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DIVISION 7
STRUCTURES

SECTION 7.1
CONCRETE

7.1.1 GENERAL

7.1.1.1 Description

(a) The work specified in this Section shall consist of the construction of all concrete structures, including reinforced, precast and composite structures, in accordance with these Specifications to the lines, levels, grades, and dimensions shown on the Drawings, and as required by the Engineer.

(b) The work shall also include preparation of the site on which the concrete work is to be placed, maintenance of the foundation, provision of concrete blinding, pumping or other measures to keep the foundation dry.

(c) The class of concrete to be used in each part of the concrete works shall be as shown on the Drawings, or relevant Sections of these Specifications, or as directed by the Engineer.

(d) The provisions of PBI NI.2, 1971 (Indonesian Reinforced Concrete Code) and SNI 03-2834-2000 Tata Cara Pembuatan Rencana Campuran Beton Normal (Methods of Ordinary Concrete Mix Design) shall apply in their entirety to all concrete work except where in conflict with the provisions of this Specification, in which case the provisions of this Specification shall govern.

7.1.1.2 Issue of Construction Details

Construction details for Concrete Work not included in the Contract Documents at the time of tender shall be furnished by the Engineer after the initial design review or design revision has been completed in accordance with Section 1.9 of these Specifications.

7.1.1.3 Related Work Specified Elsewhere

(a)	Traffic Management and Safety	:	Section 1.8
(b)	Field Engineering	:	Section 1.9
(c)	Environmental Safeguards	:	Section 1.17
(d)	Culverts and Concrete Drains	:	Section 2.3
(e)	Porous Drainage	:	Section 2.4
(f)	Excavation	:	Section 3.1
(g)	Fill	:	Section 3.3
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(j)	Structural Steelwork and Steel Painting	:	Section 7.4
(k)	Piling	:	Section 7.6
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(q)	Bearings	:	Section 7.12
(r)	Steel Bridge Railing	:	Section 7.13
(s)	Demolition of Structures	:	Section 7.15

7.1.1.4 Quality Assurance

The quality of material supplied, of the mixes produced and of the workmanship and final products shall be monitored and controlled as specified in the Reference Standards in Article 7.1.1.6 below.

7.1.1.5 Tolerances

(a) Dimensional Tolerances:

- Overall length up to 6 m + 5 mm
- Overall length over 6 m +15 mm
- Length of beams, deck slabs, columns walls, or between abutments - 0 and +10 mm

(b) Shape Tolerances:

- Square (difference in diagonal lengths) 10 mm
- Straightness or Bow (deviation from intended line) for lengths up to 3 m 12 mm
- Straightness or Bow for lengths 3 m to 6 m 15 mm
- Straightness or Bow for lengths greater than 6 m 20 mm

(c) Position Tolerances (from reference point):

- Plan position of precast columns ± 10 mm
- Plan position of horizontal surfaces ± 10 mm
- Plan position of vertical surfaces ± 10 mm

(d) Vertical Alignment Tolerance:

- Plumb alignment for columns and walls ± 10 mm

(e) Level/Elevations Tolerances:

- Top of blinding concrete under foundations ±10 mm
- Top of blinding concrete under approach slabs ±10 mm
- Top of columns, abutments and transverse beams ±10 mm

(f) Horizontal Alignments Tolerance:

- 10 mm in 4 m horizontal length

(g) Tolerances for Concrete cover over Reinforcing Steel:

- Concrete cover up to 3 cm. - 0 and + 5 mm
- Concrete cover of 3 cm - 5 cm - 0 and + 10 mm
- Concrete cover of 5 cm - 10 cm ± 10 mm

7.1.1.6 Reference Standards

Standar Industri Indonesia (SII) :

SII-13-1977 (AASHTO M85 - 75)	:	Semen Portland.

Standar Nasional Indonesia (SNI) :

PBI 1971	:	Peraturan Beton Bertulang Indonesia NI-2 (Indonesian Reinforced Concrete Code)
SNI-03-4142-1996 (AASHTO T11 - 05)	:	Metode Pengujian Jumlah bahan Dalam Agregat Yang Lolos Saringan No.200 (0,075 mm).
SNI 03-2816-1992 (AASHTO T21 - 05)	:	Metode Pengujian Kotoran Organik Dalam Pasir untuk Campuran Mortar dan Beton.
SNI 03-1974-1990 (AASHTO T22 - 07)	:	Metode Pengujian Kuat Tekan Beton.
SNI 03-4810-1998 (AASHTO T23 - 04)	:	Metode Pembuatan dan Perawatan Benda Uji Beton di Lapangan.
SNI 03-6817-2002 (AASHTO T26 - 79 (2004))	:	Metode Pengujian Mutu Air Untuk digunakan dalam Beton
SNI 03-1968-1990 (AASHTO T27 - 06)	:	Metode Pengujian tentang Analisis Saringan Agregat Halus dan Kasar.
SNI 03-2417-1991 (AASHTO T96 - 02 (2006))	:	Cara Uji Keausan Agregat dengan Mesin Abrasi Los Angeles.
SNI 03-3407-1994 (AASHTO T104 - 99 (2003))	:	Cara Uji Sifat Kekekalan Agregat dengan Cara Perendaman Menggunakan Larutan Natrium Sulfat atau Magnesium Sulfat.
SNI 03-4141-1996 (AASHTO T112 - 00 (2004))	:	Metode Pengujian Gumpalan Lempung dan Butir-butir Mudah Pecah Dalam Agregat.
SNI 03-2493-1991 (AASHTO T126 - 90)	:	Metode Pembuatan dan Perawatan Benda Uji Beton di Laboratorium.
SNI 03-2458-1991 (AASHTO T141 - 05)	:	Metode Pengambilan Contoh Untuk Campuran Beton Segar.
SNI 03-2834-2000 (BSI 1973)	:	Tata Cara Pembuatan Rencana Campuran Beton Normal

ASTM:

ASTM C 309	:	Standard Specification for Liquid Membran-Forming Compounds for Curing Concrete

7.1.1.7 Submittals

(a) The Contractor shall submit samples of all the materials he intends to use together with test data confirming that all the material properties specified in Article 7.1.2 of these Specifications are met.

(b) The Contractor shall submit his job mix design for each type of concrete he proposes to use at least 35 days prior to the intended start of concrete placement.

(c) The Contractor shall submit in writing the results of all specified quality control tests promptly they become available or are requested by the Engineer. In the case of compressive strength tests, this shall involve submitting the 3-day strength, 7-day strength, 14-day strength and 28-day strength test results 3 days, 7 days, 14 days and 28 days respectively following the date of mixing.

(d) The Contractor shall submit detailed drawings of all falsework to be used, and shall obtain the Engineer's approval before setting up any falsework.

(e) The Contractor shall notify the Engineer in writing at least 24 hours before he intends commencing mixing or placing any concrete, as specified in Article 7.1.4.1 below.

7.1.1.8 Storage and Protection of Cement

For storage of cement the Contractor shall provide a weatherproof shed that is airtight and has a raised wooden floor which is covered with polyethylene sheeting. At all times stacks of cement bags shall be kept covered with an envelope of polyethylene sheeting.

7.1.1.9 Job Conditions

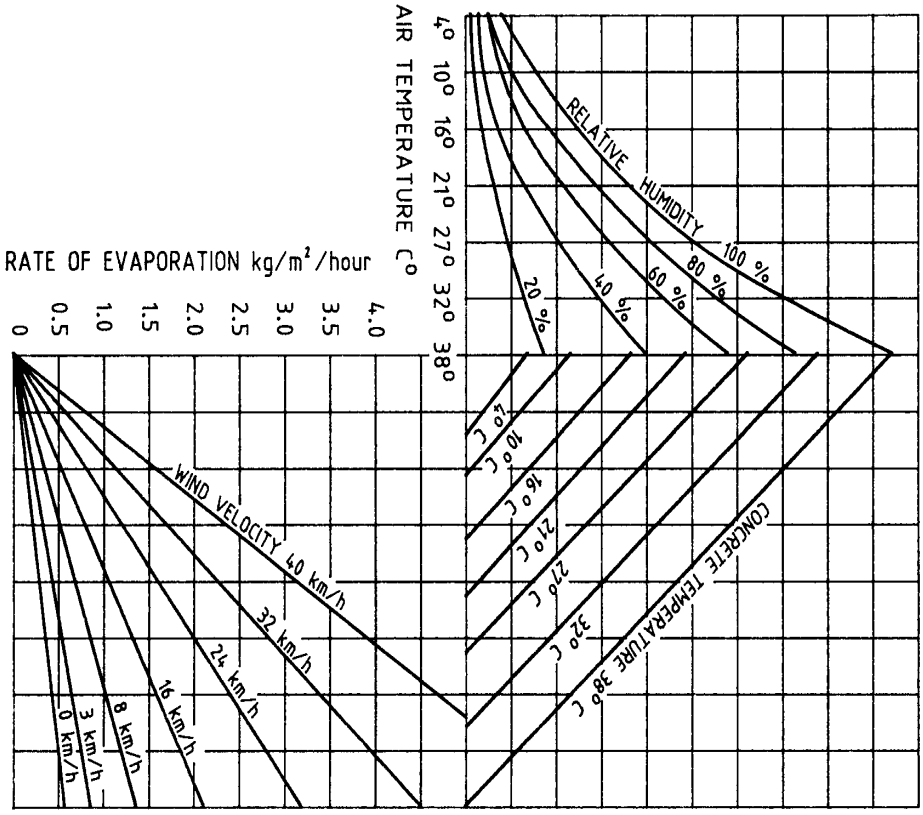
The Contractor shall maintain the temperature of all materials, particularly the coarse aggregate, at the lowest possible levels and shall maintain the temperature of the concrete below 30 ºC at the time of placement. In addition, the Contractor shall not place any concrete when:

(a) The rate of evaporation exceeds 1.0 kg/m^2/hour, as determined by the chart below.

(b) The relative humidity of the air is less than 40 %.

(c) Directed not to do so by the Engineer, during periods of rain or when the air is dust laden or otherwise polluted.

Rate of Evaporation of Water from Concrete



7.1.1.10 Rectification of Unsatisfactory Concrete Work

(a) Rectification of concrete work which does not meet the tolerance criteria specified in Article 7.1.1.4, which does not have a satisfactory surface finish, which does not meet the mix property requirements specified in Article 7.1.3.3, which fails strength test as specified in Article 7.1.6.2, shall be as directed by the Engineer and may include:

(i) Changes in the mix proportions for the remainder of the work.

(ii) Additional curing on those portions of the structure represented by the test specimens which failed.

(iii) Strengthening or complete removal and replacement of those portions of the work which he deems to be unsatisfactory.

(b) In the event of a dispute regarding the quality of the concrete work or any doubt regarding the adequacy of the available test data, the Engineer may direct the Contractor to carry out additional testing to ensure that a fair judgement of the work quality can be made. Such additional testing shall be at the Contractor's own expense.

(c) Rectification of cracked or displaced Concrete Work shall be in accordance with the Provisions of Article 2.2.1.8.(b) of these Specifications.

7.1.2 MATERIALS

7.1.2.1 Cement

(a) The cement used for Concrete Work shall be Portland cement conforming to SII-13-1977 (AASHTO M85) except type I, II, III and IV. Unless other-wise permitted by the Engineer, air-entraining admixtures shall not be used.

(b) Unless otherwise permitted by the Engineer, the product of only one mill of any one brand type of Portland Cement shall be used on the project.

7.1.2.2 Water

Water used in mixing, curing, or other designated applications shall be clean and free from harmful matter such as oil, salt, acid, alkali, sugar, or organic materials. Water shall be tested in accordance with, and shall meet the requirements of SNI 03-6817-2002 (AASHTO T26). Water known to be of potable quality may be used without being tested. When the proposed water quality is doubtful and the testing as above mentioned could not be carried out, comparison testing shall be carried out by using the cement mortar with the proposed water and with the distillated or drinking water. The proposed water could be used when the compressive strength at 7 days and 28 days of cement mortar with the proposed water is at least 90 % of cement mortar with the distillated or drinking water at the same curing period.

7.1.2.3 Aggregate Grading Requirements

(a) The coarse and fine aggregate gradations shall conform with the requirements given in Table 7.1.2.1 Aggregate Grading Requirements except that materials not meeting these grading requirements shall not necessarily be rejected if the Contractor can demonstrate by testing that concrete meeting the mix property requirements specified in Article 7.1.3.3 can be produced using them**.**

(b) The coarse aggregate shall be selected so that the maximum particle size is no greater than three quarters the minimum clear space between reinforcing bars or between the bars and the form work or between any other restrictions in the space that the concrete must occupy in the work.

Table 7.1.2.1 Aggregate Grading Requirements

Sieve Size		Percent by Weight Passing for Aggregates				
ASTM	(mm)	Fine	Coarse			
2”	50.8	-	100	-	-	-
1½”	38.1	-	95 - 100	100	-	-
1”	25.4	-	-	95 - 100	100	-
¾”	19	-	35 - 70	-	90 - 100	100
½”	12.7	-	-	25 - 60	-	90 - 100
3/8”	9.5	100	10 - 30	-	20 - 55	40 - 70
No.4	4.75	95 - 100	0 - 5	0 -10	0 - 10	0 - 15
No.8	2.36	-	-	0 - 5	0 - 5	0 - 5
No.16	1.18	45 - 80	-	-	-	-
No.50	0.300	10 - 30	-	-	-	-
No.100	0.150	2 - 10	-	-	-	-

7.1.2.4 Aggregate Properties

(a) Aggregates for concrete shall consist of clean, hard, durable particles obtained by crushing rock or boulders, or by the screening and washing (if necessary) of natural river gravel and sand.

(b) The aggregates shall be free of organic materials as indicated by SNI 03-2816-1992 (AASHTO T21) and shall conform with the other property specifications given in Table 7.1.2.2 Property of Aggregates when sampled and tested in accordance with the provisions of the relevant SNI (AASHTO) procedures.

Table 7.1.2.2 Property of Aggregates

PROPERTY	TEST METHOD	MAXIMUM PERMISSIBLE LIMITS	
		Fine Aggregate	Coarse Aggregate
Los Angeles Abrasion loss 500 revolutions	SNI-03-2417-1991	-	40 % for < K400
			25 % for ≥ K400
Sodium or Magnesium Sulphate Soundness loss after 5 cycles	SNI 03-3407-1994	10 % for Sodium Sulphate	12 % for Sodium Sulphate
		15 % for Magne-sium Sulphate	18 % for Magne-sium Sulphate
Percent of Clay Lumps and Friable Particles	SNI 03-4141-1996	3 %	2 %
Material Passing No.200 sieve	SNI-03-4142-1996	3 %	1 %

7.1.2.5 Rubble Stone for Cyclopean Concrete

Stone for cyclopean concrete shall be of approved quality, sound and durable, and free from segregation, cracks, or imperfections tending to destroy its resistance to the weather. It shall be sharp angled, free from dirt, oil or any other injurious material which may prevent the proper adhesion of the mortar.

7.1.3 MIXING AND BATCHING

7.1.3.1 Job Mix Design

The material proportions and batching weights shall be determined using the method specified in PBI and in accordance with the limits given in Table 7.1.3.1.

7.1.3.2 Determining the Proportions and Batch Weights

No structural concrete shall be placed in the works until the relevant mix has been approved by the Engineer. The determinations will be made after the materials furnished by the Contractor have been accepted.

(a) Trial Mixes

The Contractor shall, at least thirty five (35) days prior to the commencement of concreting, have laboratory trial mixes prepared which shall be witnessed by the Engineer.

The laboratory trial mixes shall be so designed by the Contractor that the resultant compressive strength result, (Preliminary Test Result), shall show an adequate working strength margin, in accordance with normal good practice, so that the

probability of site working strength test values falling below the minimum specified strength shown in Table 7.1.3.2 is reduced to a value not exceeding 5%.

