated. Evaluation shall be made in accordance with ACI 214 for more than 10 successive test result on the following basis:

- (i) The average strength of test cylinders shall not below the strength specified in Clause 9.2.
- (ii) The strength of any test cylinder shall not be below the strength specified in Clause 9.2 by more than 35 kgf/cm².

The coefficient of variation for the test on each mix shall not be greater than 15 percent. In case a greater variation is noted, the Contractor shall review the concrete batching and mixing procedures and the transportation and delivery of plastic concrete to reduce the coefficient.

Unit weight determinations shall be made at the frequency recommended by JIS or ACI standards.

- b. Slump tests shall be made on every batch of concrete, at all times when test samples are taken and whenever directed by the Engineer to check the consistency of a particular batch of concrete.
- c. Air content tests shall be performed on every alternate batch of concrete in association with the slump test in subparagraph ii. above.
- d. More frequent testing of plastic concrete will be directed under certain circumstances, such as but not limited to, times when the sand moisture content is fluctuating, and the Contractor shall not be entitled to any compensation because of any additional sampling or testing of plastic concrete at any location directed by the Engineer.

TABLE 9.14.b – CONCRETE AGGREGATE TESTING

Test	Sampling/Testing Frequency (m ³)
Sampling	*
Particle shape	2,500
Clay and fine silt	500
Material finer than 75 micron	500
Light particles	500
Friable particles	500
Organic impurities	500
Soundness	2,500
Grading	500
Los Angeles Abrasion	2,500
Unit mass	2,500
Specify gravity and absorption	2,500
Alkali Reactivity	when directed by the Engineer

* As required to suit the specific test in the Table.

The Contractor shall forward one copy of all certificates to the Engineer as soon as they are available.

9.14.3 Testing Cement at Source

Cement shall be sampled at the source and tested by the manufacturer and certified as conforming to the requirements of this Specification before being dispatched from the factory of the cement manufacturer. All costs associated with the sampling and testing shall be included in the various rates in the priced Bill of Quantities for concrete construction.

9.14.4 Sampling and Testing Plastic Concrete

- a. The Contractor shall sample concrete for testing in accordance with Sub-Sub-Clause 9.14.2 from the batching and mixing plant, delivery trucks, at the forms or elsewhere where concrete is being handled or placed. Samples shall be obtained at uniform intervals, as directed, throughout the production or delivery of concrete for a given placement. A placement shall be considered as an operation involving the continuous placing of concrete between adjacent construction joints. Unless

otherwise specified, the frequency of sampling of a type of concrete in any one placement shall be in accordance with Table 9.14.c.

TABLE 9.14.c – FREQUENCY OF SAMPLING CONCRETE

Up to 10 m ³	1 sample
10 to 40 m ³	2 samples
40 to 80 m ³	3 samples

- b. For each additional 50 m³ or part thereof, 1 additional sample shall be taken. The sample shall be sufficient to prepare the cylinder specimens specified in sub-paragraph d. of this Sub-Clause and unit weight test, slump test and air content test specified in Sub-Clause 2. of this Clause.
- c. Where the rate of concrete placement for any single structure exceeds 100 m³/day the number of samples may be reduced to 1 sample per 40 m³ at the sole discretion of the Engineer.
- d. Where the concrete is deposited into the forms directly for the agitator truck chute, sampling shall be from the discharge and the sampling procedure will be in accordance with the appropriate standard specified.
- e. In general the Engineer will require that 3 specimen cylinders for testing at 7 days and 3 specimen cylinders for testing 28 days plus as many specimens as required for other testing, be made from any one sample.
- f. The Contractor shall provide the required quantity of concrete for sampling and testing and shall include the cost of this concrete in the various rates and prices tendered in the Bill of Quantities for the various items of concrete construction.
- g. The Engineer has the right to be present at any sampling or testing conducted by the Contractor.

9.14.5 Testing Hardened Concrete in Structures

- a. If approved by the Engineer on each specific occasion, hardened concrete liable to rejection may be tested for compressive strength by obtaining core specimens 100 mm in diameter from the in-situ concrete with a height to diameter ratio in accordance with the appropriate standard specified in Clause 1.6. At least 3 specimens shall be tested and the points from which the specimens are obtained shall be as directed. Testing of cored samples shall be in accordance with the appropriate standard specified in Clause 1.6.
- b. If the average compressive strength of the core specimens so obtained is equal to or greater than the specified characteristics strength for that section of the Works, then the concrete represented by the core specimens shall be considered to be structurally satisfactory.
- c. If the concrete is considered to be structurally satisfactory then the holes left by the removal of the test cores shall be repaired to the approval of the Engineer.
- d. Unless otherwise directed concrete which fails to meet the requirements of this Clause shall be removed and replaced in an approved manner.

9.14.6 Payment

- a. The entire cost of performing the work required by this Clause 9.14 will be deemed to be included in the various rates and lump sums tendered in the Bill of Quantities for concrete construction.
- b. The entire cost of securing and testing core specimens of hardened concrete and of removing and replacing rejected concrete or repairing cored holes shall be borne by the Contractor. The cost of all equipment for testing and the testing shall be included in the rates tendered in the Bill of Quantities for the various items of concrete construction.

9.15 FORMWORK

9.15.1 General

- a. Forms shall be used to confine concrete and shape it to the required lines.
- b. The forms, unless otherwise specifically provided, shall be of timber plywood, steel or other suitable and approved materials, and shall have sufficient strength and rigidity to withstand the pressure resulting from placement and vibration of the concrete 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.
- c. Edges at intersections of concrete surfaces that will be exposed permanently to view, and other edges of concrete surfaces as shown on the Drawings or directed, shall be bevelled or rounded not less than 20 mm by the use of moulding strips.
- d. Immediately before concrete is placed, precaution shall be taken to see that all forms are in proper alignment, non-defective, sound, clean and free from projecting nails and that all form supports are thoroughly secure and tight.
- e. The Contractor shall submit the design drawings of the forms, from supports and scaffolding for the approval of the Engineer before manufacturing the forms but such submission to the Engineer and approval by him shall not relieve the Contractor from any of his responsibilities under the Contract for the successful completion of the structure and the safety of the Works.

9.15.2 Material

- a. All materials, except steel forms used in formwork, shall be new and subject to the approval of the Engineer. Lumber and timber shall be sound and straight, and free from warp, decay and loose knots. They shall be dressed smooth and be uniform in width and thickness prior to fabrication of formwork.
- b. Plywood shall be of a water resistant type and shall have sufficient thickness to support the pressure of concrete as planned for the particular placement.

9.15.3 Installation and Preparation

- a. The formwork shall be installed to the established alignment, grade and dimension shown on the Drawings and deviations from the established alignment, grade and dimensions or damages during installation shall be remedied or removed and replaced by the Contractor prior to concrete placement.
- b. Forms shall be installed such that joint marks on concrete surfaces are in alignment both horizontally and vertically and the joints between surfaces shall be smooth. All vertical joints in form lining shall be equally spaced along the length of the form lining shall be equally spaced along the length of the form for exposed concrete surfaces. The spacing will be identical in succeeding placements.
- c. 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 forms shall be surface-treated with a commercial mineral oil of a type approved by the Engineer. The form oil shall be applied before the reinforcement is placed. Forms, which have been left in place for an extended period of time such that the oil has dried out, shall receive further surface treatment as directed by the Engineer.
- d. Where forms for continuous surfaces are placed in successive lifts, care shall be taken to fit the forms tightly over the previous lift so as to prevent leakage of mortar from the concrete at the construction joints.
- e. Forms to be used more than once shall be maintained in a serviceable condition and shall be thoroughly cleaned before being reused. Forms on exterior faces of walls shall be kept clean by means of splash boards whenever practicable.
- f. Internal ties consisting of bolts and rods shall be so arranged that embedded metal shall terminate not less than 30 mm from the formed surface of the concrete after forms are removed where the maximum size of aggregate is 40 mm, and not less than 50 mm where the maximum size of aggregate is 80 mm or larger. Wire ties through forms shall not be used unless authorised by the Engineer.
 - (i) The ties shall be constructed so that the ends or end fastener can be removed without causing spalling at the faces of the concrete.
 - (ii) Recesses resulting from removal of form-ties shall be repaired as specified in Clause 9.17.
 - (iii) Where form ties are used in external walls or in walls of water retaining structures they shall be fitted with an approved water stop to prevent water seeping along the ties.