The Engineer then will determine the proportions on the basis of the trial mixes conducted with the materials to be used in the work.

Table 7.1.3.1 Mix Batching Proportion Limits

Concrete Class	Maximum Size of Aggregates (mm)	Maximum Water Cement Ratio (by weight)	Minimum Cement Content (kg/m^3 of mix)
K600	19	0.35	450
K500	37	0.40	395
	25	0.40	430
	19	0.40	455
K450	37	0.425	370
	25	0.425	405
	19	0.425	430
K400	37	0.45	350
	25	0.45	385
	19	0.45	405
K350	37	0.475	335
	25	0.475	365
	19	0.475	385
K300	37	0.50	315
	25	0.50	345
	19	0.50	365
K250	37	0.55	290
	25	0.55	315
	19	0.55	335
K175	37	0.60	265
	25	0.60	290
	19	0.60	305
K125	37	0.70	225
	25	0.70	245
	19	0.70	260

The Contractor may, subject to prior approval by the Engineer, use alternative sizes of coarse aggregate to those in Table 7.1.3.1.

Designated sizes of coarse aggregate need not be separated into component sizes. However, two sizes are preferred when the maximum size exceeds 2.5 cm. If one or more of the component sizes used fails to meet the specified grading for its respective size, but a combination of the sizes can be used to meet the specified grading for the combined size, they may be used with the written permission of the Engineer.

(b) Proportions and Batch Weights

The Engineer will designate the weight in kilograms of fine and coarse aggregate (in a saturated surface-dry condition) per cubic metre of concrete for the specified class of concrete and these proportions will not be changed except as provided in the paragraphs immediately following. In addition, the Engineer will also designate the batch weights of aggregate after he has made moisture determinations and corrected

the saturated surface-dry weights for free moisture. The last such watering of the aggregates shall have been at least 12 hours prior to the time of batching to ensure adequate draining of the stockpiles

In batching aggregate for structures containing less than 25 cubic metres of concrete, the contractor may substitute approved volumetric measuring devices in lieu of weighing devices. In such event, weighing will not be required but the volumes of coarse aggregate and of fine aggregate measured into each batch shall be those designated by the Engineer.

(c) Adjustment for Strength

If the concrete does not come up to the specified or approval strength, the contractor shall propose new job mix design or the cement content may be increased as directed by the Engineer

(d) Adjustment for Variation in Workability

If it is found impossible to obtain concrete of the desired placeability and workability with the proportions originally designated by the Engineer, he will make such changes in aggregate weights as are necessary, provided that in no case shall the cement content originally designated be changed.

(e) Adjustment for New Materials

No change in the source or character of the materials shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has designated new proportions based on tests or trial mixes as provided herein. Should the changes due to the new materials require an increase in the amount of cement, no additional payment shall be made to the Contractor for the cost of such additional cement.

7.1.3.3 Mix Property Requirements

(a) All concrete used in the work shall meet the compressive strength and slump requirements specified in Table 7.1.3.2, or approved by the Engineer, when sampled, cured and tested in accordance with SNI 03-1974-1990 (AASHTO T22), SNI 03-4810-1998 (AASHTO T23), SNI 03-2493-1991 (AASHTO T126), SNI 03-2458-1991 (AASHTO T141).

Table 7.1.3.2 Mix Property Requirements

Concrete Class	Minimum Compressive Strength (kg/cm^2)						"SLUMP" (mm)	
	15 cm x 15 cm x 15 cm Cube Specimens			15 cm x 30 cm Cylinder Specimens			Vibrated	Non Vibrated
	3 day	7 day	28 day	3 day	7 day	28 day		
K600	260	390	600	215	325	500	20 - 50	-
K500	215	325	500	170	260	400	20 - 50	-
K400	170	285	400	140	240	330	20 - 50	-
K350	150	250	350	125	210	290	20 - 50	50 - 100
K300	130	215	300	110	180	250	20 - 50	50 - 100
K250	110	180	250	90	150	210	20 - 50	50 - 100
K225	97	150	225	81	125	190	20 - 50	50 - 100
K175	75	115	175	62	95	145	30 - 60	50 - 100
K125	55	80	125	45	70	105	20 - 50	50 - 100

Note :

When a concrete pump is used, the slump may be in range of 75 $\pm$ 25 mm.

(b) Trial mixes shall be tested at 3, 7 and 28 days and the resulting strengths of the final mix recorded.

(c) Concrete not meeting the slump requirements (refer to Article 7.1.6.1) shall generally not be placed in the work, except that the Engineer may in some instances approve the limited use of small quantities of such concrete in certain low-stressed parts of certain works, The workability and texture of the mix shall be such that it can be placed in the works without the formation of hollow spaces or gaps or retention of air or water bubbles, and such that on removal of the formwork a smooth, uniform, dense surface is presented.

(d) When the results of 7-day tests give strengths below those specified in Table 7.1.3.2 the Contractor shall not place any further concrete until the cause of the low results has been ascertained and until he has taken such steps which shall ensure the production of concrete complying with the Specifications to the satisfaction of the Engineer. Concrete not meeting the specified 28-day compressive strength in accordance with Article 7.1.6.2 shall be considered unsatisfactory and the work shall be rectified as specified in Article 7.1.1.10 above. The concrete strength shall be deemed to be less than the specified strength when any series of test specimens from the part of the work in question is less than the characteristic strength obtained from the formula specified in Article 7.1.6.2.(c).

(e) The Engineer may specify tests at 3 days where required. These shall be compared against the 3 days tests for the trial mixes to determine the strength likely at later stages. No concrete will be rejected on the basis of the 3 day test.

7.1.3.4 Mixing

(a) General

Concrete shall be mixed at the construction site, at a central mixing plant, in a truck mixer, or by a combination of central plant and truck mixing. Handmixing may be used when approved by the Engineer. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

(b) Mixing at Site of Concrete Construction

Concrete shall be mixed in a batch mixer of the type and capacity approved by the Engineer. The mixing time for machines of ¾ cubic metre capacity or less shall be longer than 1.5 minutes after all the materials have been introduced into the mixer, for larger machines the time shall be increased 15 seconds for each additional 0.5 cubic metre in size, but in no case shall the mixing time exceed three times the mixing time prescribed above. Charging of water into the mixer shall begin before the cement and aggregates enter the drum. During mixing, the drum shall be operated at speeds specified by manufacturers. Pick-up blades in the drum of the mixer which are worn down 2 cm or more at any part must be replaced.

The volume of a batch shall not exceed the manufacturer's rated capacity of the mixer without written permission of the Engineer. No mixer whose rated capacity is less than a one-bag batch shall be used.

Concrete shall be mixed only in such quantities as are required for immediate use, and concrete which is not of the required consistency at the time of placement shall not be used.

Retempering of concrete will not be permitted. Entire content of the mixer shall be removed from the drum before materials for the next batch are placed therein. Upon cessation of mixing for a considerable length of time, the mixer shall be cleaned thoroughly. Upon resumption of mixing, the first batch of concrete material placed in the mixer shall contain sufficient sand, cement, and water to coat the inside surface of the drum without diminishing the required mortar content of the mix.

(c) Central Plant Mixing

When mixed at a central plant, the mixer and methods used shall be in accordance with the requirements of Article 7.1.3.4.(b). Mixed concrete shall be transported from the central mixing plant to the site of work in agitator or non-agitator trucks approved by the Engineer.

Unless otherwise permitted in writing by the Engineer, agitator trucks shall be equipped with water-tight, revolving drum, and shall be capable of transporting and discharging concrete without segregation. The agitation speed of the drum shall be between 2 and 6 revolutions per minute. The volume of mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 70% of the gross volume of the drum. Upon approval of the Engineer, truck mixers may be used in lieu of agitator trucks for transportation of central plant mixed concrete. Gross volume of agitator bodies, expressed in cubic metre, shall be as determined by the mixer manufacturer. The interval between introduction of water into mixer drum and final discharge time shall be as determined by the Engineer. During this interval the mixture shall be agitated continuously.

Bodies of non-agitator trucks shall be smooth and water-tight. Covers shall be provided when needed for protection against rainfall. The non-agitator trucks shall deliver concrete to the work site in a thoroughly mixed and uniform mass. Uniformity shall be deemed satisfactory if samples from the 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 30 minutes after introduction of mixing water into the cement and aggregates or if admixture is used at a time to be determined by the Engineer.

(d) Truck Mixing

Concrete may be mixed in truck mixers of approved design. Truck mixing shall be in accordance with the following provisions. The truck mixer shall be

either a closed, water-tight, revolving drum or an open-top revolving-blade or paddle type. It shall combine all ingredients into a thoroughly mixed and uniform mass, and shall discharge the concrete with satisfactory uniformity. A maximum difference of 2.5 cm between slumps of samples from the one-quarter and three-quarter points of the discharge load shall be deemed satisfactory.

Mixing speed for revolving drum type mixers shall not be less than 4 revolutions per minute of the drum nor greater than a speed resulting in a peripheral velocity of the drum of 1 metre per second. For the open-top type mixer, mixing speed shall be between 4 and 16 revolutions per minute of the mixing blades or paddles. Agitation speed for both the revolving-drum and revolving blade type mixers shall be between 2 and 6 revolutions per minute of the drum or mixing blades or paddles.

The capacities of truck mixer shall be in accordance with the manufacturer's ratings except that they shall not exceed the limitation herein. Standard for normal rated capacity, expressed as percentage of the gross volume of the drum, shall not be more than 50% for truck mixing and 70% for agitating.

The concrete shall be delivered to the site of the work and discharge shall be completed within 45 minutes after the introduction of the mixing water into cement and aggregates or if admixture is used at a time to be determined by the Engineer.

When the concrete is mixed in a truck mixer, the mixing operation shall begin within 30 minutes after the cement has been mixed with the aggregates. Except when intended for use exclusively as agitators, truck mixers shall be provided with a water measuring device which will measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount when the tank, if mounted on the truck mixer, is satisfactorily and practically level.

(e) Hand Mixing

Hand mixing will not be permitted, except in case of emergency, without written permission from the Engineer. For non-structural concrete (≤ K125), when permitted, it shall be performed only on water-tight mixing platforms made of metal, etc. Concrete shall be turned and returned on the platform at least six times and until all particles of the coarse aggregate are covered thoroughly with mortar and the mixture is uniform.

7.1.4 PLACEMENT

7.1.4.1 Preparation of Site

(a) The Contractor shall demolish existing structures that are to be replaced by the new Concrete Work or which must be removed to make way for the new Concrete Work. Such demolition work shall be carried out in accordance with Section 7.15 of these Specifications.

(b) The Contractor shall excavate or backfill the foundations or formation for the Concrete Work to the lines shown on the Drawings or indicated by the Engineer in accordance with the provisions of Sections 3.1 and 3.2 of these Specifications, and shall clear and grub a sufficient area around the perimeter of the Concrete Works to ensure easy access to all sides of the work. Stable walkways shall also be provided if necessary to ensure that all sides of the work may be easily and safely inspected.

(c) All footings, foundations and excavations for Concrete Work shall be kept dry and concrete shall not be placed on earth containing mud, debris or other foreign material, or in water. If approved by the Engineer, concrete may be placed in water using special methods and equipment to prevent leakage at the base of caisson or cofferdam.

(d) Before the placing of concrete is commenced, all formwork, reinforcement and items to be encased in the concrete (such as pipes or ducts) shall be correctly positioned and securely fastened and supported against displacement by the concrete placement work.

(e) If specified shown on the drawings or directed by the Engineer, bedding material for the Concrete Work shall be laid in accordance with the provisions of Section 2.4 of these Specifications.

(f) The Engineer will inspect all prepared excavation and foundations before approving the placement of formwork or reinforcing steel or concrete and may request the Contractor to carry out deep probe penetration tests, density tests or other investigations to confirm adequate bearing capacity of the foundation sub soils. In the event that unsatisfactory conditions are found, the Contractor may be directed to alter the dimensions or depth of the foundation and to excavate and replace soft areas, compact the foundation soils or carry out other stabilization measures which may be directed by the Engineer.

7.1.4.2 Formwork

(a) Earth formwork, where approved by the Engineer, shall be formed by excavation, the sides and bottom being trimmed by hand to the required dimensions. All loose dirt shall be removed prior to the placing of concrete.

(b) Fabricated formwork may be of wood or steel, with mortar-tight joints and shall be rigid enough to maintain the required position during placing, compacting and curing without deformation.

(c) Rough timber may be used for surfaces that will not be exposed in the finished structure, but dressed timber of uniform thickness shall be used for exposed concrete surfaces. Formwork shall provide chamfering of all sharp edges.

(d) Forms shall be constructed so that they can be removed without damaging the concrete.

7.1.4.3 Placing

(a) The Contractor shall inform the Engineer in writing at least 24 hours before he intends to commence the placing of concrete, or to continue the placing of concrete if operations have been suspended for more than a 24 hour period. The notification shall include the location of the work, the nature of the work, the class of concrete and the planned date and time of concrete mixing. The Engineer will acknowledge

receipt of the notification and will inspect the formwork and reinforcement and may or may not issue an approval in writing for the work to commence as planned. The Contractor shall not place any concrete without having received the Engineer's written approval to proceed.

(b) Notwithstanding the issue of an approval to proceed, no concrete shall be placed when the Engineer or his representative is not actually present to witness the mixing and placing operation in its entirety.

(c) Immediately before concrete is placed, formwork shall be saturated with water or coated internally with a non-staining mineral oil.

(d) No concrete shall be used which is not placed in its final position in the form within 60 minutes after it has been mixed, or within such shorter time as may be directed by the Engineer on the basis of the observed setting characteristics of the cement being used, unless an additive approved by the Engineer has been added to retard the hardening process.

(e) The placing of concrete shall be continued without stoppage up to an approved pre-arranged construction joint or until the work is completed.

(f) Concrete shall be placed in a way which shall avoid the segregation of fine and coarse particles in the mix. Concrete shall be placed in the forms as near as practicable to its final position to avoid flowing and shall not be allowed to flow more than one metre after placement.

(g) When placed into structures which have intricate formwork and dense steel reinforcement, concrete shall be deposited in horizontal layers not more than 15 cm thick. For concrete walls, this thickness may be 30 cm placed continuously along the entire length.

(h) Concrete shall not be dropped freely into the form from heights greater than 150 cm. Concrete shall not be deposited directly through water.

Where concrete is placed in water, pumping shall not be carried out until 48 hours after concreting, except if the concrete is placed using a tremie or drop-bottom-bucket methods, which form and type are especially used for that purpose and which have been approved by the Engineer.

The tremie shall be watertight and of sufficient size to enable the smooth flow of concrete. The tremie shall always be full during concreting. If the flow of concrete stops the tremie shall be withdrawn and refilled prior to further concreting.

Either Tremie or Drop-Bottom-Bucket shall cause entry of the fresh concrete mix under the concrete surface which has been previously placed.

(i) Placing shall be performed at such a rate that already placed concrete which is being integrated with fresh concrete is still plastic.

(j) Concrete surfaces which will be joined with new concrete shall be roughened, shall be free from loose and brittle materials. Just prior to placing of the new concrete, the contact surface shall be sprayed with water and a layer of cement mortar shall be applied.

(k) Water shall not be permitted to flow freely over or rise onto Concrete Work surface within 24 hours of placement.

7.1.4.4 Construction Joints

(a) A concreting schedule shall be prepared for each proposed structure and the Engineer shall approve the location of construction joints on this schedule, or they shall be located as shown on the Drawings. Construction joints shall not be located at the junction of structural members unless otherwise specified.

(b) Construction joints through wing walls shall be avoided. All construction joints shall be perpendicular to the principal lines of stress and in general shall be located at points of minimum shear.

(c) Where vertical joints are necessary, reinforcing bars shall extend across the joint in such a manner as to make the structure monolithic.