9.15.4 Removal

- a. Forms shall not be removed until the concrete has hardened and has sufficient strength to carry its own weight safely together with any construction load likely to be imposed upon it.
- b. Forms shall be removed only with the approval of the Engineer, and in general, shall be left for periods not less than the following number of days or hours after the concrete is placed:

Centring under beams, girders and arches days	: 14 days
Slabs having clear span more than 3 m	: 14 days
Slabs having clear span 3 m or less	: 7 days
Columns, piers, walls and sides of beams up to 4.8m high	: 24 days
Columns, piers, walls and sides of beams more than 4.8 m high	: 48 days

Beams, girders and slabs shall be solidly propped at appropriate centres immediately after and progressively with removal of forms and such props shall remain in place for a minimum of 28 days after concrete is placed.

- c. Care shall be taken in removing forms to prevent damage to the concrete.
- d. Concrete shall be cured immediately the forms have been removed and curing only temporarily stopped in the actual locations where repairs are being carried out.
- e. 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. The form for the opening shall be constructed so as to facilitate such loosening.

9.15.5 Payment

Separate payment will be not made for furnishing, installing and removing formwork, supports and scaffolding and for all works performed by the Contractor in complying with the requirements of this Clause 9.15 and all costs shall be deemed to be included in the applicable rates in the Bill of Quantities for concrete construction.

9.16 FINISHED AND FINISHING

9.16.1 General

- a. The classes of finish and the requirements for finishing concrete surfaces shall be as specified in this Clause or as shown on the Drawings. Surface irregularities in finish, as described herein, shall be distinguished from tolerances for established lines, grades and dimensions in accordance with Clause 9.24.
- b. Surface irregularities are designated as "abrupt" or "gradual" for the purpose of classifying finish. Offsets resulting from displaced, misplaced or mismatched forms, or loose knots in forms or other similar for defects, shall be considered abrupt irregularities and will be checked by direct measurement. All other surface irregularities shall be considered gradual irregularities and will be tested by use of a 1.5 meter straight edge for formed surfaces and a 3 meter straight edge for unformed surfaces.
- c. Finishing of concrete surfaces shall be performed only by skilled workmen.

9.16.2 Formed Surfaces

The classes of finish for formed surfaces are designated by symbols F1, F2, F3 and F4, as follows:

- a. F1: Finish F1 is a finish applied to formed surfaces which will be covered by fill material or by concrete. Correction of surface irregularities shall be required only for depressions which exceed 25 mm.
- b. F2: Finish F2 is a finish applied to formed surfaces which will be permanently exposed and where a reasonably attractive appearance is required, including tunnel plugs, and other surfaces for which the finishes are not specified. Surface irregularities shall not exceed 6 mm for abrupt irregularities and 15 mm for gradual irregularities.
- c. F3: Finish F3 is a finish applied to formed surfaces which will be permanently exposed to public view and where an attractive appearance is paramount and include the bridge superstructures and all concrete work in the spillway structures, intake structure and outlet structures except where F4 finish is specified in the following paragraph. Surface irregularities shall not exceed 3 mm for abrupt irregularities and 6 mm for gradual irregularities.
- d. F4: Finish F4 is a finish applied to formed surfaces for which alignment and evenness of surface are of paramount importance from the standpoint of eliminating destructive effects of water action. Included in this class are the water surfaces of the spillway walls, piers and the walls of outlet structures. Surface irregularities shall not exceed 3 mm for abrupt irregularities not parallel to the direction of flow, 6 mm for abrupt irregularities parallel to the direction of flow, and 10 mm for all gradual irregularities. Gradual irregularities that have a slope steeper than 1 in 20 parallel to the flow direction and all abrupt irregularities in excess of the allowed limits shall be ground to a slope of the allowed limits shall be ground to a slope of the abovesaid limit except that abrupt irregularities such as pitting or air holes shall be remedied in accordance with Clause 9.17.

9.16.3 Unformed Surfaces

- a. The classes of finish for unformed surfaces are designated by the symbols U1, U2, U3, as follows:
- b. U1: Finish U1 is a screeded finish applied to unformed surfaces which will be covered by fill material or by concrete. Finish U1 is also the first stage of finish U2 and finish U3. Finishing shall consist of sufficient levelling and screeding to produce uniform surfaces. Surface irregularities shall not exceed 25 mm.
- c. U2: Finish U2 is a floated finish applied to unformed surfaces of waterways or surfaces which will be generally exposed to view such as spillway structures, intake structures, outlet structures, slabs, decks, landings, tops of walls and piers. Finish U2 is also the second stage of Finish U3. Floating may be performed by use of hand power-driven equipment. 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 of screed marks and uniform in texture. Surface irregularities shall be in accordance with the requirements of Finish F4 except that no abrupt irregularities shall be acceptable. The surface irregularities of spillway crest blocks shall be accordance with the requirements of Finish F4.

- d. U3: Finish U3 is a trowelled finish applied to the unformed surfaces of building floors. When the floated finish has hardened sufficiently to prevent an excess of fine material from being drawn to the surface, steel trowelling shall be started. Steel trowelling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Surface irregularities shall be in accordance with the requirements of Finish F4 except that no abrupt irregularities shall be acceptable and surface irregularities shall not exceed 5 mm. Immediately following steel trowelling, the surface of floor slabs shall be floated with foam-rubber face float to achieve a uniformly textured slightly roughened non-skid surface as directed.

9.16.4 Sprinkling with Cement

Sprinkling of the surfaces with dry cement or other material during finishing operations for drying of the concrete to facilitate trowelling or any other purpose will not be permitted.

9.17 DAMAGED OR DEFECTIVE CONCRETE SURFACES

9.17.1 General

Defective concrete and concrete damaged from any cause shall be removed and replaced by the Contractor with acceptable concrete at his expense. Irregularities of alignment due to inaccurate finishing for surfaces, bulging of forms, or other defects specified in Clause 9.16 shall be repaired by and at the expense of the Contractor.

9.17.2 Repair of Concrete

- a. Repair of concrete shall be performed by skilled workmen and shall be subject to rigid inspection by the Engineer. Before final acceptance of the work, the Contractor shall clean all exposed concrete surfaces of all encrustation of cement, mortar, or grout, and shall remove all unsightly stains to the satisfaction of the Engineer.
- b. All porous and fractured concrete and surface concrete, to which additions are required to bring it to prescribed lines, shall be removed by chipping openings into the concrete to expose the reinforcement. The extent and dimensions of the chipped openings shall be as directed by the Engineer. The chipped openings shall be sharp-edged by sawing cutting to a minimum depth of 20 mm and keyed and shall be filled to the required lines with fresh concrete, dry-pack or mortar, as directed by the Engineer. Where concrete is used for filling, the chipped openings shall not less than 80 mm in depth and the fresh concrete shall be reinforced and doweled to the surface of the openings as directed by the Engineer.
- c. Mortar for patching shall consist of one part of cement and two parts of sand by volume and just enough water so that after thorough mixing of the ingredients the mortar will just stick together when moulded into a ball by squeezing with the hand and will not exude water but leave the hands damp. The mortar shall be fresh when placed and any mortar that is not used within 1 hour after preparation shall be wasted. Immediately prior to mortar application, the surface to which the mortar is to be bonded shall be dampened then brushed with a small quantity of mortar using a wire brush.

Where repairs are more than 30 mm deep, the mortar shall be applied in layers not more than 20 mm thick to avoid sagging. After each layer is placed, it shall be thoroughly roughened by scratching with a trowel to provide an effective bond with the succeeding layers. The last 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 repair 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 to the same colour as the adjoining concrete. All patches shall be thoroughly bonded to the surfaces of the chipped opening and shall be sound, free from shrinkage cracks and drummy areas.

Dry-pack mortar shall be used for filling holes having a depth greater than the least surface dimension, for narrow slots cut for repair of cracks and for tie-rod fastener recesses. Mortar shall be placed and packed into under-cut holes in layers each having a thickness of approximately 10 mm. Packing shall be carried out with an approved electrical or mechanical rammer, unless otherwise approved, to compress the dry-pack thoroughly into contact with the surfaces of the hole.