(d) Keyways at least 4 cm deep shall be provided in all construction joints in walls, slabs, and between footings and walls. For slabs on grade, joints shall be located in a manner to divide the slab into areas not larger than 40 sq.m, with the larger dimension no greater than 120 percent of the smaller dimension.

(e) The Contractor shall provide additional labor and materials as necessary to make additional construction joints in case of any unplanned suspension of the work caused by rain or by breakdown in the concrete supply or by suspension of the work by the Engineer.

(f) Subject to the Engineer's approval, an additive may be used to bond the construction joints, which method shall be in accordance with the manufacturer's instructions.

(g) In salt water, construction joints shall not be permitted between a depth of 75 cm under the lowest water level and 75 cm above the highest water level, unless otherwise shown on the Drawings.

7.1.4.5 Consolidation

(a) Concrete shall be consolidated with approved internal or external mechanical vibrators. When required, and when approved by the Engineer, vibrating shall be supplemented by hand rod with suitable tools to assure proper and adequate consolidation. Vibrators shall not be used to transport concrete from point to point inside the forms.

(b) Care shall be taken during consolidation to ensure that all corners and spaces between and around reinforcing bars are properly filled without displacement of the reinforcing cage and that all voids and air bubbles are filled with concrete.

(c) Vibration shall be limited to the time necessary to produce satisfactory consolidation without causing segregation of aggregates.

(d) External mechanical vibrators shall be capable of producing at least 5000 cycles per minute with an effective weight of 0.25 kg, and able to be located on the form work so as to produce even vibrations.

(e) Internal mechanical vibrators shall be of the pulsating type and shall be capable of producing at least 5000 cycles per minute when used in concrete that has a slump of 2.5 cm or less, with vibrated radius area shall not be less than 45 cm.

(f) Each internal vibrator shall be inserted into the wet concrete vertically so that it penetrates to the bottom of the freshly placed concrete and provides consolidation throughout the full depth of the section. The vibrator shall then be withdrawn slowly and inserted again at an adjacent position no more then 45 cm away. Vibrators shall not remain for more than 30 seconds in one location, shall not be used to move concrete to adjacent locations and shall not be allowed to touch the reinforcing.

(g) The minimum number of internal mechanical vibrators shall be as shown on the following Table 7.1.4.1.

Table 7.1.4.1 Minimum Number of Internal Mechanical Vibrator

Concreting Speed (m^3/hour)	Vibrator Number
4	2
8	3
12	4
16	5
20	6

When other equipment is used, the method and number of pieces of equipment shall be as directed by the Engineer. It is desirable to provide spare vibrators to prevent the delay of work activities when vibrators are broken.

7.1.4.6 Cyclopean Concrete

Cyclopean concrete shall consist of Class K175 containing large embedded stones. The stones shall be carefully placed and shall not be dropped into place. They shall be cast to avoid damage to the forms or to the partially set adjacent masonry. Stones shall be washed and saturated with water before placing. Total volume of stone shall not be greater than 1/3 of total volume of cyclopean concrete.

For retaining walls or piers greater than 60 cm thickness, stone having a maximum size of 25 cm may be used. Each stone shall be surrounded by at least 15 cm of concrete and no stone shall be closer than 30 cm to any top surface nor closer than 15 cm to any coping.

7.1.5 FINISHING WORKS

7.1.5.1 Removal of Formwork

(a) Formwork shall not be removed from vertical faces, walls, slender columns and similar structures until 30 hours after the completion of the placement of the concrete. Formwork supported by falsework under slabs, beams, girders, or arches shall not be removed until tests indicate that at least 60 % of the design strength of the concrete has developed.

(b) To facilitate finishing, forms used for ornamental work, railings and parapets, shall be removed not less than 9 hours nor more than 30 hours following concrete placement, depending upon weather conditions.

7.1.5.2 Surfacing (Ordinary Finish)

(a) Unless otherwise approved, the surface of the concrete shall be finished immediately after form removal. All projecting wire or metal devices that have been used for holding the forms in place, and forms which pass through the body of the concrete, shall be removed or cut back at least 2.5 cm beneath the surface of the concrete. Lips of mortar and all irregularities caused by form joints shall be removed.

(b) The Engineer shall inspect the concrete surfaces immediately upon removal of the forms and may direct the patching of minor imperfections which will not affect the structural or other functioning of the concrete work. The patching shall involve filling of small holes and depressions with cement mortar.

(c) If the Engineer approves the filling of large cavities of honeycombs, the work shall be chipped back to sound material, forming faces perpendicular to the work surface. The cavity shall be saturated with water and a thin layer of neat cement mortar (cement and water, without sand) shall be applied to the faces of the cavity. The cavity shall then be packed and rammed with stiff mortar composed of one part of Portland cement to two parts of sand, which shall be preshrunk by mixing it approximately 30 minutes before using.

7.1.5.3 Surfacing (Special Finishes)

Exposed, usually visible surfaces shall be given further finishing work as follows or as directed by the Engineer:

(a) Tops of slabs, curbs, sidewalk surfaces and other horizontal surfaces as directed by the Engineer, shall be struck off with templates to provide the required levels or crowns immediately following placing of the concrete and shall be hand finished to smooth, even surfaces by both longitudinal and transverse movement of wooden floats, or by other suitable means, before the concrete has started to set.

(b) Float finished horizontal surfaces, which must not be slippery, such as for sidewalks, shall be slightly but uniformly roughened by brooming, or other methods directed by the Engineer, just as the concrete starts to set.

(c) Non-horizontal visible surfaces that have been patched or still rough shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place.

7.1.5.4 Curing

(a) Immediately after placement concrete shall be protected from premature drying, excessively hot temperatures, and mechanical damage. Concrete shall be maintained with minimal moisture loss and a relatively constant temperature for a specified period to ensure proper hydration of the cement and hardening of the concrete.

(b) The concrete shall be cured, as soon as it has sufficiently hardened, by covering with water absorptive sheathings, which shall be thoroughly saturated for a period of at least 7 days. All curing mats or blankets shall be sufficiently weighted or tied down

to keep the concrete surface covered and to prevent the surface from being exposed to currents of air.

Where wooden forms are used, they shall be kept wet at all times until removed, to prevent the opening of joints and drying out of the concrete. Traffic shall not be allowed on concrete surfaces for 14 days after the concrete has been placed.

(c) Where the deck slab concrete will act as a wearing course it shall be cured after hard setting has occurred by covering with moist sand, 5 cm thick, for at least 21 days. The sand shall be kept moist throughout this period.

(d) Concrete of high early strength Portland cement or ordinary Portland cement with additive material shall be kept wet until it reaches 70 % of 28-day concrete design strength.

7.1.5.5 Steam Curing

(a) Steam curing may be used to get high early strength. Additive material shall not be permitted unless otherwise approved by the Engineer.

(b) Steam curing shall be applied continuously until the concrete reaches 70 % of its 28-day design strength. Steam curing shall follow the requirements below:

(i) Steam pressure shall not exceed atmospheric pressure

(ii) The temperature shall not exceed 38 °C within 2 hours after concreting, and may gradually increase to 65 °C, with a maximum rate of increase of 14 °C/hour.

(iii) The temperature difference between two locations on the steamer shall not exceed 5.5 °C.

(iv) The rate of temperature decrease during the cooling down period shall not exceed 11 °C/hour.

(v) The concrete temperature at the time of removal from the steamer shall not differ by more than 11 °C from the air temperature.

(vi) During steam curing, the steamer shall always be in a saturated condition.

(vii) After finishing steam curing, each part of the structure shall be kept wet for 4 days.

(c) The Contractor shall ensure that the equipment is in good working condition and the temperature in the steamer can be adjusted in accordance with the above requirements and variations in the weather.

(d) The steam pipe shall be located and the beam protected such that steam will not be directly sprayed on the concrete, as this may cause temperature differences between adjacent concrete parts.

7.1.6 FIELD QUALITY CONTROL

7.1.6.1 Testing for Workability

One slump test, or more as directed by the Engineer, shall be carried out on every batch of concrete produced, and the test shall not be deemed to have been carried out unless witnessed by the Engineer or his representative.

7.1.6.2 Compressive Strength Testing

(a) Sampling

The compressive strength of concrete during construction shall be determined by testing a required number of test samples of every separate concrete batch and also by statistical evaluation of the gross number of tests carried out on the same mix design over a number of different batches or days.

The Contractor shall prepare test specimens which will be cured and tested at 7 days and 28 days or as determined by the Engineer, or at any other interval that may be deemed necessary to determine the strength of the concrete.

Specimens shall be made in pairs and there shall not be less than eight pairs (one pair per test sample) made for every 100 cubic metres of concrete or fraction thereof placed during one day's work or as deemed necessary by the Engineer. One specimen from each pair shall be tested at 7 days and one specimen at 28 days.

Irrespective of the quantity, every day's production of concrete shall be tested both for strength and for slump and every structure and every component of every structure shall likewise be so tested for strength and slump. The checking and testing of the concrete shall be the prerogative of the Engineer, and he may increase the specified strength and condition as required for the project.

The concrete test specimens will be tested by the Contractor at a conveniently located and properly equipped approved laboratory.

The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling, transporting and storing.

(b) Strength Requirements

(i) Specimen Preparation

The ultimate compressive strength of the concrete shall be determined on specimens obtained and prepared in accordance with "Peraturan Beton Bertulang Indonesia, 1971" or, if this is not possible with SNI 03-2458-1991 (AASHTO T141) and SNI 03-4810-1998 (AASHTO T23). Test cylinders made in the laboratory shall conform to SNI 03-2493-1991 (AASHTO T126). The compression test performed on cylinders shall be according to specifications SNI 03-1974-1990 (AASHTO T22).

(ii) Compressive Strength

The average site working strength value of any 4 consecutive results of the tests at the age of 28 days shall not be less than the minimum strength specified in Table 7.1.3.2 for the respective class of concrete and only one

sample tested is permitted to fall below the minimum 28 days compressive strength and that sample shall not fall to less than 90% of the minimum 28 day compressive strength.

In the event of failure to comply with this requirement all of the concrete in all the batches represented by such specimens, including any batches within the sequence which were not sampled shall be deemed not to comply with the strength requirement of this clause.

If at any time the average of any 4 consecutive results of tests at the age of 7 days falls below the minimum 7 day compressive strength given in Table 7.1.3.2 the cement content of the concrete will be increased by at least 20 kg per cubic metre of compacted concrete, without extra payment, until any necessary mix modifications have been agreed following examination of 28 day tests.

(iii) Characteristic Strength

The characteristic strength of the various classes of concrete shall be determined as soon as the first 30 test results of each class become available.

The characteristic strength shall be calculated by the equation :

$$\sigma_{bk} = \sigma_{bm} - K.S$$

$$\sigma_{bm} = \frac{\sum_{i=1}^{n} \sigma_i}{n}$$

$$S = \sqrt{\frac{\sum_{i=1}^{n} (\sigma_i - \sigma_{bm})^2}{n - 1}}$$

where:

σ_d = minimum 28 days compressive strength

σ_{bk} = characteristic strength

σ_{bm} = average test strength

S = standard deviation

σ_i = result of the test on the specimen

K = 1.64

If the characteristic strength so determined falls below the minimum 28 day compressive strength the Contractor will increase the cement content in the same manner as described in Item (ii) above until such time as adjustments shall be made in the mix proportions or improvements made in the quality control measures to raise the average strength or reduce variation to the satisfaction of the Engineer.

(iv) Failure to Comply with Compressive Strength Requirements

In the event of compressive strength results not complying with the strength requirements of this clause or in the event of doubtful results, the Engineer will proceed to check the compression strength by means of crushing tests performed on test specimens taken with a rotary core borer at suitable points in the completed structure indicated by the Engineer.

Such tests shall be carried out by an agreed authority having suitable test facilities. If such tests show strength in compliance with the requirements herein specified, the concrete will be considered satisfactory. If such tests do not comply with the requirements, the Engineer may direct the Contractor to cut out and make good the defective work at the Contractor's expense.

(v) Care of Specimens

The cost of taking specimens and performing the tests including the cost of providing stout, substantial packing cases and the cost of shipping or transporting the test specimens from the site to the laboratory shall be included as part of the price bid for Portland cement concrete. The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling and transporting.

(vi) Records

The records of all tests shall be kept by the Engineer but results shall be available at all times to the Contractor. The Contractor shall be responsible for making such adjustments as may be necessary to produce specification concrete and the test results shall include whether or not the concrete is satisfactory.

7.1.6.3 Additional Testing

The Contractor shall carry out any additional testing that may be required to establish the quality of materials or mix or finished concrete work, as directed by the Engineer. Such additional testing may include :

(a) Nondestructive testing using a sclerometer or other testing device,

(b) Load testing of the structure or structural element in question.

(c) The taking and testing of concrete cores.

(d) Such other tests as the Engineer may specify.

7.1.7 MEASUREMENT AND PAYMENT

7.1.7.1 Method of Measurement

(a) Concrete shall be measured by the number of cubic metres used and accepted in the work in accordance with the dimensions shown on the Drawings or directed by the Engineer. No deduction shall be made for the volume occupied by pipes less than 20 cm in diameter or by other embedded items such as water stops, reinforcing steel, conduit or weep hole pipes.

(b) No additional measurement or allowance shall be made for formwork, falsework for beams and slabs, pumping, finishing of surfaces, provision of weep hole pipes, other work incidental to satisfactory completion of the concrete work, the cost of this work being deemed to be included in the unit prices for the Concrete Work.

(c) The quantities of bedding material, porous drainage material, reinforcing steel and other Pay Items which are associated with the completed and accepted structure shall be measured for payment as provided for elsewhere in these Specifications.

(d) Concrete placed and accepted shall be measured and paid for as either Structural Concrete or Un-reinforced Concrete. Structural Concrete shall be concrete specified or approved by the Engineer as Class K250 or higher and Un-reinforced Concrete shall be concrete specified or approved as either Class K175 or Class K125. Where a higher strength class of concrete is permitted to be used in place of a specified lower strength class of concrete, the volume shall be measured as the lower strength class of concrete.

(e) Where falsework is required to be installed to support formwork for cast in situ beams or decks and the height of the falsework measured from the ground to the underside of the lowest point of the falsework is equal or above 4 metres, there shall be additional payment made to the Contractor for the falsework in accordance with the following : a 10% increase in the cost of the related pay item shall be paid for each full one metre height of falsework above 4 metres, proportional in whole of percentage for increments of 10 cm.

Example :

For an average height above 9.7 metres, the percentage increase to the related Pay Item is (9.7 - 4) x 10% = 57 %.

7.1.7.2 Measurement of Rectification Concrete Work

(a) Where work has been rectified under Article 7.1.1.10 above, the quantity to be measured for payment shall be that which would have been paid for if the original work had been satisfactory.

(b) No additional payment shall be made for any increased cement content or any admixtures, nor for any testing or additional work or material incidental to achieving the specified quality of the concrete work.

7.1.7.3 Basis of Payment

(a) The accepted quantities of the various classes of concrete determined as provided above shall be paid for at the Contract Prices for the Pay Items and using the units of measurement shown below and in the Bill of Quantities.

(b) The prices and payments shall be full compensation for all furnishing and placing all materials not otherwise paid for under other Pay Items, including water stops, weep holes, formwork, false work for beams and slabs for mixing, placing, finishing and curing the concrete, and for all other costs necessary or usual for the proper completion of the work prescribed in this Section.