- d. In repairing damaged or defective concrete at important locations or for shallow repairs not deeper than the near face reinforcement, the Contractor shall use an approved epoxy resin bonding agent and mortar or an approved epoxy mortar as directed by the Engineer. Such repairs shall not be made until 28 days after the concrete has been placed.
- e. All patches and repairs, except epoxy mortar repairs, shall be kept continuously damp for a period of not less than 7 days and kept out of the direct rays of the sun for at least 7 days immediately following completion of the patch or repair.

9.17.3 Staining of Concrete

For concrete surfaces for which Class F2, Class F3 and Class F4 formwork or U2 and U3 finish is specified, care shall be taken that accumulation of foreign materials or staining due to any cause does not occur on the finished surface. Any accumulation or staining shall be cleaned off by the Contractor using an approved method. The Contractor shall not be entitled to any extra payment above the rates bid in the Bill of Quantities on account of this work.

9.17.4 Plugging Form-Tie holes

In formed concrete, surface holes remaining after dismantling form-ties shall be cleaned out and neatly plugged with dry-pack and cured all as previously specified. The dry-pack shall be colour matched with the surrounding concrete.

9.17.5 Materials used in Repairs

All materials used in the repair of concrete shall conform to the requirements of this Specification and the repairs shall be made in accordance with the procedures of Chapter VII of the Eighth Edition of the United States Bureau of Reclamation Concrete Manual. All fillings shall be bonded tightly to the surface of the holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been cured and have dried.

9.17.6 Payment

All materials, labour and equipment required for the repair of concrete or removal of stains shall be provided at the expense of the Contractor.

9.18 BLOCKOUTS IN CONCRETE

9.18.1 General

- a. Blockouts in concrete shall be constructed by the Contractor, as shown on the Drawings or as directed by the Engineer, to permit the installation and adjustment of metalwork for Water Control Plant or steel structures to be embedded in concrete and shall be filled with mortar or concrete after the installation is completed.
- b. The concrete surfaces of the blockouts shall be chipped and roughened by suitable means before mortar or concrete is placed in the blockouts.
- c. After cleaning the roughened surface and keeping it moist for at least 24 hours, and after approval by the Engineer, the blockout shall be filled with mortar of the mix designated by the Engineer or concrete of the same mix as designated for the surrounding concrete.
- d. Exceptional care shall be taken in placing mortar or concrete in blockouts to ensure satisfactory bond with the concrete placed and to secure complete contact with all metalwork in the blockouts. Any voids between the concrete in the blockouts and the metalwork will be filled by means approved by the Engineer at the expense of the Contractor.
- e. The Engineer may approve the use of a suitable expanding agent in the mix design for blockout concrete to facilitate bonding to the existing concrete surface.
- f. Mortar or concrete placed in blockouts shall be cured in accordance with Clause 9.13.

9.18.2 Payment

- a. Payment for concrete in blockouts shall be made at the rate tendered in the Bill of Quantities for concrete Type C, (Item I.11).
- b. Separate payment will not be made for dry-pack grout or mortar under baseplates of plant or equipment or other metalwork in accordance with Sub-Clause, and such costs shall be deemed to be included in the rate or lump sum prices tendered therefor in the Bill of Quantities for the item of plant, equipment or metalwork.

9.19 CONSTRUCTION, CONTRACTION AND EXPANSION JOINTS

9.19.1 General

- a. Concrete surfaces, upon or against which concrete is to be placed and to which new concrete is to adhere, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed are defined as construction joints. This definition shall also apply to any surface resulting from a sufficiently prolonged interruption in the concrete placing such that the hardening of the concrete does not allow penetration of a vibrator. Further, whenever work is suspended on any section for more than one hour, the concrete surface shall be considered as an additional construction joint.

- b. The location of construction joints and sequence of concrete placements shall be nominated by the Contractor. At least 90 days before commencing construction of a separate feature the Contractor shall submit for approval, drawings showing the location of all his proposed construction joints and sequence of concrete placements for that feature. Construction joints proposed by the Contractor may require the inclusion waterstops, if directed by the Engineer, and these waterstops will be placed at the expense of the Contractor.
- c. Certain joints will be shown on the Drawings as compulsory construction joints. These joints shall not be altered and no concrete shall be placed adjacent to the joint for at least 7 days for features up to 1 m in thickness and for 10 days where the thickness exceeds 1 m.
- d. Construction joints shall be approximately horizontal or vertical unless otherwise shown on the Drawings or directed and shall be given the prescribed shape by the use of forms, where required, or by other approved means that will ensure suitable jointing with subsequent work. 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 and shall be protected from damage caused by carrying out the procedures detailed in paragraphs e. of this Sub-Clause.
- e. Horizontal construction joints and unformed inclined construction joints shall be immediately and carefully protected from any condition that will adversely affect the hardening of the concrete after the lift has been completed. The shape and position of all construction joints shall be as shown on the Drawings or as approved by the Engineer. During the initial stage of setting, but before final setting of the concrete, the surface of the joint shall be washed with water and compressed air jets (green-cutting), with the intention of eliminating the mortar from the surface, removing semi-detached parts, and uniformly laying bare the large aggregates without however removing or loosening or undercutting them.

If the surface of a lift is congested with reinforcement steel and is relatively inaccessible, or, if for any other reason green cutting is not completed adequately or not completed at all the use of wet sandblasting shall be required. When employed in the preparation of construction joints, wet sandblasting shall be performed immediately before placing the following lift. The operation shall be continued until all unsatisfactory concrete and all laitance, coating, stains, debris, and other foreign matter are removed and large aggregates are uniformly laid bare without removing or loosening or undercutting them. Immediately before pouring is resumed, air and water jet cleaning shall be repeated until the washing water remains clear. The Contractor shall discharge the water employed in washing away from the pouring zone leaving the surface wet but without water puddles.

The air pressure used in air-water jets shall not be less than 7 kgf/cm² and the water pressure shall be just sufficient to bring the water into the effective influence of the air pressure.

- f. Vertical or inclined construction joints shall be provided at the locations shown on the Drawings or as nominated by the Contractor and approved by the Engineer or as otherwise directed by the Engineer. The surfaces of vertical or inclined construction joints shall be sound and free from honeycombing and areas of unconsolidated concrete. Vertical or inclined construction joints including blockouts and recesses which will be filled

with grout mortar, or by other approved means to expose the surface of coarse aggregate, unless otherwise directed.

- g. Vertical construction joints for slabs, beams or girders, when unavoidable, shall be located near mid-span. In the case of a girder being intersected by a beam at mid-span, the construction joint of the girder shall be moved away from mid-span by a distance equal to twice the width of the beam. The joint may be stepped, or provided with shear bars, or given both applications, as directed by the Engineer. Joints in footing and base slabs shall not be permitted except by written authorisation of the Engineer. Concrete for girder spans may be placed in 2 operations, the first operation consisting of placing the girder stems followed by green cutting, and the second operation consisting of placing the top deck slab. At least 5 days shall elapse between the first and second placing operations unless otherwise permitted by the Engineer. In all cases, no new concrete shall be placed on or against the older concrete until the joint is thoroughly cleaned of laitance, mortar coatings, or loose matter, whether on the older concrete surface, on the forms, around reinforcement, or over items to be embedded.
- h. Concrete columns and piers shall be placed in one continuous operation unless otherwise directed. No loadings on the concrete shall be super-imposed until column or pier forms have been stripped sufficiently to determine the character of the concrete in the column or pier. The full super-imposed load shall not be allowed to bear on columns or piers until the concrete therein is at least 14 days old except as otherwise directed. Construction joints in columns and piers framing into girders or beams shall be at the underside of the deepest girder or beam framing hereto. Placing of concrete shall invariably be preceded by thorough cleaning of all joints including complete removal of mortar coatings around reinforcement and loose particles on the old concrete surface to ensure bond with the new concrete.