Pay Items No.	Description	Unit of Measurement
7.1.1	Structural Concrete Class K500	Cubic Metre
7.1.2	Structural Concrete Class K400	Cubic Metre
7.1.3	Structural Concrete Class K350	Cubic Metre
7.1.4	Structural Concrete Class K300	Cubic Metre
7.1.5	Structural Concrete Class K250	Cubic Metre
7.1.6	Un-reinforced Concrete Class K175	Cubic Metre
7.1.7	Cyclopean Concrete Class K175	Cubic Metre
7.1.8	Concrete Class K125	Cubic Metre
7.1.9	Precast Concrete Plate for Deck Slab, Furnished	Cubic Metre
7.1.10	Additional Price to items No.7.1.1 to 7.1.5 for falsework in average height of over 4 metres and for every 10 cm increase	Cubic Metre

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SECTION 7.2

PRESTRESSED CONCRETE

7.2.1 GENERAL

7.2.1.1 Description

This work consists of the fabrication of precast prestressed concrete structures, precast prestressed concrete portions of composite structures and precast piles constructed in accordance with these Specifications and in close conformity to the lines, grades, and dimensions shown on the Drawings. It includes the manufacture, transportation and storage of beams, piles, slabs and other structural members of precast concrete, prestressed by the pre-tensioning or post-tensioning method. It also includes the installation of all precast prestressed members, except piles which are covered in Section 7.6. The requirements of Sections 7.1 and 7.3 shall apply to this Section in addition to the following Articles.

In this section Pre-Tensioning (Article 7.2.5) is defined as any method of prestressing concrete in which the tensioned reinforcement is tensioned before concrete is placed and Post-Tensioning (Article 7.2.6) is defined as any method of prestressing concrete in which the tensioned reinforcement is tensioned after concrete is placed. Prestressing reinforcement is defined as any reinforcement to which prestress is applied by Pre-Tensioning or Post-Tensioning.

7.2.1.2 Related Work Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Concrete	:	Section 7.1
(c)	Reinforcing Steel	:	Section 7.3

7.2.1.3 Quality Assurance

The quality of materials supplied, concrete mixes produced, workmanship and final product shall be monitored and controlled as specified in Articles 7.1.1.5 and 7.3.1.5, together with the following reference standard :

AASHTO M203M/ M203 - 07	:	Steel Strand Uncoated Seven-Wire Stress-Relieved for Prestressed Concrete
AASHTO M204M/ M204 - 06	:	Uncoated Stress-Relieved Wire for Prestressed Concrete.

7.2.1.4 Tolerances

(a) Beams and Planks

(i) Dimension Tolerance

The overall length of any unit from the centre to centre of bearings shall not vary by more than 0.06% from the specified length, with a maximum variation of 15 mm. The centre to centre spacing of holes for transverse reinforcement, bars or cables shall not vary by more than 6 mm from the specified position as measured from the transverse centre line of the unit.

(ii) Shape Tolerances

- Overall widths up to 600 mm ± 3 mm
- Overall widths greater than 600 mm ± 5 mm
- Overall depth ± 5 mm

(iii) Void Location

- Vertically measured from soffit ± 10 mm
- Transversely measured from longitudinal centre line of the unit ± 5 mm

(iv) Out of Square

Transverse cross-section : The adjacent faces shall not be out of square by more than the larger of 5 mm per metre or 4 mm overall.

Longitudinal cross-section : The slope of the end face shall not deviate from that specified by more than :

- On overall length of face : 5 mm up to 400 mm
- For dimensions greater : 15 mm per metre to a Maximum than 400 mm of 12 mm overall

(v) Hog or Sag

The hog or sag values of similar units to be used in the same span shall lie within a maximum overall range of 20 mm for the same conditions of age, curing etc.

(vi) Bow

Longitudinal centre lines shall not deviate in the transverse direction from a straight line joining the centre points of the ends of the member by 6 mm or 0.06 % of the specified length, whichever is the larger.

(vii) Twist

The angular rotation of any cross-section relative to an end cross-section shall not exceed 5 mm per metre for the edge being checked.

(viii) Tendons

- Tendon exit holes in formwork ± 2 mm
- Cover to tendon ± 5 mm

(b) Piles

(i) Dimension Tolerances

- Cross-sectional dimensions ± 6 mm
- Total length ± 25 mm
- Deviation from straight line 1 mm per metre length

- Head out of square 2 mm in width of head
- Clear cover to reinforcement (including tendons) + 5 mm, - 3 mm
- Tendon exit holes in formwork and plates ± 2 mm
- Tendons generally ± 1.5 mm

(ii) Shoes and Prefabricated Splice Joints

Shoes and joints, when spices are permitted, shall be firmly bonded to the pile, centrally and in line with the pile axis.

(iii) Cast length

Unless otherwise shown on the Drawings, piles shall be cast in single lengths, without splices.

7.2.1.5 Prestressing System

The prestressing system to be used shall be selected by the Contractor subject to all the requirements herein and to the approval of the Engineer. Generally no changes in the position of the centroid of the total prestressing force over the length of the member and in the magnitude of the final effective prestressing force as prescribed in the Drawings shall be allowed.

7.2.1.6 Submittals

(a) Prestress System and Equipment

The Contractor shall submit details of the system, equipment and materials he intends to use in the prestressing operation. Such details shall include the method and sequence of stressing, the full specification for the prestressing steel, the anchoring devices, types of ducts and any other data relative to the prestressing operations. In addition such details shall indicate any rearrangement of non-prestressed reinforcing steel from that shown on the Drawings.

(b) Modifications to Prestress System

If the prestress system proposed by the Contractor requires any modification in the number, form or dimensions of the reinforcing steel, he shall present sufficiently detailed drawings and calculations to the Engineer for approval. The reinforcing steel provided shall not be less than indicated on the Drawings.

(c) Agreement Certificate
A certificate of official approval (agreement) for the prestressing system shall be submitted and approved by the Engineer before the placing of any tendons. This agreement certificate must be issued by an authorized testing institution. Otherwise the Engineer may order such an agreement certificate from a laboratory of his choice at the cost of the Contractor. All rules referring to this agreement certificate hereinafter are subject to the approval of the Engineer.

(d) Shop Drawings

For each type of prestressed member the Contractor shall submit two sets of all shop detail drawings, prepared specially for the construction, to the Engineer for review. After review and approved by the Engineer, three sets shall be submitted to the

Engineer for use during construction. Shop detail drawings shall include the job title, name of the structure as shown on the contract drawings, and contract number. The Contractor shall not cast any member to be prestressed before review of the shop detail drawings is complete.

7.2.1.7 Supervision

The Contractor shall place at the disposal of the Engineer, free of charge, a team specialized in the proposed prestressing method, including at least one higher grade expert, in order to furnish the necessary expertise and instructions during the prestressing operations.

7.2.2 MATERIALS

7.2.2.1 Concrete

Concrete shall be manufactured in accordance with Section 7.1 for the applicable grade. The grade of concrete for each type of unit shall be as shown on the Drawings.

7.2.2.2 Formwork

Formwork for precast units shall conform with the requirements of Section 7.1 and with the particular requirements of this Section.

Formwork shall be made of metal, or of timber lined with metal, or waterproof plywood, and shall be sufficiently strong such that it shall not deflect beyond the tolerance limits during casting.

Seals shall be fitted to prevent loss of cement paste through joints in the formwork.

Chamfers shall be provided on all corners and shall be straight and true to shape and line.

Void formers shall have tightly fitting ends and shall be wrapped with adhesive tape sealant as required to prevent entry of slurry.

7.2.2.3 Grout

Unless otherwise directed by the Engineer on the basis of grouting trials, grout shall consist of ordinary Portland cement and water. The water-cement ratio shall be as low as possible consistent with the necessary workability but shall never exceed 0.45.

Admixtures may be used if approved by the Engineer. Commercial plasticizers for use in grout shall be utilized in accordance with the manufacturer's instructions. Admixtures shall not contain chlorides, nitrates, sulphates or sulphides.

7.2.2.4 Reinforcing Steel

Steel bar and mesh fabric shall comply with Section 7.3 of this Specification.

7.2.2.5 Prestressing Steel

(a) Prestressing strand shall consist of seven wire high tensile strength, stress relieved, low relaxation strand in continuous lengths without splices or couplings, conforming to AASHTO M203M / M203-07. The strand shall have a minimum yield strength of

16,000 kg/cm^2 and minimum ultimate strength of 19,000 kg/cm^2, or as shown on the Drawings.

(b) Wire for prestressing shall consist of high tensile wire in continuous lengths without splices or couplings and shall conform to AASHTO M204M / M204-06.

(c) High-tensile strength - alloy bars shall be stress relieved and then cold stretched to a minimum of 9,100 kg/cm^2.

After cold stretching, the physical properties shall be as follows :

- Minimum ultimate tensile strength 10,000 kg/cm^2
- Minimum yield strength, measured by the 0.7 % extension under load method shall be not less than 9,100 kg/cm^2
- Minimum modulus of elasticity 2,500,000 kg/cm^2
- Minimum elongation after rupture, calculated as average of 20 bars 4 %
- Diameter tolerance + 0.76 mm
- 0.25 mm

(d) Supply

High tensile steel wires or high tensile steel bars which shall be used in prestressing shall be supplied in coils of sufficient diameter in order to maintain the properties and to be self-straightening. The material shall be in good condition, not kinked or bent.

The material shall be free of corrosion, dust, other loose materials, oil, lubricant, paint, mud or other unintended material, but shall not be polished.

(e) Marking

The wires shall be stored in groups based on size and length, shall be securely bound and tagged with a label identifying the size of the wire in the bundle.

(f) Storage

The materials for cable, wire, steel bars, anchorage, ducts shall be stored under a waterproof roof, placed clear of the ground surface and shall be protected from any potential damage.

7.2.2.6 Anchorages

Anchorages shall be capable of developing at least 95% of the guaranteed minimum tensile strength of the prestressing steel, and shall provide an even distribution of the stress in the concrete at the end of the tendon. Provision shall be made for the protection of the anchorage against corrosion.

Anchor devices for all systems of post-tensioning shall be set exactly normal in all directions to the axes of the post-tensioned tendons.

Anchors shall be provided with pipes or other suitable connections to allow the injection of grout.

7.2.2.7 Ducts

Ducts provided for post-tensioning tendons shall be formed by means of flexible ribbed or corrugated galvanized metal conduit, and shall be stiff enough to maintain the desired profile between points of support under working stresses. The end of the duct shall be made to provide free movement of end anchorages. Joints between sections of duct shall be positive metallic connections and shall be completely sealed using waterproof tape to prevent leakage of mortar.

The ducts shall be free from fissures, cracks, etc. Joints shall be carefully made in such a manner that they are mortar tight. Damaged ducts shall be removed from the site. Air vents shall be provided at crests and elsewhere as required so that the injection of grout shall completely fill all void spaces along the entire length of the duct.

7.2.2.8 Cleaning Duct

Water used for flushing ducts shall contain either quicklime (calcium oxide) or slaked lime (calcium hydroxide) at a rate of 12 gram per liter. Compressed air used to blow out ducts shall be oil free.

7.2.3 TESTING

7.2.3.1 General

Testing of Prestressing Steel shall be in accordance with the requirement of AASHTO Specifications for the type of system intended to be used. Wire, strand, anchorage assemblies and bars for prestressing work shall be assigned a lot number and tagged for identification purposes prior to transporting to site. Samples for testing submitted shall be representative of the lot to be furnished and in the case of wire and strand, shall be from the same master roll. Samples for testing shall be submitted in time for the results to be received well in advance of the anticipated time of use.

7.2.3.2 Pre-tensioning Strand

Samples at least 2.5 metres long shall be submitted for testing, a sample being taken from each roll.

7.2.3.3 Post-tensioning Strand, Wire or Bar

Sufficient length of wire to make up one parallel lay cable 1.5 metres long, consisting of the same number of wires as the cable to be furnished shall be submitted for testing.

- Strand furnished with fitting : a 1.5 metres length of strand between near ends of fitting shall be submitted.
- Bars to be furnished with threaded ends : a 1.5 metres length of bar between ends of the threads shall be submitted.

7.2.3.4 Anchorage Assemblies

When anchorage assemblies are not attached to reinforcing samples, two assemblies shall be furnished, complete with distribution plates, for each type and size to be used.

7.2.3.5 Previous Acceptance

If the prestressing system to be used has been previously tested and approved by the Employer or another agency acceptable to the Engineer, samples need not be submitted provided there is no change in the materials, design or details previously approved.

7.2.4 CONSTRUCTION OF UNITS

7.2.4.1 General

(a) Casting Yard

The casting yard shall be approved by the Engineer.

(b) Voids and Holes

Cores for forming transverse holes in the finished work or other forming devices which would restrict longitudinal strains in the member shall be loosened as soon as practicable after the placement of concrete so that concrete shrinkage or thermal movements are restrained.

When voids are required, void formers shall be rigidly secured in an approved manner so that no appreciable movement can occur in any direction during casting operations.

If void formers are secured to the tendons precautions shall be taken to ensure that the strand pattern is not distorted by the buoyant uplift of the void.

All precautions shall be taken to prevent the formers being damaged during casting.

(c) Prestressing Equipment

Tensioning equipment shall be approved by the Engineer prior to use and shall be calibrated as a complete unit by an approved laboratory every six months (or more often if directed by the Engineer) in order to give a correlation between the force applied to the tendon and the reading indicated by the pressure gauge.

Tensioning equipment shall be provided with at least two pressure gauges with a face diameter not less than 150 mm, one to read initial sag pull-up and the second to read the loads during the final stressing operation. Pressure gauges shall be accurate to within approximately 1 % of their full capacity. Calibration certificates shall be kept in the works office at the casting yard and made available to the Engineer on demand.

(d) Assembling Tendons

Tendons shall be assembled in accordance with the instructions accompanying the manufacturer's agreement certificate.

Prior to assembly, the surfaces of the prestressing steel shall be inspected for corrosion. Loose rust shall be removed by hand using burlap rags or soft steel wool and any lubricant shall be thoroughly removed using detergent.

A light film of rust is not considered detrimental provided the steel is not visibly pitted. Badly rusted or pitted steel shall be rejected and removed from site.

Foreign matter adhering to steel shall be removed after prestressing or prior to placement in ducting. When stressing steel for post-tensioning works is installed prior to concreting of the unit, or when it will not be grouted within 10 days of placement, it shall be subject to the above requirements for protection against corrosion rejection due to rusting. In such cases, corrosion inhibitor shall be used in the duct following installation of the steel.

Anchorages shall be assembled with tendons in a manner that shall prevent any shift in position, either during installation or concreting.

(e) Concrete Cover

Unless otherwise specified, concrete cover thickness shall not be less than twice tendon diameter or 3 cm, whichever is the greater. This shall be increased by 1.5 cm for concrete in direct contact with the ground or in water and by 3 cm where the element will be installed in salt water.

(f) Placement of Concrete

The Contractor shall give the Engineer at least 24 hours notice prior to the scheduled commencement of concrete operations in order that the Engineer may inspect the preparation work.

Concrete shall not be placed until the Engineer has inspected and approved the placing of the reinforcement, ducts, anchorages, and prestressing steel. Ducting that is ripped or torn shall be replaced.

Concrete placement shall be in accordance with the requirements of Section 7.1. Concrete shall be vibrated with care to avoid displacement of cables, wires, ducts or reinforcement. In deep, slender sections, external vibrators attached to forms shall be used to supplement internal vibration. Prior to, and immediately after, placement of the concrete, the Contractor shall demonstrate to the satisfaction of the Engineer that all ducts are unobstructed.

(g) Curing

Steam curing may be used in accordance with Section 7.1.

7.2.4.2 Prestressing

(a) General

No stressing shall be carried out without the prior approval of the Engineer. The stressing operations shall be performed, under the supervision of a competent person provided by the manufacturer of the equipment to be used, by a team fully experienced in the use of the equipment and in the presence of the Engineer or his representative.

The contractor shall notify the Engineer 24 hours in advance of the time of stressing will be carried out.

(b) Stressing

(i) Safety of Work

During stressing the Contractor shall not permit any person to stand in front of the jack.