9.19.2 Expansion and Contraction Joints

- a. All joints designed to allow possible displacement of a concrete structure with respect to an adjacent one due to expansion, shrinkage and differential settlement of the respective foundations shall be considered as expansion or contraction joints.
- b. Joints shall be located and constructed as shown on the Drawings, or otherwise directed or approved by the Engineer, and shall be in accordance with details shown. In no case shall any embedded metalwork be placed continuously through an expansion or contraction joint, except as otherwise specified, or shown on the Drawings or directed by the Engineer.
- c. Expansion or contraction joints shall be either plain and smooth or provided with a key so as to guarantee alignment of the structures. The opposite faces which form the joint shall be completely separated. The Contractor shall undertake the pouring of the second surface only after the first one has thoroughly hardened. Joint filler complying with Clause 9.21 or other approval material may be placed to form the expansion joints as shown on the Drawing or directed. The surface of the concrete first placed at contraction joints shall be coated with curing compound to break the bond before concrete on the other side of the joint is placed.

9.19.3 Payment

The cost of construction, contraction and expansion joints shall be included in the rates tendered in the Bill of Quantities for the concrete in which the joints are required except that payment for waterstop, joint filler and metal seals will be made in accordance with Clauses 9.20, 9.21 and 9.27.

9.20 PVC WATERSTOP

9.20.1 General

Waterstops nominally 30 cm wide shall be provided where concrete structures require watertightness at joints as shown on the Drawings or as directed by the Engineer. The width of the waterstop shall be within a tolerance of 10 mm of the nominal width exclusive of the nailing strips.

9.20.2 Material

The waterstop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride (PVC). The compound shall contain any extruded additional resins, plasticizers, or other materials needed to ensure that, when the material is compounded, it will have the physical characteristics specified herein:

Physical Characteristics	Requirement	Method of Test
Tensile Strength, min	140 kgf/cm ²	ASTM D 412
Ultimate Elongation, min	300%	ASTM D 412
Hardness, Durometer (Type-A)	65 to 80	ASTM D 2240
Specific Gravity	1.40 ± 0.2	
Water Absorption, max	0.15%	
Tensile Strength after Accelerated Extraction Test, min	110 kgf/cm ²	
Ultimate Elongation after Accelerated Extraction Test, min	240%	
Changes in Weight Effect of Alkali Test	± 5%	

The manufacturer's certification of conformity to the specified requirements shall be submitted to the Engineer for approval.

9.20.3 Fabrication

- The shapes and dimensions of PVC waterstops shall be as shown on the Drawings or as approved by the Engineer.
- Extruded waterstop shall be dense, homogeneous, and free from holes, scratches and other imperfections. The cross-section of PVC waterstop shall be uniform along its length and shall be transversely symmetrical so that the thickness at any given distance from either edge of the waterstop shall be uniform.

9.20.4 Splices

- a. Splices in waterstops or at the intersection of runs of the PVC waterstop shall be made with fusion-welded butt splices in accordance with the manufacturer's instruction. All splices shall be neat with the ends of the joined surfaces in alignment and in good contact. The continuity of the characteristics patterns of the cross-sections of the waterstop shall be maintained across the splice. All intersection splices shall be prefabricated at the manufacturer's factory.
- b. The number of splices in the waterstop shall be kept to a minimum and all splices shall be approved by the Engineer. The equipment used for making splices and the splicing method shall also be as approved. The equipment used for making field joints shall be a temperature controlled apparatus furnished by the Contractor.
- c. The Contractor shall make the splices in such a manner as to ensure that the splices have a tensile strength not less than 80 percent of that of the unspliced material. The Contractor shall undertake testing to confirm the strength of field splices. The splice shall be watertight, free of air bubbles and the rib and centre bulb, where applicable, shall match up exactly and be continuous.

9.20.5 Installation

- a. To eliminate faulty installation that may result in joint leakage, particular care shall be taken to see that the waterstops are correctly positioned during installation. Adequate provision shall be made to support the waterstops during the progress of work and to ensure the proper embedment in concrete. The method of securing the waterstops will be to the approval of the Engineer. The symmetrical halves of the waterstops shall be embedded in the concrete on each side of the joints. Waterstop shall be thoroughly cleaned of foreign material before concrete is placed.
- b. Care shall be exercised in placing and vibrating the concrete about the waterstop to ensure complete filling of the concrete under and about the waterstop and to obtain a continuous bond between the concrete and the waterstop at all points around the perimeter of the waterstop.
- c. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstop from mechanical damage at all times. Any PVC waterstop which will remain exposed for more than 10 days shall be covered or shaded to protect it from the action of temperature and ultraviolet rays.
- d. The Contractor shall replace or repair any punctured or damaged waterstop.

9.20.6 Measurement and Payment

- a. Measurement, for payment, for furnishing and placing PVC waterstop will be made of the lengths placed as shown on the Drawings or directed.

- b. Payment for furnishing and installing PVC waterstop 300 mm wide will be made at the rate per linear meter tendered therefor in the Bill of Quantities (Item I.1) which rate shall include the cost of all labour, materials, equipment, tools and incidentals for testing, furnishing, cutting, splicing and installing the waterstops and other works connected therewith.

9.21 JOINT FILLERS AND SEALANTS

9.21.1 General

- a. The Contractor shall furnish and install joint fillers and joint sealants at the locations shown on the Drawings or as directed or approved.
- b. The Contractor shall submit a sample of all proposed fillers and sealants and the details of the proposed methods of application for approval at least 60 days before their intended use.

9.21.2 Elastic Joint Filler

- a. Elastic joint filler shall be placed in the expansion and contraction joints as shown on the Drawings.
- b. Elastic joint filler shall be pre-formed, highly resilient-type sponge or cellular rubber conforming to ASTM D 1056, of 10 mm thickness and of density not less than 30 kg/m³. Elastic joint filler shall be held in place against the completed side of an expansion joint by a waterproof cement or other approved means.
- c. All joint surfaces to be filled shall be clean, dry and fully cured.

9.21.3 Polysulphide Mastic Joint Sealant

- a. Polysulphide mastic joint sealant shall be placed in the joints of the concrete pavement of the reservoir access road.
- b. Polysulphide mastic joint sealant shall be an approved two-part polysulphide liquid polymer.
- c. All joint surfaces to be filled shall be clean, dry and fully cured prior to application of the filler.

9.21.4 Bitumen-Rubber Mastic Joint Filler

- a. Bitumen-rubber mastic joint filler shall be placed in the upper surface of the contraction joints of the gallery.
- b. The bitumen-rubber based mastic shall be "Igas" made by the Sika Chemical Company, USA, or approved equivalent.
- c. The mastic shall have a medium-stiff consistency suitable for flowing into the joints in the gallery.
- d. During placement of the impervious fill care shall be taken not to damage the mastic by hand placing the initial impervious material on the mastic.

9.21.5 Measurement and Payment

- a. Measurement, for payment, for furnishing and placing elastic joint filler 10 mm thick will be made of the area of joint filler installed as shown on the Drawings or directed.
- b. Measurement for payment, for furnishing and placing polysulphide mastic joint sealant and bitumen-rubber mastic joint filler will be made of the volume of joint filled with mastic as shown on the Drawings or as directed.
- c. Payment for furnishing and installing elastic joint filler will be made at the rate per square meter tendered therefor in the Bill of Quantities (Item I.5.1) which rate shall include the cost of all labour, materials, equipment, tools and incidentals for testing, furnishing and installing the joint filler and other works connected therewith.
- d. Payment for furnishing and placing polysulphide mastic joint sealant and bitumen-rubber mastic joint filler will be made at the applicable rate per litre tendered therefor in the Bill of Quantities (Items I.5.2 and I.5.3)

9.22 PVC PIPE DRAINS

9.22.1 General

- a. The Contractor shall furnish and install PVC pipe of 50 mm diameter and 4.5 mm wall thickness conforming to ASTM D 2241 or JIS K 6742 in retaining walls, stone bed protection, shotcrete, concrete walls and elsewhere shown on the Drawings to serve as weep holes. Except as otherwise shown on the Drawings or as directed by the Engineer, such relief holes or wall drains shall be provided for every 2 m² of wall surface. Care shall be taken to avoid clogging drains during the progress of the work and should any drain be clogged or obstructed from any cause before the final acceptance of the Work it shall be cleaned out by and at the expense of the Contractor.
- b. Gravel fill complying with Clause 3.7 shall be placed where PVC wall drain pipes (weep holes) are installed as shown on the Drawings or as directed.
- c. The Contractor shall furnish and install PVC pipe drains 100 mm diameter and 6.0 mm wall thickness conforming to ASTM D 2241 or JIS K 6742 as bridge deck drains in the spillway bridge as shown on the Drawings or as directed.

9.22.2 Measurement and Payment

- a. Measurement, for payment, for furnishing and installing PVC relief holes or pipe drains shall be made of the length along the centreline of the pipes in place as shown on the Drawings or as directed.
- b. Payment for furnishing and placing PVC pipe drains 50 mm diameter as weep holes will be made at the rate per linear meter tendered therefor in the Bill of Quantities (Item I.2.1) which rate shall include all costs of furnishing, installing complete with gravel fill and keeping clear the PVC pipe and any other works connected therewith.
- c. Separate payment will not be made for PVC pipe drains and gravel fill for shotcrete of any thickness or stone masonry and all costs thereof shall be deemed to be included in the rates for the applicable items for shotcrete and stone masonry in the Bill of Quantities.

- d. Payment for furnishing and placing 100 mm dia PVC bridge deck drains (Item 1.2.2) will be made at the rate per linear metre tendered therefor in the Bill of Quantities which rate shall include all costs of furnishing, installing and any other works associated therewith.

9.23 DRAINAGE

9.23.1 General

The Contractor shall furnish and install perforated PVC pipes of 200 mm and 250 mm diameter under the spillway slab and behind spillway walls and outlet structure walls and elsewhere as shown as the Drawings or as directed by the Engineer to serve as drainage systems.

9.23.2 Materials

- a. The drain pipes shall be PVC pipe of nominal diameter 200 mm with 6.5 mm wall thickness and nominal diameter 250 mm with 7.8 mm wall thickness conforming to JIS K 6741 and manufactured to the details shown on the Drawings.
- b. The perforation holes shall be neatly formed in a radial direction with clean sharp edges to the details shown on the Drawings.
- c. The drain pipes shall be neatly cut or formed at intersections such that any gap between adjacent pipes is not greater than 5 mm.
- d. Pipe joints shall be solvent welded spigot and socket type.
- e. The drain pipes shall be surrounded with gravel fill as specified in Clause 3.7 to the detail shown on the Drawings.

9.23.3 Installation

- a. The Contractor shall furnish, place and compact the gravel fill in the trench or on the concrete footing to the underside of the drains.
- b. After drain pipes are installed and inspected by the Engineer, the Contractor shall furnish, place and compact the gravel fill around and over the pipe to fill the trench or to the lines and levels shown on the Drawings.
- c. The Contractor shall seal the top of the drainage trenches under spillway slabs as soon as each length or section has been completed and accepted by the Engineer. The method of sealing will be to ensure that the gravel fill does not become contaminated until concrete is placed. No sealing is required for drain pipes behind retaining walls.

9.23.4 Measurement and Payment

- a. Measurement, for payment, for furnishing and placing drain pipes shall be made of the length along the centerline of the pipes in place as shown on the Drawings or as directed. No deduction in length will be made for intersections.
- b. Payment for furnishing and placing drain pipes will be made at the applicable rate per linear metre tendered therefor in the Bill of Quantities (Items 1.3 and 1.4) which rates shall include all costs of furnishing and installing perforated drain pipes, and sealing, where required, and any other works connected therewith.

- c. Payment for gravel shall be in accordance with Sub-Clause 3.7.2.

9.24 TOLERANCE FOR CONCRETE CONSTRUCTION

9.24.1 General

- a. Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings are defined as 'tolerances'. Tolerances shall be inclusive of surface irregularities as defined in Clause 9.16. The intent of this Clause is to establish tolerances that are consistent with modern construction practice yet governed by the effect that permissible deviations will have upon structural action or operational function of the structure. Deviations from established lines, grades and dimensions will be permitted to the extent set forth in this Clause. Provided that the Engineer may reduce these tolerances set forth in this Clause if such tolerances impair the structural action or operational function of a structure or item.
- b. Where tolerances are not stated in the Specification or shown on the Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provision of this Clause. Notations on the Drawings of specified tolerances in connection with any dimensions shall be considered as supplementary to the tolerances specified in this Clause.
- c. 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 in this Clause. Concrete work that exceeds the tolerance limits specified in this Clause shall be remedied or removed and replaced by and at the expense of the Contractor.

9.24.2 Concrete

- a. Tolerances for reinforced concrete structures shall be in accordance with the requirements of the appropriate JIS or ACI Standard or as specified below, except where such tolerances are reduced by the Engineer.
- b. Variation from the plumb:

Side walls of screen, and bulkhead gates (first and second stage concrete)	In 2 m or more	3 mm
In the lines and surfaces of columns, piers, walls, towers	In 3 m	5 mm
	In 6 m	8 mm
	In 12 m or more	16 mm
- c. Variations from the level or from the grades indicated on the Drawings:

Sills of screens and bulkhead gates (first and second stage concrete)	In 3 m	3 mm
In floors, slab inverts, ceilings and beam soffits	In 3 m	5 mm
	In any bay or 6 m max.....	8 mm
	In 12 m or more	16 mm

d.	Variations of the linear structure lines from established position in plan and related position of walls	In any bay or 8 m max.....12 mm In 12 m or more25 mm
e.	Variation in locations of sleeves and sizes and locations of floor openings and wall openings5 mm
f.	Variation in cross-sectional of columns, beams and in thickness of slabs and walls	Minus.....5 mm Plus.....10 mm
g.	Variation in steps:	
	In a flight of stairs	Risers3 mm Tread5 mm
	In consecutive steps	Risers.....2 mm Tread.....3 mm

9.24.3 Reinforcement

Tolerances for reinforcing steel:

a.	Length of splice	-25 mm
b.	Variation of protective cover	+/- 5 mm
c.	Variation in indicated position of reinforcement :	
	Starter bars	One bar diameter
	Slabs and walls	0.25 of the indicated spacing
	Beams and columns	+/- 5 mm

Provided the number of bars required by the specified spacing is not varied.

d.	Dimensions of bent bars :	
	Stirrups and ties	+/- 5 mm
	Other	+/- 10 mm

9.24.4 Embedded Metalwork

Tolerances for placing embedded metalwork unless otherwise specified in this Specification. +/- 5 mm

9.24.5 Soleplates

Tolerances for placing soleplates:

a.	Variation in level	+/- 3 mm
b.	Maximum tilt along a diagonal	3 mm

9.25 REINFORCEMENT

9.25.1 General

The Contractor shall furnish and install all reinforcement required for execution of the Works where shown on the Drawings or directed.

9.25.2 Materials

- a. All reinforcement bars shall be of a deformed type U30 reinforcing steel locally produced in accordance with the requirements of Indonesian Code PBI-71 or SD30 conforming to JIS G 3112 or approved equivalent.
- b. Test certificates will be required for all reinforcement furnished by the Contractor to be used in the Works.
- c. As specified in Clause 1.4 the Contractor shall prepare and submit for approval reinforcement detail drawings for all structures including bar-placing drawings, bar bending diagram and bar lists. The Contractor's reinforcement detail drawings shall be prepared from the Drawings issued by the Engineer and in accordance with the Specification. The Contractor's drawings shall include bar lists which identify each bar by shape and number for checking the bars during placement and shall show the total weight of reinforcement bar for use in establishing payment quantities.

9.25.3 Fabrication and Placing

- a. Reinforcement bars shall be placed in concrete where shown on the Drawings or where directed. Clear distances between bars and concrete surfaces, hooks, bends, splicing, and anchorage shall all conform to the standard details shown on the Drawings, or in case of lack of such drawing, shall conform to the requirement of JCEA or ACI.
- b. When it is necessary to splice reinforcement bars at points other than shown on the Drawings, the position and methods of splicing shall be as approved by the Engineer. Care shall be exercised to avoid locations of high stress concentrations and to prevent concentration of splices at the same positions. Splicing shall be kept to a minimum and alternate splices shall be staggered.
- c. If the Contractor proposes to use mechanical couplings for reinforcing bars, he shall submit samples of the proposed coupling to the Engineer for approval not less than 60 days prior to their proposed use.
- d. If the Contractor proposes to use welded splices in reinforcing bars, the equipment, materials and all welding and testing procedures shall be to the approval of the Engineer. The Contractor shall carry out test welds and tests as required by the Engineer.
- e. Before the reinforcement is placed, the surfaces of the bars and the surfaces of all supports shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease, or other foreign substances, which, in the opinion of the Engineer, are objectionable. If necessary previously placed bars shall be cleaned of rust and mortar encrustation's or any other material which may prevent bond before being covered by concrete.
- f. Reinforcement bars shall be accurately placed and fixed in position so that they will not be displaced during the placing of concrete.