Measurement or other activities shall be carried out from the side of the jack or from another safe place. At the time of stressing, clear signs shall be installed at both ends of the unit to warn people to stay clear from the stressing location.

(ii) Equipment

Prior to stressing, the equipment shall be inspected, calibrated or tested, as deemed necessary by the Engineer. Dynamometer and other measuring equipment shall have a tolerance of 2%. The pressure gauge equipment shall be adjusted in accordance with the requirements of the manufacturer. This equipment shall be manufactured in such a way that if there is an unexpected decrease in stress the equipment will not be damaged.

For recording purposes, as considered necessary, it is permissible to install more than one gauge.

(c) Recorded Data

(i) General

For both pre-tensioning and post-tensioning stressing the following data shall be recorded:

- Job title and number.
- Beam/girder number
- Casting finishing date
- Prestressing date

(ii) Pre-tensioning Tendon

The following data shall be recorded :

- Manufacturer, tolerance and identification numbers of dynamo-meters, gauges, pumps and jacks.
- Force recorded by dynamometer.
- Pump or jack pressure and piston area.
- Final elongation immediately after anchoring.

(iii) Post-tensioning Tendon

The following data shall be recorded :

- Manufacturer, tolerance, types and identification numbers of dynamometers, gauges, pumps and jacks
- Cable identification
- Starting force at the beginning of stressing
- Final force and elongation at the end of stressing

- Force and elongation at defined intervals if and when directed by the Engineer.
- Elongation after the jack is released

Copies of these records shall be submitted to the Engineer within 24 hours after each stressing operation.

7.2.5 PRE-TENSIONING METHOD

7.2.5.1 Stressing Bed

The stressing bed for supporting prestressed forces during prestressing shall be designed and constructed to withstand the forces generated during the prestressing operation. The stressing bed shall be made in such a manner that if slippage occurs at the anchorage it shall not be damaged.

The stressing bed shall be of sufficient strength such that no deflection or damage shall occur under concentrated or dead loads from the units being supported.

7.2.5.2 Placing Tendon

The tendons shall be placed as shown on the Drawings and secured such that it shall not shift during concrete pouring. In placing the tendon, attention shall be given so that the tendon shall not touch the lubricating on the formwork. If the tendon touches the lubricant, it shall be cleaned immediately using kerosene or other suitable material.

If possible, tendon stressing shall be carried out before lubricating the formwork. Anchorage shall be placed in the required position and shall not shift during concrete pouring.

7.2.5.3 Required Stressing Force

Unless otherwise stated on the Drawings, the force required is the force remaining in the tendons at the middle of each unit immediately after all tendons have been anchored to the abutments of the stressing bed and are in their final deflected position. The allowable variation of this force from its required value shall be 5 percent. The jacking force applied shall allow for any anticipated slip at the anchorage devices, wedge draw-in, and friction losses.

The method of tensioning tendons including the arrangement and layout of each line, calculations showing forces at anchorages and all deflection points, and estimated friction losses, shall be submitted to the Engineer for his approval before manufacture of members commences.

The Contractor shall carry out trial stressing operations to establish the frictional resistance offered by the hold-downs and also to confirm that the stated wedge draw-in is consistent with the type of jack and operator technique proposed.

Tendons shall be deflected, where shown on the Drawings, with devices strong enough to hold the tendons firmly in their proper positions, especially during concreting and vibrating operations. Unless otherwise directed by the Engineer hold-downs shall be located longitudinally within 200 mm and vertically within 5 mm of the locations shown on the Drawings.

Hold-downs shall be designed such that the deflector in contact with the strand shall have a diameter of not less than the tendon diameter or 15 mm whichever is the greater. The deflector shall be constructed from material no harder than AASHTO M183 (ASTM A36) grade 36 steel.

The Contractor shall submit calculations showing that the hold-downs have been designed and constructed to withstand concentrated loads resulting from the application of the tensioning force.

The method of tensioning shall ensure that the required force is produced in all tendons at the middle of all units, especially where more than one tendon or one unit is tensioned in the one operation.

Concrete shall not be cast later than 12 hours after tensioning. Should this time be exceeded, the Contractor shall check that the required tendon force has been maintained. Should re-stressing be required, tendon extensions shall be maintained by the use of shims without disturbing the bedded wedges.

Elongation measurement may be used only after the Engineer has examined the calculations and determined that the system meets the requirements. Jack pressure readings shall be used as a comparison with elongation measurements. If the jack pressure reading and the elongation measurement differ by more than 3%, the Engineer shall be informed prior to starting the concrete pour and, if considered necessary, the tendon shall be tested and the equipment shall be calibrated as directed by the Engineer.

7.2.5.4 Prestressing Procedure

The tensioning operation shall be performed only by personnel trained and experienced in this type of work.

The tensioning force shall be applied and released at a uniform rate.

In order to remove slack and to lift tendons off the bed floor an initial force of 100 kg or as otherwise approved by the Engineer shall be applied to the tendons. Allowance shall be made for this force in calculating the required elongation.

Tendons shall be marked for measurement of elongation after the initial force has been applied. When required by the Engineer tendons shall be marked at both the jacking end and dead end of the stressing bed and at couplers (if used) so that slip and draw-in may be measured.

Should slip occur in any one of a group of tendons tensioned together, the tensioning of the whole group shall be relaxed, the tendons re-set, and the whole group tensioned again. Alternatively, if not more than two tendons have slipped the tensioning of the group may be completed with the loose tendons being tensioned after this.

The prestressing force shall be transferred from the tensioning jack to the abutment of the stressing bed immediately the required force (or elongation) has been reached in the tendons, and the pressure in the jack shall be relaxed before any other operation is commenced.

Where deflected strands have been specified the Engineer may direct that elongation or strain gauge measurements be taken at various positions along the tendon to determine the force in the tendon at those positions.

7.2.5.5 Transfer of Prestress

(a) Approval

The Contractor shall submit to the Engineer details of his proposed method of transfer of prestress for approval prior to commencing the transfer of prestress.

(b) Concrete Strength Requirements

No tendon shall be released before the concrete has attained a compressive strength greater than 85 % of the specified 28 day strength shown on the Drawings and proven by the standard specimens made and cured identically with the units.

If, after 28 days, the compressive strength of the concrete fails to meets the minimum required the tendon shall be released and the concrete unit will be rejected.

(c) Procedure

The tendons shall be examined prior to being released to ensure that no tendons are loose. If there are any loose tendons the Contractor shall immediately inform the Engineer who shall inspect the unit and decide whether the unit shall be used or replaced.

Each tendon shall be marked on both ends of the prestressed beam, so it is possible to record slippage or draw-in whenever these occur.

Release of the tendons shall be done gradually and shall not be interrupted.

Subject to the approval of the Engineer, tendons may be released by applying heat, in which case the following conditions shall apply :

(i) The Contractor shall submit to the Engineer details of his method of transfer of prestress including the lengths of free tendons between units, the lengths of free tendons at both ends of the bed, the locations where the heat will be applied, the order of severance of tendons and of release of devices for deflecting tendons, the method of applying heat and the equipment he proposes to use.

(ii) The heat shall be applied over a length of tendon and for a period of time sufficient to ensure that the tendon so treated is entirely relaxed before severing. Concrete shall not be heated excessively, and heat shall not be applied directly to any part of any tendon within 100 mm of the concrete surface of the units.

(iii) The Engineer shall be present on every occasion of releasing tendons by heat. After the prestress has been transferred to the units, the tendons between the units shall be severed working along the line from the point of release.

On completion of the transfer of prestress the projecting lengths of tendon shall be cut off flush with the end surface of the unit by means of a mechanical cutter. Every effort shall be made to avoid damage to the concrete.

7.2.5.6 Permissible Draw-in of Tendons

The maximum draw-in of any tendon shall not exceed 3mm at any end unless shown otherwise on the Drawings.

If draw-in exceeds the maximum clearance the work may be rejected

7.2.6 POST-TENSIONING

7.2.6.1 Approval

Unless otherwise shown on the Drawings, the Contractor may determine the prestressing procedure, which procedure and work plan shall be submitted to the Engineer for approval prior to commencing any work on post-tensioned units.

7.2.6.2 Placing Anchorage

Each anchorage shall be placed at right angles to the prestressed force work line, and secured such that it does not move during concrete pouring.

If shown on the Drawings that a steel plate is to be used as an anchorage, the concrete surface in contact with the steel plate shall be smooth, ductile and placed at right angles to the prestress force direction. The steel plate anchorage may be bedded on mortar as approved or directed by the Engineer.

After finishing prestressing and grouting, the anchorage shall be encased with concrete with at least 3 cm cover.

7.2.6.3 Placing Tendon

Anchor holes shall be sealed to ensure that no mortar or other material enters the hole during pouring.

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

7.2.6.4 Required Concrete Strength

Prestressing shall not be carried out before the concrete has attained the required strength as shown on the Drawings, and shall not be less than 14 days after concrete pouring if wet curing is applied, or less than 2 days after concrete pouring if steam curing is applied.

Where units consist of jointed elements, the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the concrete in the unit.

7.2.6.5 Required Prestressing Force

The measurement of prestressing force is carried out by directly measuring the jack compression or indirectly by measuring tendon elongation. Unless otherwise specified on the Drawings, the Engineer shall decide which procedure is to be adopted after observation of the condition and accuracy which can be reached by the said procedures.

The Engineer shall determine the estimated elongation and jack compression.

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

The Contractor shall add to the forces required for prestress an allowance for anchorage friction and jack losses. The total forces and calculated extensions shall be approved with the Engineer before stressing is commenced.

Immediately after anchoring, the stresses in the prestressing tendons shall not exceed 70 % of their specified loads. During stressing the value shall not exceed 80%.

The tendons shall be stressed at a gradual and steady rate. The force in the tendons shall be obtained from readings on two load cells or pressure gauges incorporated in the equipment. The extension of the tendons under approved total forces shall be within 5 % of the approved calculated extension. If the required elongation cannot be reached, the jacking force may be increased to 75 % of the specified load for the tendon. If the difference between the measured and calculated elongation is more than 5% however, no further tensioning shall be done until the calculations and the equipment are checked.

When stressing tendons with a stressing anchorage at both ends, the pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.

When prestressing has been applied to the satisfaction of the Engineer, the tendons shall be anchored. The jack pressure shall then be released in such a way as to avoid shock to the anchorage or tendons.

If the pull-in of the tendons at completion of anchoring is greater than that approved by the Engineer, the load shall be released at a gradual and steady rate and the tensioning shall be repeated.

7.2.6.6 Stressing Procedure

(a) General

All tendon stressing works shall be attended by the Engineer or his representative.

Jack releasing shall be carried out gradually and continuously. Tendon stressing shall be in the order as specified on the Drawings. Partial prestressing is allowed only if specified on the Drawings or directed by the Engineer. Prestressing more than the maximum in order to decrease the friction may be allowed, if approved by the Engineer and in accordance with his directions, followed by decreasing to the required force. In any condition, the tendon shall not be stressed more than 85% maximum strength, and the jack shall not be forced to work beyond its maximum capacity.

Prior to stressing, the tendon shall be cleaned by compress air spraying to the duct. The anchorage shall also be in clean condition. The tendon shall be cleaned from undesired materials, rust/corrosion, mortar leftovers, grease, oil or other dust material which may have an effect on its adhesiveness with anchorage work. Tendons shall be pulled out and in to the duct in order to detect resistance due to duct leakage, and steps to rectify may be taken as necessary.

At the commencement of applying the jacking force the applied force shall be only that required to force the tendon.

After the tendon has been stressed, both ends shall be marked to start elongation measurement. If the Engineer intends to determine zero error in measuring

elongation during stressing, dynamometer reading data and elongation measurement shall be recorded and graphs shall be made for any stage of stressing.

If slippage occurs on one or more tendons from the group of the tendons, the Engineer may permit an increase in the elongation in the rest of the tendon as long as the given force shall not more than 85% maximum strength.

In the case that slippage or break of tendon occurs, with the result that tolerance limitation is exceeded, the tendon shall be released or replaced if needed, before re-stressing.

(b) Stressing Using 2 Jacks

In general, the prestressing operation shall be carried out by jacks at each end operating simultaneously. Every endeavor shall be made to keep almost identical forces at each jack throughout the tensioning operation which shall continue until the required force in the jacks is reached or until the sum of the elongations equals the total elongation required.

Stressing from one end shall be used to determine friction losses when requested by the Engineer. Jacks shall be connected at both ends of each tendon. One jack shall be extended by at least 25 mm prior to connecting the second jack. The slack in the tendon shall be taken up, and the tendon stressed initially from the jack which was not extended (leading jack). The non-stressing jack (trailing jack) shall be set so that the force transmitted to this end may be recorded. Stressing from one end shall continue until the elongation is approximately 75 percent of the total the trailing jack end. Stressing shall then continue by working the trailing jack only, until both jacks are registering the same force. Both jacks shall then be worked, keeping forces equal, until tensioning is completed.

(c) Stressing Using 1 Jack

If specified on the Drawings that the tendons shall be stressed from one end (usually for short span), 1 jack shall be used. After stressing, both ends shall be marked to measure draw-in elongation.

7.2.6.7 Grouting Hole

Grout holes or vents shall be provided at the anchorages, at high and low points in the tendon profile and at other suitable points. The number and location of these points shall be approved by the Engineer but shall be no more than 30 m apart along the ducting. Grout holes and vents shall be at least 10 mm in diameter and each shall be fitted with a plug valve or similar device capable of withstanding a pressure of 10 kg/cm^2 without loss of water, grout or air.

7.2.6.8 Grouting and Finalizing after Prestressing

The tendons shall be grouted within 24 hours after prestressing, unless otherwise approved by the Engineer.

The grouting hole shall be water tested at 8 kg/cm^2 for one hour prior to grouting. The ducts shall then be completely cleaned out with water and compressed air.

Mixing equipment shall produce a grout of homogeneous consistency and shall be capable of providing a continuous supply to the injection equipment. The injection equipment shall

be capable of continuous operation with little variation of pressure and shall include a system for recirculation of the grout while grouting is not in progress. Compressed air shall not be used. The equipment shall have a constant delivery pressure not exceeding 8 kg/cm^2. All piping to the grout pump shall have a minimum of bends, valves and changes in diameter. All baffles to the pump shall be fitted with 1.0 mm sieve strainers. All equipment, especially piping, shall be thoroughly washed through with clean water after every series of operations and at the end of use for each day.

The interval between washings shall not exceed 3 hours. The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a valve that can be locked off without loss of pressure in the duct. Water shall be added to the mixer first, then the cement. When these are thoroughly mixed, the admixture, if any, shall be added. Mixing shall continue until a uniform consistency is obtained. The water/cement ratio of the mix shall not exceed 0.45 by weight unless otherwise approved by the Engineer. Mixing shall not be by hand. Injection shall be continuous, and shall be slow enough to avoid producing segregation of the grout. The method of injection of grout shall ensure complete filling of the ducts and complete surrounding of the steel. Grout shall be allowed to flow from the free end of the duct until its consistency is equivalent to that of the grout injected. The opening shall then be firmly closed. Any vents shall be closed in a similar manner one after another in the direction of the flow. After an appropriate time, further injections shall be carried out to fill any possible cavities.

After all holes are closed, grout pressure shall be maintained at 8 kg/cm^2 for at least one minute.

The injection tubes shall not be subjected to shock or vibration within 1 day of grouting.

Not less than 2 days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good as necessary.

Tendons shall not be cut within 7 days after grouting. The end of the tendon shall be cut such that there shall be at least 3 cm cover to the tendon after the end block is cast.

7.2.7 HANDLING, TRANSPORT AND STORAGE OF UNITS

7.2.7.1 Unit Identification Marks

Immediately after removing side formwork and carrying out any minor repairs required, units shall be marked to facilitate future identification of the unit. A weather proof paint shall be used to mark the units. Data to be marked on all units shall include a reference number and date of casting. In addition precast slabs shall have this data scratched into the top surface immediately after casting. Piles shall in addition to the above, have length marks clearly and permanently marked along their length at one metre intervals measured from the toe.