- g. Bars shall be tied at all intersections, and splices ties at several points using annealed iron wire more than 0.9 mm in diameter or with suitable clips.
- h. Distances from the surfaces of forms of foundation shall be maintained correctly by means of metal hangers, mortar blocks, metal supports, or other supports approved by the Engineer.
- i. Reinforcement bars will be inspected by the Engineer after fixing and before concrete placing. When a long period of time has elapsed after placing reinforcement bars, they shall be cleaned and will be inspected again by the Engineer before placing concrete.

9.25.4 Measurement

- a. Measurement, for payment, of furnishing and placing of deformed reinforcement bars will be made only for the weight of bars embedded in concrete or shotcrete in accordance with the Contractor's working drawings and reinforcement schedules approved by the Engineer. Clips, ties, chairs, spacers, binding wire or other materials used for positioning and fastening the reinforcement bars in place will not be measured for payment. The reinforcement bars in place will not be measured for payment. The reinforcement bars in laps indicated on the Drawings or required by the Engineer will be included in the measurement for payment. Additional joints or splices will not be measured for payment.
- b. Measurement, for payment, of splices formed by welding or mechanical splices will be made for the equivalent lap length at the location of the splice.

9.25.5 Payment

- a. Payment for furnishing and placing deformed reinforcement bars in Diversion Tunnel, in Spillway, in Gallery, in Hydropower Station and in other Structure will be made at the respective rates per tonne tendered therefor in the Bill of Quantities (Item I.6.1, I.6.2, I.6.3, I.6.4, and I.6.5) which rates shall include the cost of all labour, equipment and materials required for furnishing, transportation, cutting, bending, supporting, fixing and placing reinforcement bars and all other works connected therewith.
- b. Payment will not be made for joints and splices except as provided in Sub-Clause 9.25.4.b.

9.26 DOWELS

9.26.1 GENERAL

The Contractor shall furnish and install all dowel bars and accessories required for execution of the Works where shown or on the Drawings or directed.

9.26.2 Materials

- a. All dowel bars shall be of plain round steel bar SR 30, 25 mm in diameter, produced in accordance with the requirements of JIS G 3112 or approved equivalent.

- b. As specified in Clause 1.4 the Contractor shall include the detail of the location of the dowel bars on the reinforcement drawings, prepare bar lists for checking the bars during placing and shall show total weight of bar for use in establishing payment quantities.
- c. All sleeves for dowel bars shall be PVC pipe 30 mm in diameter conforming to ASTM D 2241 or JIS K 6742 and shall have an inside diameter to fit the dowel bar as snugly as practicable.

9.26.3 Fabrication and Placing

- a. The dowel bars shall be fabricated to the detail shown on the Drawings or directed. The dowel bars shall be placed in the locations shown on the Drawings or directed.
- b. The hooked end of the dowel bar shall be always placed in the first concrete placement and the bars shall be accurately placed and fixed in position so that they will not be displaced during the placing of concrete.
- c. The dowel bar shall be placed so that the straight end of the bar is perpendicular to the plane of the joint. Any bar which is not perpendicular to the plane of the joint shall be replaced or rectified by the Contractor at his expense.
- d. Prior to pouring the second concrete placement the 30 mm diameter PVC pipe sleeves shall be placed over the straight length of the dowel bar. The PVC pipe will be 20 mm longer than the straight length of the dowel bar and both ends of the PVC will be sealed by approved means to prevent the ingress of concrete.

9.26.4 Measurement

Measurement, for payment, of furnishing and placing of dowel bars shall be made for the weight of bars embedded in concrete in accordance with the Contractor's working drawings and bar schedule approved by the Engineer. Clips, ties, chairs, spacers, binding wire or other materials used for positioning and securing the dowel bars in place will not be measured for payment. PVC pipe and sealant will not be measured for payment.

9.26.5 Payment

Payment for furnishing and placing dowel bars will be made at the rate per tonne tendered therefor in the Bill of Quantities, (Item 1.7) which rate shall include the cost of all labour, equipment and materials required for furnishing, transportation, cutting, bending, supporting, fixing and placing dowel bars, PVC pipe sleeves and sealant and all other works connected therewith.

9.27 METAL SEALS

9.27.1 Requirement

- a. The Contractor shall furnish and install metal seals lining in the locations of the diversion tunnel plugs as shown on the Drawings. The Contractor shall prepare these metal seals in accordance with the requirements of this Clause and as shown on the Drawings.
- b. The metal seals shall be made from corrosion resistant copper conforming to ASTM B36 and shall be 1.6 mm thick.

9.27.2 Installation of Metal Seals

- a. The metal seals shall be installed at the upstream end of the tunnel plug concrete as shown on the Drawings.
- b. The metal seals shall be continuous and water tight for their entire length.
- c. All joints and splices for metal seals shall be completed using brass solder or other approved methods capable of developing the full strength of the copper seal.
- d. The metal seals shall be supplied pre-bent prior to delivery to the Site to suit the curvature of the diversion tunnel.
- e. The metal seals shall be protected by a steel plate immediately after the removal of the tunnel lining formwork.

9.27.3 Measurement and Payment

- a. Measurement, for payment, of furnishing and placing metal seals shall be made of the length of metal seal installed as measured on the centre line of the seal as shown on the Drawings or directed.
- b. Payment for furnishing and installing metal seals will made at the rate per linear meter tendered therefor the priced Bill of Quantities. (Item I.8)

9.28 PRECAST CONCRETE

9.28.1 General

- a. The Contractor shall furnish and install precast reinforced concrete units as shown on the Drawings or as directed.
- b. Precast units which are required to be prestressed shall comply with the additional requirements specified in Clause 9.29.

9.28.2 Materials and Manufacture

- a. Except as otherwise provided in these Clauses, all units shall be constructed and erected in accordance with the applicable requirements of Section 9 of the Specification.
- b. The reinforcement for the precast concrete units shall comply with the requirements of Section 9 hereof and the length and shape shall be to the details shown on the Drawings. The Contractor shall submit the working drawings and bar lists in accordance with Clause I.4.
- c. Concrete for precast concrete units shall be of concrete of the following classes of concrete in accordance with the Indonesian Concrete Code (PBI 71).

- h. The construction joint on the top surface of the precast concrete beams shall be prepared in accordance with Clause TS8.19.1.ii. ensuring that the edges of these surfaces are protected from damage from the wet sand blasting. The precast concrete units shall be protected from heavy rains for 12 hours, direct rays from the sun for 3 days and shall be cured in accordance with Section 8 hereof unless steam curing is approved. Staining of the concrete surfaces caused by curing or other reasons shall not be acceptable. No fire or excessive heat, including the heat resulting from welding of reinforcing steels, shall be permitted near or in direct contact with precast concrete units at any time.

9.28.3 Approval of Methods

At least 30 days before commencing manufacture of all precast reinforced concrete units, the Contractor shall submit for approval all details of the methods to be used in manufacture, handling, transport, storage and erection of the units.

9.28.4 Handling and Installation

- a. Precast concrete units shall remain in the original position on the casting platform and be allowed to cure for at least 28 days before being moved, except that this 28 days requirement may be decreased with the approval of the Engineer if test specimens made from the concrete used in the precast concrete units and cured under the same conditions and at the same location develop the required strength prior to the expiration of the 28 days period.
- b. The method of handling, transporting and installing precast concrete units shall be to the approval of the Engineer and shall be such as to minimise the risk of fracture of the unit by impact or due to bending stress while being handled and transported.
- c. Unless otherwise directed or approved the precast concrete units shall be handled by means of suitable slings or other approved lifting system with spreader beam, if necessary, attached to the units at locations indicated on the Drawings or approved. The handling of precast units shall be performed using a crane with enough capacity to hoist.
- d. Precast concrete units loaded on a trailer or equivalent transport equipment shall be secured to prevent movement and by means that do not damage the concrete surface.
- e. The precast concrete units shall be checked for cracks prior to being installed. The crack on any precast unit shall be less than 0.2 mm when the member is supported at its designed support locations without any additional load. The test of crack width shall be performed by using a microscope or other instrument so that the crack can be accurately measured in the presence of the Engineer.

9.28.5 Measurement and Payment

- a. Payment for furnishing and installing precast concrete panels for the spillway bridge will be made in accordance with the lump sum price tendered therefor in the Bill of Quantities (Item I.16).

- b. Payment for furnishing and installing precast concrete diaphragms for spillway bridge will be made in accordance with the lump sum tendered therefor in the Bill of Quantities (Item I.15) which shall include the cost of furnishing 6 diaphragms, handling, erection, tensioning and all associated costs.
- c. Payment for furnishing and installing precast prestressed concrete beams for spillway bridge will be made in accordance with the lump sum tendered therefor in the Bill of Quantities (Item I.14) which shall include the cost of furnishing 3 beams, handling, erection, tensioning and all associated costs.

9.29 PRESTRESSED CONCRETE

9.29.1 General

The Contractor shall furnish and install precast, prestressed, post-tensioned spillway bridge beams and diaphragms which shall be procured from a specialist manufacturer with at least 5-years experience in the making of such products.

9.29.2 Materials

Concrete and reinforcement shall comply with the requirements of Clause 9.28.

Prestressing tendons shall be as shown on the Drawings and shall be 7-wire stress-relieved strand complying with AASHTO M203 or equivalent standard.

9.29.3 Submittals

The Contractor shall submit a complete set of working drawings, specifications and method statements in accordance with the requirements of Clauses I.4 and I.5.

The submittals shall include, but not be limited to the following

- Material specification
- Concrete manufacturing procedures
- Stressing procedures
- Transportation to the Site
- Handling and erection
- Safety precautions

9.29.4 Payment

Payment for complying with the requirements of this Clause will not be made exclusively and all costs incurred shall be deemed to be included in the prices in the Bill of Quantities for the items to which these requirements apply.

9.30 MEASUREMENT AND PAYMENT OF CONCRETE

9.30.1 General

This Clause refers to the measurement, for payment, of concrete types A, B, C, D, and E used in the various parts of the works and shown in the Bill of Quantities as payment item numbers I.9, I.10.1, I.10.2, I.10.3, I.10.4, I.11, I.12.1, I.12.2, I.12.3, I.12.4, I.12.5, I.13.1, I.13.2.

Measurement and payment for other related concrete items is specified elsewhere.

9.30.2 Measurement

a. General

Measurement, for payment, of concrete shall be made of the volume concrete in cubic metres measured to the neat lines of the structure in which the concrete is placed and subject to the qualifications of paragraphs b. to g. as follows.

b. Payment Lines for Surface Excavation:

Unless otherwise specified, measurement, for payment, of concrete required to be placed against surface excavations shall be made to the lines of the excavation for which excavation payment is made in accordance with Clause 3.4.

c. Payment Lines for Diversion Tunnel Lining:

Measurement, for payment, shall be made to the neat lines of the inner surface and end faces and to the approved inner surface payment line for shotcrete. (Ref. Item I.9)

d. Payment Lines for Outlet Tunnel

Measurement, for payment, shall be made to the outer surface of the steel outlet pipe and the approved inner surface payment line for shotcrete. (Ref. Item I.12.2)

e. Payment Lines for Backfill Concrete

Measurement, for payment, for concrete required for backfill of seams, cavities etc. excavated in accordance with Sub-Clause 3.4.1.3 (Item I.13.2) and abandoned exploration adits (Item I.12.4) shall be made of the actual volume of concrete placed in these locations as directed.

Measurement of concrete placed in over-excavated areas as specified in Sub-Clause 3.4.1.1 para (i) shall not be measured for payment.

f. Concrete for Instrumentation

No measurement shall be made of concrete for instrumentation items specified in Section 13 of the Specification.

g. Payment Lines for Blockout Concrete or under Base Plates

Measurement, for payment, of concrete in blockouts shall be made of the actual volume of such concrete placed. (Ref. Item I.11).

No measurement shall be made of the volume of concrete, dry-pack or non-shrink mortar under plant base plates or under metalwork components specified in Section 11 and the cost of such work shall be deemed to be included in the items for which the concrete is applied.

9.30.3 Payment

a. General

Payment for concrete in the various parts of the Works will be made for the respective volumes of concrete measured in accordance with Sub-Clause 9.30.2 at the rates per cubic metres tendered in the Bill of Quantities for the payment items for each type of concrete. The rates shall include the cost of all labour, equipment and materials required for the planning and testing, furnishing, mixing, transporting, placing and curing of concrete, furnishing and placing forms, supports, scaffolding and of the finishes applied to each item of concrete work.

Payment items to be paid under this Sub-Clause 9.30.3, para a are : I.9, I.10.1, I.10.2, I.10.3, I.10.4, I.11, I.12.1, I.12.2, I.12.3, I.12.4, I.12.5, I.13.1, I.13.2.

Payment provisions, additional to those specified in this paragraph a, specific to particular payment items, are specified hereunder.

b. Concrete Type D in Concrete Plug in Diversion Tunnel

Payment for Concrete Type D in the concrete plug in the diversion tunnel (Item I.12.3) shall include the cost of cooling the concrete as specified in Clause 9.11.11 and the cost of injection grouting as specified in Clause 5.10.

c. Concrete Type D in Adits

Payment for Concrete Type D in adits shall include the cost of injection grouting as specified in Clause 5.11.

**CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM
PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING
APPURTENANT STRUCTURES**

SPECIFICATION

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SECTION 10. ROAD CONSTRUCTION

10.1 GENERAL

10.1.1 Permanent Access Roads

- a. The Contractor shall construct the following permanent access road construction works as shown on the drawings.
 - (i) Left bank access road from the existing public Semarang-Jatibarang road to the dam crest.
 - (ii) Right bank access road from the existing public Semarang-Jatibarang road to the dam crest.
 - (iii) Access road from dam crest to the hydropower station.
 - (iv) Access road to the inclined intake structure.
 - (v) Access road to the reservoir.
 - (vi) Access road on the dam crest.
 - (vii) Paved parking and traffic manoeuvring areas.
 - (viii) Paving on the spillway bridge.
- b. The left bank access road from the existing Semarang – Jatibarang road to the Dam Management Complex shall be completed within the time of completion of 384 days in accordance with Sub-Clauses 43.1 and 48.2(a) of the Conditions of Contract.
- c. Not less than 30 days before commencing construction of any section of the required road system, the Contractor shall submit plans for the construction of the section of road. The plans shall be based on the proposals submitted by the Contractor in his Tender and approved in the Letter of Acceptance.

10.1.2 Temporary Access and Haul Roads

The Contractor shall design, construct and maintain temporary access and haul roads in accordance with Clause 1.9.5.

10.1.3 Use of Access Roads

- a. Until sealed, use of the permanent roads as haul roads by the Contractor shall be as approved by the Engineer.
- b. Sealed roads once sealed shall not be used as haul roads or used by heavy construction equipment unless otherwise approved.
- c. During the period of the Contract, the contractor for Package 2 will be engaged on other work in the vicinity of the Works and the Contractor shall allow the Employer and the Package 2 contractor full and unrestricted use of all roads described in this Clause.

10.1.4 Soil Conservation

The Contractor shall carry out soil conservation measures on all works for permanent access roads, where and when directed, in accordance with Clause 7.10.

10.1.5 Payment

Payment for the various items of road construction will be made at the applicable rates tendered therefor in the Bill of Quantities as provided for in the Specification.

10.2 CLEARING AND GRUBBING

The area to be occupied by the road construction works shall be cleared and grubbed within the right-of-way shown on the Drawings in accordance with Clause 3.1.