7.2.7.2 Handling and Transportation

Extreme care shall be exercised in handling and moving precast units. Precast girders and slabs shall be lifted by lifting devices or holes cast into the units, and shall be transported in an upright position. Lifting points, form and positions shall be approved by the Engineer. Suitable bridles or slings shall be used at all times and no unit shall be moved until it is fully clear of the ground.

Units damaged by improper storage or handling shall be replaced by the Contractor at his own expense.

If methods of erection and transportation of girders are not specified on the Drawings, the Contractor shall submit his proposed method to the Engineer. After approval by the Engineer, the Contractor shall follow the approved method.

7.2.7.3 Storage

Units shall be stored clear of level and cleared ground on timber supports placed on firm ground which is not liable to subside, whether wet or dry, under the weight of the units. Where units are stacked in layers, they shall not be stacked more than 3 high with timber supports placed between each layer. Supports for each layer shall be placed above those of the preceding layer. For girders and piles, supports shall be placed not more than 20 % of the length of the unit from each end.

7.2.7.4 Prestressing Steel

All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting. Prestressing steel that has sustained physical damage at any time shall be rejected. Prestressing steel shall be packaged in containers or other shipping forms for the protection of the steel against physical damage. A corrosion inhibitor shall be placed in the package or form, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition. This shipping package or form shall be clearly marked with a statement that the package contains high-strength prestressing steel, and the care to be taken in handling, the type, kind and amount of corrosion inhibitor used (including the date when placed), safety orders and instruction for use.

7.2.8 POST TENSIONED SEGMENTAL CONSTRUCTION

7.2.8.1 Description

This work consists of the assembling, joining and stressing of precast segments on Site. The units shall be manufactured in accordance with the requirements of this Section of these Specifications.

7.2.8.2 Assembly of Precast Segments

Handling of precast units for segmental construction during placing operations shall be in accordance with the requirements of Article 7.2.7.

The Contractor shall submit details of the falsework design and the method of erection and assembly to the Engineer for his approval at least four weeks prior to the proposed date for commencing assembly of the segments.

Segments shall be assembled on falsework or on bearers at ground level. The Contractor shall design the supporting system to carry all the loads that may be applied to it, and shall incorporate provision for adjusting the position of each segment during assembly.

The unit shall be assembled with minimum misalignment of ducts and outside surfaces and shall be within the tolerances given in Article 7.2.1.4.

7.2.8.3 Joint Concrete

Concrete for joints and associated diaphragms or other infill concrete involved in the assembly of segments for post-tensioned construction shall comply with the requirements of Section 7.1 of this Specification except where modified below.

The cement content shall be not less than 450 kg nor greater than 500 kg per cubic metre of concrete.

Unless otherwise approved by the Engineer the effective maximum size shall be 10 mm.

Joint concrete shall be subject to the same strength requirements prior to stressing as given in Article 7.2.6.4 of this Specification.

Concrete materials shall be carefully selected and proportioned to produce joint concrete of the specified strength and of a similar colour to that of the segments. If requested by the Engineer the Contractor shall supply cured samples of the proposed joint concrete for colour comparison.

Joint concrete between segments shall be placed in forms which shall conform to the shape, lines and dimensions required in the finished work. Forms shall be rigid, watertight, and braced and tied together so that they will maintain position and shape during placing of concrete. The fit of the forms against the segments shall be such that a completely watertight joint, flush with adjacent surfaces is obtained. Forms shall be such that a Class 2 surface finish can be produced.

Where necessary, temporary openings shall be provided in the formwork to enable the adequate placing and compaction of concrete especially around and underneath ducting and anchorages.

The joints between segments shall be completely filled with compacted concrete of a strength as shown on the Drawings. Surfaces against which concrete is to be placed shall be scabbed to a dense hard surface. Just prior to placing concrete, these surfaces shall be cleaned to remove all dirt and other foreign matter.

Joint concrete shall be placed in the presence of the Engineer and any joint concrete placed during his absence or not placed to his satisfaction shall be broken out by the Contractor and made good at no extra cost to the Employer.

Care shall be taken during placing and compaction of concrete to avoid damage to the ducting. Vibrators shall not come into direct contact with the ducting. If the ducting is damaged during concreting the whole or a portion of the concrete cast may be rejected by the Engineer.

After placing the concrete the top surface of the joint shall be screeded flush with the tops of the adjacent segments and covered to prevent premature drying. Joint concrete shall be cured by one or more of the methods specified in Article 7.1.5 of this Specification for a minimum period of 7 days.

7.2.8.4 Concreting of Anchorage Recesses

Concreting of anchorage recesses of the post tensioned segmental member shall be carried out as shown on the Drawings and in accordance with the requirements of these Specifications.

7.2.8.5 Damage to Units

In the event of any unit, which has been manufactured or accepted by the Contractor, sustaining damage such as cracking, spalling or deformation of projecting reinforcement, the unit shall be set aside until it has been inspected by the Engineer, who will decide whether it shall be rejected and removed from the site of the works, or repaired by the Contractor.

The cost of such repairs, or the removal of rejected units, and all costs of replacing these units at the site of the works shall be borne by the Contractor.

7.2.9 ERECTION OF PRESTRESSED UNITS

7.2.9.1 Acceptance of Units

If units are manufactured off site the Contractor shall check these for quality and condition upon taking delivery and shall immediately report in writing to the Engineer any defect or deficiency. The Contractor is responsible for all damage to the units occurring after he accepts delivery thereof.

7.2.9.2 Seating for Units

(a) Unit placed on Neoprene Pads or Elastomeric Bearings.

Where the units are to be placed on neoprene pads or elastomeric bearings the pads shall be located as shown on the Drawings and shall be retained in position by gluing to the concrete bearing surface with an approved contact adhesive, in order to prevent dislodgment of the pads during unit placing.

(b) Units Bedded on Mortar.

Where the Drawings show that the units are to be bedded on cement mortar, a mortar seating strip shall be prepared on the substructure immediately before erection of the prestressed units. The mortar shall be made of a 1 : 3 mixture of Portland cement and fine sand plus an approved bonding agent; mixed to give widths shown on the Drawings and approximately 10 mm thick, and shall provide an even seating strip is laid the prestressed units shall be seated on the prepared substructure in the position indicated on the Drawings. Any excess mortar shall be struck off.

7.2.9.3 Positioning Units

All holding down bolts and holes for transverse reinforcement, etc. shall be carefully aligned during placement of the units. Bars shall be placed through holes for transverse reinforcement as erection proceeds, in order to ensure the correct alignment of the holes.

7.2.10 MEASUREMENT AND PAYMENT

7.2.10.1 Measurement

(a) Precast Prestressed Units

The quantity to be measured, for payment for precast pre-tensioned and post-tensioned units shall be the actual number of precast prestressed concrete structural units, except piles, of the several types and sizes installed in place, complete and

accepted. Each unit shall include the concrete, reinforcement, formwork and prestressing steel together with ducts, anchorages, plates, nuts, lifting devices and other such materials contained within or attached to the unit. Pile fabrication and installation shall be measured separately in accordance with Section 7.6

(b) Cast In-situ Post-Tensioned Work

Concrete shall be measured in accordance with Section 7.1. Reinforcement shall be measured in accordance with Section 7.3. Prestressing steel shall be measured as the theoretical weight in kilogram of the prestressing steel shown on the Drawings. This shall be taken as the weight of strands or bar measured between the outer faces of the anchorages, and shall not include the weight of the ducting, anchorages etc.

(c) Rejected Units

Units that have been rejected due to inadequate concrete quality, damage during handling, storage, transportation or erection, or for any other reason, shall not be measured for payment.

7.2.10.2 Payment

(a) Precast Prestressed Units

The accepted quantity of precast prestressed units, completed and in place, measured as provided above shall be paid for at the Price for the Pay Items shown below and listed in the Bill of Quantities. Such prices and payments shall be deemed full compensation for furnishing and placing all materials including concrete, formwork, reinforcement, prestressing steel, ducting, anchorages, couplers, spirals, spacers, supports for tendons, tensioning, grouting and finishing work. They shall cover all handling, storage, marking, transportation and erection of the units, including all labor, equipment, tools, testing and all other costs necessary or usual for the proper completion of the work prescribed in this Section.

(b) Cast In-situ, Post-tensioned Concrete Work

Concrete shall be paid for under Section 7.1. Reinforcing steel shall be paid for under Section 7.3

Prestressing strand or bar, measured as provided above, shall be paid for at the Price for the Pay Items per kilogram in place, tensioned and accepted, as shown below and listed in the Bill of Quantities. Such prices and payment shall be deemed full compensation for the prestressing steel, ducting, anchorages, couplers, spirals, supports for tendons, tensioning, grouting and finishing work, including all labor, equipment, tools, testing and all other costs necessary or usual for the proper completion of the work prescribed in this Section.

(c) External Prestressed Cables

The quantities shall be measured for the pay item listed below, shall be paid for the contract price per unit of the bridge in place, tensioned and accepted. Such prices and payment shall be deemed full compensation for the prestressing steel, ducting, anchorages, steel deviator, couplers, spirals, supports for tendons, tensioning, grouting and finishing work, including all labor, equipment, tools, testing and all other costs necessary or usual for the proper completion of the work prescribed in this Section.

The contractor may request a payment based on the material on site in the amount 60% maximum material on site times the unit price. The contractor shall store materials in a site warehouse with materials identified and the date of acceptance recorded, in the presence of the Engineer to ensure that this material is kept separate from the materials which will come later.

Pay Item No.	Description	Unit of Measurement
7.2.1	Precast Prestressed Units Type I Girder span 16 m	Each
7.2.2	Precast Prestressed Units Type I Girder span 20 m	Each
7.2.3	Precast Prestressed Units Type I Girder span 22 m	Each
7.2.4	Precast Prestressed Units Type I Girder span 25 m	Each
7.2.5	Precast Prestressed Units Type I Girder span 28 m	Each
7.2.6	Precast Prestressed Units Type I Girder span 30 m	Each
7.2.7	Precast Prestressed Units Type I Girder span 31 m	Each
7.2.8	Precast Prestressed Units Type I Girder span 35 m	Each
7.2.8a	Precast Prestressed Units Type I girder span... .m	Each
7.2.8b	Precast Prestressed Units TypeU girder span.. m	Each
7.2.9	Strand for Cast In-Situ Post-tensioned Concrete Work	Kilogram
7.2.10	Precast Hollow Slab span 21 m	Each
7.2.11	Diaphragm Concrete Class K 350 including Post Tensioning Work	Cubic Metre
7.2.12	External Prestressed Cable	Unit of Bridge
7.2.13	Precast Plank span ……m	Each

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SECTION 7.3

REINFORCING STEEL

7.3.1 GENERAL

7.3.1.1 Description

This section covers furnishing and placing reinforcing steel in accordance with these Specifications and with the Drawings, or as directed by the Engineer.

7.3.1.2 Issue of Construction Details

Construction details for Reinforcing Steel not included in the Contract Documents at the time of tender will be furnished by the Engineer after the initial design review or design revision has been completed in accordance with Section 1.9 of these Specifications.

7.3.1.3 Related Work Specified Elsewhere

(a)	Field Engineering	:	Section 1.9
(b)	Environmental Safeguards	:	Section 1.17
(c)	Concrete	:	Section 7.1

7.3.1.4 Reference Standards

SNI 03-6816-2002 (A.C.I. 315)	:	Tata Cara Pendetailan Penulangan Beton.
AASHTO M31M / M31-07	:	Deformed and Plain Billet-Steel Bar for Concrete Reinforcement.
SNI 07-6401-2000 (AASHTO M32M/ M32-07)	:	Spesifikasi Kawat Baja dengan Proses Canay Dingin untuk Tulangan Beton.
SNI 03-6812-2002 (AASHTO M55M/ M55-07)	:	Spesifikasi Anyaman Kawat Baja Polos Yang Dilas Untuk Tulangan Beton.
AWS D 2.0	:	Standards Specifications for Welded Highway and Railway Bridges.

7.3.1.5 Tolerances

(a) Fabrication tolerances shall be as specified in SNI 03-6816-2002 (ACI 315).

(b) Steel reinforcing shall be placed so that the minimum clear covering of concrete over the outermost edge of the main steel bar is as follows:

(i) 3.5 cm for concrete not exposed to weather or to ground water (for example, bottom of deck slab)

(ii) As shown in Table 7.3.1 for concrete which is submerged, exposed to weather or to earth backfill, but which can easily be made accessible for inspection.

(iii) 7.5 cm for all submerged concrete which cannot be made accessible, for inaccessible concrete in which failure due to rusting of reinforcement could cause loss of life or of the structure, for concrete placed directly against the

ground or rock, or for concrete subjected to sewerage or other corrosive liquids.

Table 7.3.1 Minimum Cover over Reinforcing Steel for Exposed but Accessible Concrete

Size of Reinforcing Bar to be Covered (mm)	Minimum Clear Cover (cm)
16 mm bar and smaller	3.5
19 mm & 22 mm bars	5.0
25 mm bar and larger	6.0

7.3.1.6 Storage and Handling

(a) The Contractor shall deliver reinforcement to the site bundled, tagged, and marked with metal tags indicating bar size lengths and other information corresponding to the markings shown on the placement diagrams.

(b) The Contractor shall handle and store all reinforcing steel in a manner as to prevent distortion, contamination, corrosion, or damage.

7.3.1.7 Submittals

(a) Before ordering material, all order lists and bending diagrams for each section of the works shall be furnished by the Contractor for the approval of the Engineer with certified lists from the steel manufacturer or manufacturers giving the nominal unit weight in kilograms of every size and grade of reinforcing bar or welded steel mesh to be used in the work.

(b) Before commencing Steel Reinforcing work the Contractor shall supply the Engineer with certified lists from the steel manufacturer or manufacturers giving the nominal unit weight in kilograms of every size and grade of reinforcing bar or welded steel mesh to be used in the work, and test certificates indicating the standards applying to each group of reinforcing.

7.3.1.8 Quality of Work and Rectification of Unsatisfactory Work

(a) Approval of order lists and bending diagrams shall in no way relieve the Contractor of his responsibility for ascertaining the accuracy of such lists and diagrams. Revision of material furnished in accordance with such lists and diagrams to comply with the design drawings shall be at the expense of the Contractor.

(b) Reinforcing steel with any of the following defects shall not be permitted in the work:

(i) Bar lengths, depths, and bends exceeding the fabrication tolerances specified in SNI 03-6816-2002 (ACI 315).

(ii) Bends or kinks not indicated on the Drawings or final shop drawings.

(iii) Bars with reduced cross sectional area due to excessive rusting or any other cause.

(c) In the case of reinforcement fabrication errors, bars shall not be re-bent or straightened without the Engineer's approval or in a manner that will injure or weaken the material. Re-bending of bars shall be done cold unless otherwise

approved by the Engineer. In no circumstances shall a bar be permitted in the works which has been re-bent in the same place more than once. Errors which cannot be rectified by re-bending, or when re-bending is not approved by the Engineer, shall be rectified by replacement with new reinforcement bent correctly to the required shapes and dimensions.

(d) The Contractor shall provide on-site facilities for cutting and bending reinforcement, whether ordering steel bent off-site or not, and shall maintain an ample stock of straight bar on site for bending as required to rectify errors or omissions.

7.3.1.9 Substitution of Bar Sizes

Substitution of different size bars shall be permitted only if specifically authorized by the Engineer. If steel is substituted it shall be of equivalent cross sectional area to the design size, or larger.

7.3.2 MATERIALS

7.3.2.1 Reinforcing Steel

(a) Reinforcing steel shall be plain or deformed billet steel bars in accordance with the Drawings and conforms to Table 7.3.2.1 below :

Table 7.3.2.1 Characteristic Yield Strength of Reinforcing Steel

Grade	Type	Characteristic Yield Strength or Characteristic Strength that give the fixed strain of 0.2 (kg/cm^2)
U24	Soft	2,400
U32	Mild	3,200
U39	Hard	3,900
U48	Hard	4,800

(b) Steel mesh reinforcement shall be in accordance with SNI 03-6812-2002 (AASHTO M55M / M55-07).

7.3.2.2 Support for Reinforcement

Supports for reinforcement shall be formed from lightweight wire bar or precuts concrete blocks of Class K250 concrete as specified in Section 7.1 of these Specifications, unless otherwise directed by the Engineer. Wood, bricks, stone or other materials shall not be used as supports.

7.3.2.3 Ties for Reinforcement

Tie wire for fastening reinforcement shall be annealed steel wire conforming to SNI 03-07-6401-2000 (AASHTO M32M / M32-07).

7.3.3 FABRICATION AND PLACING

7.3.3.1 Bending

(a) Unless otherwise approved by the Engineer, all reinforcing shall be bent cold and in accordance with SNI 03-6816-2002 (ACI 315) procedures, using bar that is initially

straight and free of kinks, bends or damage. Should the Engineer approve the use of heat for field bending, precautions shall be taken to ensure that the physical properties of the steel are not substantially altered.

(b) Bars of 2 cm diameter and greater shall be bent in a bending machine.

7.3.3.2 Placing and Fastening

(a) Reinforcement shall be cleaned immediately prior to placement to remove dirt, mud, oil, paint, rust and mill scale, splashed mortar or other foreign coatings, which may reduce or destroy bonding with the concrete.

(b) Reinforcement shall be accurately positioned in accordance with the Drawings and with the minimum clear cover requirements specified in Article 7.3.1.5 above or as directed by the Engineer.

(c) Reinforcing bars shall be securely fastened together using tie wire so that they cannot be displaced by the concrete placement operation. Crossing bars or stirrups shall not be welded to main tension reinforcement.

(d) All reinforcement shall be furnished in the full lengths shown on the Drawings. Except where shown on the Drawings, bars shall not be spliced without the written approval of the Engineer. Any splices that may be approved shall be staggered as far as possible and shall be located at points of minimum tensile stress.

(e) Where lapped splices are approved the lap length shall be 40 bar diameter and the bars shall be provided with hooks.

(f) Reinforcing steel shall not be welded unless detailed on the Drawings or specifically approved in writing by the Engineer. If the Engineer approves welding of splices, the splices in this case shall be full penetration but welds conforming with the requirements of AWS D 2.0. Welds shall not be water quenched.

(g) The twisted ends of tie wire shall be directed away from concrete surfaces that will be exposed.

(h) Welded Wire fabric shall be installed in as long lengths as practicable, with adjoining pieces lapped at least one full mesh. The fabric shall be cut to fit at curbs and openings, and shall be discontinuous at joints between slabs.

(i) When fixed reinforcement is to be left exposed for a delayed period of time, it shall be thoroughly cleaned and painted with neat cement grout.

(j) No part of the placed reinforcement shall be used to support concrete conveying equipment, access ways, working platforms or any other construction loads.

7.3.4 MEASUREMENT AND PAYMENT

7.3.4.1 Method of Measurement

(a) Reinforcing steel shall be measured as the number of kilograms complete in place accepted by the Engineer. The number of kilograms placed shall be calculated from the actual lengths of bars placed, or actual areas of welded mesh laid, and the approved unit weights in kilogram per metre length for bars or kilogram per square

metre area for mesh. The unit weights approved by the Engineer will be based on the nominal weights provided by the steel manufacturer or, if the Engineer directs, on actual weighing tests carried out by the Contractor on samples selected by the Engineer.

(b) Clips, ties, separators or other material used for positioning or fastening the reinforcing steel in place shall not be included in the weight for payment.

(c) Reinforcement placed in pipe culverts or in any other structure for which a separate payment for the completed structure is provided elsewhere in these Specifications shall not be measured for payment under this Section.

7.3.4.2 Basis of Payment

The accepted quantities of reinforcing steel, determined as provided above, shall be paid for at the unit price for the Pay Item shown below and listed in the Bill of Quantities, which payment shall be full compensation for supplying, fabricating and placing the materials, including all labor, equipment, tools, testing and other work incidental to satisfactory completion of the work.

Pay Item No.	Description	Unit of Measurement
7.3.1	Reinforcing Steel Plain Bars U-24	Kilogram
7.3.2	Reinforcing Steel Plain Bars U-32	Kilogram
7.3.3	Reinforcing Steel Deformed Bars U-32	Kilogram
7.3.4	Reinforcing Steel Deformed Bars U-39	Kilogram
7.3.5	Reinforcing Steel Deformed Bars U-48	Kilogram
7.3.6	Welded Wire Mesh	Kilogram

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SECTION 7.4

STRUCTURAL STEELWORK AND STEEL PAINTING

7.4.1 GENERAL

7.4.1.1 Description

This work consists of steel structures and the steel portions of composite structures, constructed in close conformity to the lines, grades and dimensions shown on the Drawings or established by the Engineer. It shall cover completely new construction and the widening and repair of existing structures. The work shall include the furnishing, fabricating, erecting, galvanizing or painting of structural metal as required in these Specifications or as shown on the Drawings. Structural metals shall include structural steel, rivets, welding, special and alloy steels, metallic electrodes and steel forgings and castings. This work shall also include any incidental metal construction not otherwise provided for, all in accordance with these Specifications and with the Drawings.

The steel painting work is to provide a protective coating on existing steel structures on site or new steel structure in order to prevent rusting. This work consists of surface preparation and application of the paints or protective paintings as described in this Article.

7.4.1.2 Related Work Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Concrete	:	Section 7.1
(c)	Reinforcing Steel	:	Section 7.3
(d)	Erection of Steel Bridge Structures	:	Section 7.5
(e)	Bearing	:	Section 7.11
(f)	Expansion Joint	:	Section 7.12
(g)	Demolitions of Existing Structures	:	Section 7.15
(h)	Reinstatement of Existing Bridges	:	Section 8.5

7.4.1.3 Quality Control

The quality of the materials supplied, workmanship and final products shall be monitored and controlled as specified in the Reference Standards in Article 7.4.1.5 below

7.4.1.4 Tolerances

(a) Hole Diameter

- Hole in main member : + 1.2 mm, - 0.4 mm.
- Hole in secondary member : + 1.8 mm, - 0.4 mm.

(b) Hole Alignment

- Main member, shop positioned : ± 0.4 mm
- Secondary member, field positioned : ± 0.6 mm

(c) Girders

Camber : deviation from specified camber ± 0.2 mm per metre length beam or ± 6 mm vehicle is less.

Lateral deviation from straight line between centers of bearings 0.1 mm per metre length of beam to a maximum of 3 mm.

Lateral deviation between center line of web and center line of flange in built up girders mm maximum.

Combined warpage and tilt of flange of welded beams or girders shall be determined by measuring the offset at toe of flange from a line normal to the plane of the web through the intersection center line of web with the outside surface of the flange plate. This offset shall not exceed 1/200 of total width of flange or 3 mm whichever is greater.

Out of flatness or seats or bases:

- To be set on grout : 3.0 mm, max.
- To be set on steel, hard masonry, or lead : - 0.25 mm, max.

The maximum deviation from specified depth for welded beam and girders, measured at the web center line, shall be as follows:

- For depths up to 900 mm : ± 3 mm
- For depths over 900 mm to 1.8 metres

inclusive : ± 5 mm

- For depths over 1.80 m : + 8 mm
  -5 mm

(d) Struts

Maximum deviation from straightness, including that of individual flanges in either direction : length/1000 or 3 mm whichever is the greater.

(e) Machined Surfaces

Machined bearing surfaces shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5 m.

7.4.1.5 Reference Standards

AASHTO M160M/ M160-07	:	General Requirements for Rolled Steel Plates, Shapes, Sheet Piling and Bar for Structural Use.
AASHTO M164M - 05	:	High Strength Bolts for Structural Steel Joints.
AASHTO M169 - 06	:	Steel Bars, Carbon, Cold Finished, Standard Quality.
AASHTO M183M - 90	:	Structural Steel
ASTM A233	:	Mild Steel, Arc Welding Electrode
ASTM A307	:	Mild Steel Bolts and Nuts (Grade A)
AWS D20	:	Standard Specification for Welded Highway and Railway Bridges

7.4.1.6 Submittals

(a) The contractor shall submit mill test reports showing chemical content and physical tests for each type or grade of steel to be used in the works. If these are not available

the Engineer shall order the Contractor to carry out, at an approved testing institution, tests necessary to establish the quality and other properties of the steel. These shall be submitted with or in lieu of the manufacturer's certificate.

(b) Three copies of all detailed working drawings prepared by or on behalf of the Contractor shall be submitted to the Engineer for his approval. This approval shall in no way relieve the Contractor of his responsibilities for the work under the Contract.

(c) The Contractor shall submit his proposed construction program and methods, including all necessary drawings and design for temporary works. The data submitted shall include, as necessary, dates for workshop visits, delivery and erection, proposals for removing existing works, erection methods, temporary supports and bracing for girders during erection, detail of joints and connections, deviation of traffic on or away from existing bridges and any other relevant information to complete the work

(d) The Contractor shall notify the Engineer in writing at least 24 hours before he intends to commence demolition of existing structures or the erection of new steelwork.

7.4.1.7 Storage and Protection of Materials

Steel work, at both the fabrication yard and at site, shall be stacked on blocks, racks or platforms so as not to be in contact with the ground and in a manner approved by the Engineer. When steelwork is stacked several levels high, supports for all levels shall be in line. Materials shall be protected from corrosion and other damage and shall be kept free of dirt, oil, greases and other foreign matter. Surfaces to be painted shall be carefully protected both at the fabrication shop and in the field. Threads to fixings shall be protected from damage.

7.4.1.8 Rectification of Unsatisfactory Work

(a) Steelwork damaged during storage, handling or erection shall be repaired to the approval of the Engineer. Any material or joint damaged beyond repair shall be rejected and immediately removed from the works.

(b) Steel members with dimensions outside the tolerances indicated in Article 7.4.1.4 shall not be accepted for use in the works.

7.4.1.9 Mainance of Accepted Work

Not withstanding the Contractor’s obligation to carry out rectification of unsatisfactory or failed work as specified in Article 7.4.1.8 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted structural steelwork throughout the Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7.

7.4.2 MATERIALS

7.4.2.1 Structural Steel

Unless otherwise shown on the Drawings structural carbon steel for riveted, bolted or welded construction shall conform to the requirements of AASHTO M183. Miscellaneous steel shall have a minimum yield stress of 2,500 kg/cm^2 and a minimum tensile strength of 4,000 kg/cm^2. Structural steel for Composite Girders shall have a minimum yield strength of 3,500 kg/cm^2 and a minimum tensile strength of 4,950 kg/cm^2.

The quality of steel, and other relevant data shall be clearly marked on units to allow identification during fabrication and erection.

7.4.2.2 Bolts, Nuts and Washers

(a) Standard Bolts and nuts shall conform to the requirements of ASTM A307 grade A, having hexagonal heads and nuts.

(b) High Strength Friction Grip Bolts, Nuts and Washers

High Strength Bolts, nuts and washers shall be fabricated from heat treated carbon steel conforming to AASHTO M164 - 05 with a minimum yield stress of 5,700 kg/cm^2 and a minimum elongation of 12 %.

(c) Bolts and nuts shall be marked for identification in accordance with AASHTO M164 - 05. Sizes of bolts shall be as indicated on the Drawings.

7.4.2.3 Welded Stud Shear Connectors

Shear connector studs shall conform to the requirements of AASHTO M169 - 06 : Cold Finished Carbon Steel Bars and Shafting, and be cold drawn bar, grade 1015, 1018 or 1020, either semi-killed or fully killed.

7.4.2.4 Welding Consumables

Welding consumables used in the metal-arc welding of grades of steel complying with the requirements of AASHTO M183 - 90 shall comply with the requirements of ASTM A233.

7.4.2.5 Certificates

All raw material or form of processing supplied for the works shall, if requested by the Engineer, be accompanied by a certificate from the manufacturer certifying that the material has been manufactured in accordance with the standard formulation and that it conforms in all respects to the manufacturer's quality control tests. All test certificates showing the results of any physical testing on the raw material shall be supplied to the Engineer at no extra cost.

This Clause shall specifically apply but not be limited to rolled products or sections, bolts, materials and manufacture of bridge bearings and galvanizing.

7.4.2.6 The paint to be used on previously painted surfaces or existing steel structures shall be compatible with the original type of paint of the steel element. The paint to be used shall be in accordance with the following requirement and shall be supplemented with the manufacture's certificate which guarantees the originality and shall be approved by the Engineer prior to using.

To ensure a satisfactory final result, a qualified supervisor shall be assigned to give guidance on paint methods, well explain for the defect category and paint characteristics.

The paint to be used shall satisfy the following requirements:

Galvanized Steel Structures:

Priming Coat : Aluminium epoxy mastic which has the following characteristics:

- consists of 2 components
- has an aluminium pigment content
- has a bond property (mastic) to the galvanized layer
- solid content (90 + 2)%, based on volume

Finishing Coat : Polyurethane Alkyd Copolymer which has the following characteristics:

- consists of 1 component.
- Abrasion resistance
- has color variations and glossy
- solid content (49+ 2)%, based on volume

Non Galvanized Steel Structure:

Priming Coat : Chlorimated Rubber Primer which has the following characteristics:

- contains white anti rust pigment
- solid content (90 + 2)%, based on volume

Intermediate Coat : Chlorimated Rubber which has the following characteristics:

- specific gravity minimum of 1.30 kg/lt

Finishing Coat : Chlorimated Rubber which has the following characteristics:

- specific gravity minimum of 1.27 kg/lt

7.4.2.7 Painting Tools

(a) Surface Preparation Tools

*Palm Fiber or Plastic B*rush for cleaning the dirt or mud from steel.

Scraper for cleaning the loose paint prior to further cleaning.

Steel Wire Brush for cleaning the surface which has started to rust.

Mechanical Wire Brush for cleaning the surface which has started to rust prior to further surface preparation, minimum of 2 sets.

Sand Blasting equipped with compressor for cleaning the steel surface until the original color appears, minimum of 1 set

High Pressure water jet (diesel or electric) with 2000-2500 psi capacity for cleaning the steel surface, minimum 1 set

(b) Painting

Airless spray for spraying the paint on the prepared surface, minimum of 2 sets

Air spray for spraying the paint on the prepared surface, minimum of 2 sets

Compressor, to be connected to the paint sprayer. The pressure of this equipment shall be suitable to the requirement of the paint sprayer.

Brush for applying paint to unreachable part by sprayer.

(b) Painting Thickness Gauge

Wet thickness gauges

Dry thickness gauges

(c) Other Equipment and Safety Equipment

Other equipment will be needed such as falsework and safety equipment i.e. safety belt, helmet, goggles etc. to support the work activities.

7.4.3 WORKMANSHIP

7.4.3.1 Fabrication

All parts in an assembly shall fit together accurately within the tolerances specified in Article 7.4.1.4.

Bolted splices shall be provided with packing plates, where necessary, to ensure that the sum of any unintended steps between adjacent surfaces does not exceed 1 mm for high strength friction grip bolts and 2 mm for other joints.

For welded butt joints any unintended deviation from planarity due only to a misalignment of parts to be joined shall not exceed the lesser of 0.15 times the thickness of the thinner part or 3 mm. However, if due either to different thicknesses arising from rolling tolerances or a combination of rolling tolerances with the above permitted misalignment, this deviation exceeds 3 mm, it shall be smoothed by a slope not steeper than 1 : 4.