10.3 DRAINAGE FOR ROADWORKS

10.3.1 Scope of Work

- a. The Contractor shall construct surface drains including lined surface drains, covered drains and catch basins to the lines, grades and dimensions shown on the Drawings in accordance with Section 8 or as directed by the Engineer.
- b. At least 28 days prior to the commencement of construction of each grated road crossing drain, the Contractor shall submit his working drawings to the Engineer for approval as specified in Clause 1.4.4. The Contractor shall also provide at the site, when directed by the Engineer, setting-out markers for the culvert showing the exact position, levels, dimensions and alignment of the structure for the Engineer to examine whether the proposed arrangement fits the actual topographical or other conditions of the site.

10.3.2 Payment

Payment for the construction of surface drains of various type, and catch drains will be made in accordance with the relevant payment clauses for the various types of surface drains in Section 8.

10.4 EARTHWORKS FOR ROADWORKS

10.4.1 Stripping

Stripping of the natural surfaces on which embankments are to be constructed and of the surfaces of required excavation shall be carried out in accordance with Clause 3.3.

10.4.2 Excavation

- a. All excavation shall be carried out to the lines, grades and dimensions shown on the Drawings or directed in accordance with the relevant provisions of Section 3 of the Specification.
- b. As far as is practicable, approved excavated material shall be used in the construction of road embankments or for backfill of excavation below formation.
- c. Surplus material not required for the Works shall be disposed of in accordance with Sub-Clause 3.4.2.

10.4.3 Payment

- a. Payment for stripping will be made in accordance Clause 3.3.4.
- b. Payment for excavation for roadworks will be made in accordance with Clause 3.4.11 or 3.4.12 as applicable.

10.5 COMMON EMBANKMENT

10.5.1 Scope of Work

- a. The common embankments for roadways and other works shall be constructed to the lines and grades shown on the Drawings or established by the Engineer. The excavation, placing, moistening, drying and compacting operations shall be such that the materials are uniformly compacted throughout the embankment, homogeneous, free from lenses, pockets, streaks, laminations, discontinuities or other imperfections.
- b. The material required for common embankment shall be obtained from the required excavation to be performed under the Contract and shall consist of common soil, rock and gravel suitable for the respective kinds of embankment.
- c. When the Contractor requires material from borrow areas other than those provided by the Employer or from required excavations, he may do it at his own cost and responsibility after obtaining approval from the Engineer. The material proposed for use in road subgrade shall be CBR tested.

10.5.2 Approval of Embankment Materials

Prior to the commencement of embankment, the Contractor shall carry out under the direct supervision and to the satisfaction of the Engineer a series of field and laboratory tests to investigate the physical quality, conditions and soil mechanical properties of materials to be used in embankment construction to determine the optimum conditions for compaction. The field and laboratory tests shall include, but not be limited to, in-situ moisture content and density tests, compaction tests, grading, trial embankments and rolling trials. The cost of carrying out such tests shall be included in the rate for common embankment in the Bill of Quantities. (Item J.2)

10.5.3 Placing and Compaction

- a. Before material for the first layer of the embankment is placed, the foundation for the embankment shall be cleared and grubbed or excavated to the depth shown on the Drawings. Where the slope is steeper than 4 horizontal to 1 vertical, benches of not less than 0.5 meter in height and not less than 1.0 meter in width shall be cut into the foundation to obtain a suitable bond with the embankment and shall be moistened or dried and compacted in the manner specified hereinafter for the embankment to be placed thereon. All embankment foundations grubbed in accordance with Sub-Clause 3.2 shall be compacted to the specified density prior to the placement of the first layer of fill.
- b. Areas of soft and yielding material in the foundations of embankments shall be removed from any area and to the depth directed by the Engineer and replaced with approved material compacted as specified hereunder.

- c. Approved material shall be placed in embankment in approximately horizontal layers for the full width of the embankment to a thickness of not more than 300 mm after compaction. The travel of equipment over the road embankment during construction shall be routed so as to obtain maximum consolidation of the embankment. Special care shall be taken to control the passage of hauling equipment on the embankment to compact it uniformly whenever it is possible.

Compaction shall be performed by rollers travelling parallel to the road centre line and rolling shall begin from the sides in such a manner that every roller track will overlap with the immediately preceding and adjacent track by half of the roller width. The roller pass shall be preceded by sprinkling of water, if required, as determined by the Engineer.

- d. Approved materials for embankment construction acquired from required excavation or borrow areas shall be handled during the excavation and placing operations to achieve sufficient blending such that when compacted the materials secure the highest practicable dry density and ensure sufficient impermeability and stability of the embankment.
- e. Insofar as practicable as determined by the Engineer, conditioning of the material to bring it to within the required range of moisture content shall be performed at the site of stockpiles but such moistening shall be supplemented by sprinkling at the time of compaction if necessary. If the moisture content is beyond the required range, placing of material shall not proceed, except with the specific approval of the Engineer, until the conditioned material comes within the required range of moisture content. No adjustment in the unit rate shall be made on account of any delay occasioned thereby nor for conditioning of the material at stockpiles.
- f. If the surface of the prepared foundation of the surface or the surface of any compacted layer of embankment is too dry or smooth to bond properly with the layer of materials to be placed thereon, it shall be moistened and/or scarified in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer is placed. If the surface of any compacted layer of embankment in place is too wet for proper compaction of the layer of embankment to be placed thereon, it shall be removed, allowed to dry, or scarified to reduce the water content to the required moisture content, and then recompacted before the next succeeding layer is placed. The moisture content of the soil shall be carefully controlled either by natural drying or wetting with a fine spray. Prior to and during compaction operations, the material shall have a moisture content of not more than 2 percent and not less than 2 percent of optimum moisture content and the moisture content shall be uniform throughout each layer.
- g. When the material has been conditioned as specified hereinabove, the new layer shall be compacted by compactor or by mechanical tamper and such other compacting equipment as approved by the Engineer following the results of tests carried out in accordance with Sub-Clause 10.5.2 of this Clause. Hand tamping will not be permitted.
- h. The dry density of compacted soil in each layer shall not be less than 90 percent of the maximum dry density as determined by the Standard Proctor Compaction Test (Moisture-Density Relation) in accordance with AASHTO T 99, JIS A 1210, or ASTM 698.

The material in the top 600 mm of embankment which forms the foundation of a structure shall be compacted to not less than 95 percent

of its maximum dry density.

The subgrade of roads constructed in embankment condition shall be compacted to not less than 95 percent of its maximum dry density. The thickness of the subgrade shall be as shown on the Drawings.

- i. Clayey and highly moistened materials for which the application of quality control by the Proctor test method is impracticable shall not be approved for use in embankment construction.
- j. During the course of embankment construction, the Contractor shall at all times provide positive adequate drainage so that surface water is not at any time impounded on any portion of the embankment surface. During embankment construction, a minimum transverse slope of 4 percent shall be provided, and the embankment surface shall be maintained in a smooth, compact, drainable condition, particularly when work is to be suspended at the end of the day or for other reasons.
- k. The embankment and side slopes shall be carefully built up true to line in accordance with the Drawings and overfilling or bulging of the side slope surfaces from the required lines shall be avoided and shall be rectified to the specified slope. Embankment slopes after trimming shall be compacted by mechanical tampers or approved means.

10.5.4 Testing

The Contractor shall carry out field density testing of the compacted embankment at a rate of 1 test per 500 m³ of material placed at locations as directed.

10.5.5 Sod Facing

The Contractor shall carry out strip or full face sodding on the slope of embankment and excavation as shown on the Drawings or as directed in accordance with Clause 7.10.

10.5.6 Measurement

Measurement, for payment, of common embankment shall be made of the volume of materials placed to the lines, grades and dimensions above the stripped or excavated line and levels shown on the Drawings or as directed by the Engineer.

10.5.7 Payment

- a. Payment for common embankment, including embankment materials placed and compacted in areas from which soft and yielding material is removed at the direction of the Engineer, will be made at the rate per cubic meter tendered therefor in the Bill of Quantities (Item J.2) which rate shall include all costs of excavation and transportation of materials from the temporary stockpile to the place of final use, placing, moistening or drying, compaction, all materials tests required in accordance with this Clause and all necessary works connected therewith, and all costs of labour, materials, equipment and incidentals.
- b. Payment for excavating soft and yielding material from embankment foundation will be made in accordance with Sub-Clauses 3.4.3 or 3.4.11 as applicable.