7.4.3.2 Cutting

Cutting shall be done accurately, carefully and neatly. Any deformations that occur from cutting shall be removed by straightening. Corner of the cut edges of main members that shall be free edges after completion shall be rounded with a radius of about 0.5 mm or chamfered. Fillers, tie plates, lacing bars and lateral bracing may be shaped by shearing but any burring shall be removed. Any damage caused by cutting shall be corrected. Corners shall generally be rounded to a radius of 10 mm.

7.4.3.3 Holes for Rivets and Bolts

(a) Holes for rivets, countersunk bolts and black bolts (excluding close tolerance, turned barrel bolts and high strength friction grip bolts) shall be 2 mm larger than the nominal diameter of the cold rivet or bolt as manufactured. All holes shall be drilled or shall be drilled small and reamed or sub-punched and reamed.

Where several plates or sections form a compound member they shall, where practicable, be firmly connected together by clamps or service bolts and the holes drilled through all the thicknesses at one operation, or alternatively, and in the case of repetitive work, the plates and section may be drilled separately from jigs or templates. All burrs shall be removed.

(b) Holes for Close Tolerance and Turned Barrel Bolts

The diameter of holes shall be equal to the nominal diameter of the bolt shank or barrel, subject to a tolerance of + 0.15 mm and – 0 mm.

Preferably, parts to be connected with close tolerance or turned barrel bolts shall be firmly held together by service bolts or clamps and the holes drilled through all the thicknesses at one operation and subsequently reamed out after assembly. Where this is not practicable, the separate parts shall be drilled through hard bushed steel jigs and reamed if necessary. All burrs shall be removed.

(c) Holes for High Strength Friction Grip Bolts

Holes shall be cylindrical and perpendicular to the surface of the plate unless otherwise specified.

Generally the diameter of holes shall be 1 mm larger than the nominal diameter of the bolt for bolts to 16 mm diameter and 1.5 mm larger than the nominal diameter for larger bolts.

Distance from hole centers to plate edges shall depend upon plate thicknesses. However, the minimum distance from the hole center to the edge of a plate with sheared edges shall be 1.7 times the nominal diameter of the bolts, while for plate with rolled or flame cut edges the distance shall be 1.5 times the nominal diameter of the bolts.

Preparatory holes may be drilled first, steel sections assembled and holes enlarged to the specified diameters by reaming. Burrs around bolt holes shall be removed by scraper. The edges of holes shall be chamfered to 0.5 mm. Any relief roll marks in the member at the bearing faces of washers, bolts and nuts shall be removed. Drift pins may be placed through holes to facilitate positioning of steel members, but excessive force shall not be used during such operations and care shall be taken not to damage holes.

7.4.3.4 Stiffeners

End stiffeners to girders and stiffeners intended as supports for concentrated loads shall have full bearing (either milled, ground or, on wieldable steel in compression areas of flanges, welded as shown on the plans or as specified) on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless shown or specified otherwise, fit sufficiently tight to exclude water after being galvanized.

7.4.4 CONSTRUCTION

7.4.4.1 Shop Assembly

Where required by the Engineer units shall be assembled at the fabrication shop prior to delivery to site.

7.4.4.2 Standard Bolted Connections (other than high strength friction grip bolts)

Bolts not tightened to the proof load shall have single self-locking nuts. Bevel washers shall be used where bearing faces have a slope of more than 1 : 20 with respect to a plane normal to the bolt axis. Bolts shall be of such length that they shall extend entirely through their nuts but not more than 6 mm beyond them.

Bolts shall be driven accurately into the holes without damage to the threads. A snap shall be used to prevent damage to the heads.

The heads and nuts shall be drawn tight against the work with the full effort of a man using a suitable wrench not less than 38 cm long for bolts of nominal diameter 19 mm and over. Heads of bolts shall be tapped with a hammer while the nuts are being tightened.

The threads on turn bolts shall be entirely outside the bolt holes. Washers shall be used unless otherwise specified.

7.4.4.3 High Strength Friction Grip Bolts

(a) General

The slope of surfaces of bolted parts in contact with bolt heads and nuts shall not exceed 1 : 20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all joint surfaces, including those adjacent to bolt heads, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of burrs, din, and other foreign material that would prevent solid seating of the parts.

(b) Surface Finish to Contact Surfaces

The contacting surface and the immediate area around the steel members shall be cleaned of all rust, mill scale, paint, grease, primer, lacquer or other foreign matter. Any burrs or other defects that would prevent solid seating of the parts or would interfere with the development of friction between them shall be removed.

Contact surfaces shall be finished with a suitable roughness. No joint shall be made until surfaces to be connected are inspected and accepted by the Engineer.

(c) Tensioning Bolts

Special attention shall be paid to differences of plate thickness of parts being placed to ensure that no warping occurs and that the base metal and splice plate are in close contact.

Tightening tools, either torque wrenches or power wrenches, as approved by the Engineer, shall be used for tightening bolts.

Any equipment utilized in tightening bolts shall be regularly calibrated to the satisfaction of the Engineer. Torque values given by the supplier shall be justified before any bolt is used in the works.

Tightening may be carried out either by the half turn method or the torque control method as approved by the Engineer.

The Contractor may use load indicating washers to measure bolt tension.

7.4.4.4 Welding

Welding procedures for shop and site welds, including particulars of the preparation of fusion faces, shall be submitted, in writing, for the approval of the Engineer before commencing fabrication. No departure from the approved welding procedure or from the details shown on the Drawings shall be made without the approval of the Engineer.

The method of marking any temporary attachments shall be approved by the Engineer. Any scars from temporary attachments shall be made good to the satisfaction of the Engineer. Where weld repairs are necessary these shall be carried out to the approval of the Engineer.

Visible weld surfaces shall be cleaned of slag residues. All weld spatter shall be removed and affected surfaces shall be dressed and cleaned.

To enable full throat thickness to be provided at the ends of butt welded joints “run-on” and “run-off” plate extension pieces shall be used.

7.4.4.5 Painting and galvanizing

All miscellaneous steel surfaces shall be painted in accordance with Section 8.5 of these Specifications. All components for Composite Steel Girders including beams, plates, bolts, washers, diaphragms and the like shall be hot-dipped galvanized in accordance with ASTM A123 - 89.

7.4.4.6 Transportation

Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished by the contractor with erection marks shown thereon.

Structural members shall be loaded in such a manner so that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts and packages of bolts, washers, and nuts shall be shipped in boxes, crates or barrels, but the gross weight of any package shall not exceed 150 kg. A list and description of the contained materials shall be plainly marked on the outside of each shipping container.

7.4.4.7 Equipment and Falsework

The contractor shall provide all tools and falsework necessary for the expeditious handling of the work. This shall include temporary bracing, all tools, machinery, and appliances, including drift pins and fitting-up bolts.

Falsework and temporary bracing shall be properly designed, constructed and maintained to carry all applied erection and permanent forces.

7.4.4.8 Assembling Steelwork

(a) Components fabricated by Contractor

The parts shall be accurately assembled as shown on the plans and any match- marks shall be followed. The material shall be carefully handled so that no parts are bent, broken, or otherwise damaged. Hammering that may injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected in a manner so as to give the trusses proper camber. Any temporary blocking shall be left in place until the tension chord splices are fully bolted and all other truss connections pinned and bolted. Permanent bolts in splices of but joints of compression members shall not be driven or tightened until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

(b) Components supplied by Employer

Component supplied by the Employer shall be erected strictly in accordance with the manuals and Drawings supplied by the manufacturer.

7.4.4.9 Painting Implementation

(a) Assessment of Coating Damage

Painting work is divided into 2 (two) categories based on the type of the damage:

Category A:
- initial rust has not appeared yet.
- decrease in the galvanized coating, many white spots on the coating appear
- sporadic damage of the coating caused by scratching, friction, or sticking etc.

Category B:
- Paint coating shown some damage although not the whole surface; bubbling paint coats, peeled paint coats, cracking paint (through to the steel surface);
- rust appearing not only on the spots where scratching, friction or sticking occurs;
- rust generally occurs in the sharp edges, bolt and nut areas, welding areas, angles etc.

(b) Surface Preparation

The steel surface to be re-coated shall be cleaned to make it free from dirt, oil grease and other deleterious material, using proper equipment for the type of damage.

Where heavy corrosion occurs or paint coat is damaged, it shall be cleaned using scraper and wire brush.

Surface preparation shall be carried out using the following equipment/methods:

Category A:
- High pressure water jet washing
- Scraping wire brushing

- Solvent washing or dry air blowing

Category B:

Alternative 1:
- High pressure water jet washing and brushing
- Abrasive blasting standard minimum SSPC-SP7 (Steel Structure Painting Council -USA).

Alternative 2:
- High pressure water jet washing and brushing
- Hand and power tool cleaning, standard minimum SSPC-SP3/SP2

Following surface preparation and cleaning, gaps between unwelded steel plates shall be covered using epoxy. Surface preparation shall be carried out based on the above procedure, and the time between completions of surface preparation and priming coat painting shall be not more than 3 hours.

(c) Painting

Priming shall be carried out using a large sprayer machine, and by brushing the surface of parts which are unreachable with the sprayer machine. Prior to application, painting material which consists of 2 components shall be stirred separately before being thoroughly mixed with ratios recommended by the manufacturer, and in the presence of a supervisor. Thinner may be added as recommended by the manufacturer.

Intermediate and final coatings shall be carried out using a sprayer machine and brush, a minimum of 24 hours and maximum 72 hours after the priming coat or the intermediate coat.

Painting consists of 2 coatings for a galvanized surface and 3 coatings for a non-galvanized surface. Protection/coating type to be used for this painting shall comply with Article 7.4.4.9.(b) with thickness as follows:

Galvanized Coating

Category A:
- Aluminium epoxy mastic: 100 µm
- Polyurethane alkyd copolymer topcoat 1 component: 50 µm.

Category B:
- Aluminium epoxy mastic: 225 µm
- Polyurethane alkyd copolymer topcoat 1 component: 50 µm.

Non-Galvanized Coating

Category A:
- Chlorinated Rubber Primer (White anti rust pigment): 80 µm.
- Chlorinated Rubber Finish Topcoat: 30 µm.

Category B:
- Chlorinated Rubber Primer (White anti rust pigment): 80 µm.
- Chlorimated Rubber Finish Undercoat: 35 µm.
- Chlorimated Rubber Finish Topcoat: 30 µm.

This work shall be carried out by experienced personnel, with a thorough understanding of the equipment, cleaning and other procedures as described in the Article 7.4.4.9.

7.4.5 MEASUREMENT AND PAYMENT

7.4.5.1 Measurement

(a) Composite Steel Girder

The quantity of structural steel measured for payment shall be the number of kilograms complete in place and accepted in the works. For computing the nominal weight of rolled or cast steel, the material shall be assumed to have a density of 7,850 kilograms per cubic metre. The weights of other metals shall be as indicated on the Drawings or as approved by the Engineer.

The computed weight of material shall be the nominal weight of finished steelwork comprising plates, rolled section, shear connectors, stiffeners, cleats, packs, splices plates, and all fittings, without allowance for rolling margin and other permissible deviations from standard weights or nominal dimensions, and excluding the weights of welds, fillets, bolts, nuts, washers, rived heads and protective coatings. No deduction shall be made for notches, bolt holes and rivet holes etc which are less than 0.03 square metres in area.

(b) Painting and Galvanizing

Painting and other protective coatings shall not be paid for, the cost of this work being deemed to be included in the prices bid for structural steelwork.

The final painting for existing steel structures shall be approved by the Engineer prior to measurement and payment. This work shall be measured by the Engineer using a dry thickness gauge i.e. elcometer, to determine the thickness which shall conform to the requirements of these Specifications and the Manufacturer's guidlines. The painting shall produce a uniform color and smooth surface in close contact with previously applied painting.

Any painting found unsatisfactory by the Engineer due to faulty paints, improper cleaning and application or from any cause whatsoever, shall be repainted by the Contractor at his own expense, and refer to the procedures determined by the manufacturer.

The quantity to be measured for payment is the finished painting work in square metres which is accepted by the Engineer.

7.4.5.2 Payment

The quantities of structural steelwork determined as provided above, shall be paid for at the price per unit of measurement for the Pay Item listed below and shown in the Bill of Quantities. Such price and payment shall be deemed full compensation for supplying, fabricating and erecting the materials, including all labor, equipment, tools, testing and other incidentals necessary or usual for the satisfactory completion of the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement

7.4.1	Structural Steel, Yield Point of 2,500 kg/cm^2, galvanized or painted, furnished and installation	Kilogram
7.4.2	Structural Steel, Yield Point of 2,800 kg/cm^2, galvanized or painted, furnished and installation	Kilogram
7.4.3	Structural Steel, Yield Point of 3,500 kg/cm^2, galvanized or painted, furnished and installation	Kilogram
7.4.4	Preparation and Application of Coatings to Galvanized Steel Work, Category A	Square Metre
7.4.5	Preparation and Application of Coatings to Galvanized Steel Work, Category B	Square Metre
7.4.6	Preparation and Application of Coatings to Non-Galvanized Steel Work, Category A	Square Metre
7.4.7	Preparation and Application of Coatings to Non-Galvanized Steel Work, Category B	Square Metre

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SECTION 7.5

SUPPLY, TRANSPORTATION, ERECTION OF STEEL BRIDGE STRUCTURES

7.5.1 GENERAL

7.5.1.1 Description

This work consists of the erection of steel bridge structures of proprietary design, such as Steel Truss, Girder and Bailey Bridges or other design systems provided by the Employer, or supplied by the contractor or fabricator of steel bridge materials on prepared foundations at locations designated by the Engineer. The erection work will include as necessary, handling, checking, identification and storage of all free issue material, setting of bearings, pre-assembly, launching and final positioning of the bridge structure, the fitting of deck components and any other operations required to satisfactorily erect the steel bridge structures in accordance with the requirements of this Specification.

The work may also include, when so directed by the Engineer, the collection of the free issue material from a designated storage location and the provision of suitable timber deck material when the deck components do not form part of the free issue materials supplied by the Employer.

7.5.1.2 Issue of Construction Details

Assembly and erection details, including all necessary manuals, marking plans and parts lists, for each steel bridge structure included in the scope of work of the Contract for which no details were included in the tender documents, shall be furnished to the Contractor after detailed field survey has been completed in accordance with Section 1.9 of these Specifications.

7.5.1.3 Related Work Specified Elsewhere

(a)	Mobilization	:	Section 1.2
(b)	Traffic Management and Safety	:	Section 1.8
(c)	Field Engineering	:	Section 1.9
(d)	Materials and Handling	:	Section 1.11
(e)	Construction Schedules	:	Section 1.12
(f)	Concrete Work	:	Section 7.1
(g)	Reinforcing Steel	:	Section 7.3
(h)	Cement Mortar	:	Section 7.8
(i)	Stone Masonry	:	Section 7.9
(j)	Demolition of Existing Structures	:	Section 7.15
(k)	Reinstatement of Existing Bridge Structures	:	Section 8.5
(l)	Routine Maintenance of Pavement, Shoulders, Drainage, Road Furniture and Bridges	:	Section 10.1

7.5.1.4 Submittals

(a) The Contractor shall submit details of work schedules and traffic control provisions for all steel bridges to be erected and shall obtain the Engineer's approval prior to the commencement of erection operations.

(b) Where the Engineer has directed that the supply of deck timber is included in the Contractor's scope of work, the Contractor shall submit samples of all such proposed materials to the Engineer for his approval. However, any such approval given by the Engineer will not relieve the Contractor of his responsibility to supply all new materials in compliance with the material requirements of these Specifications.

7.5.1.5 Rectification of Unsatisfactory Bridge Components

Components of the bridge structure that, in the opinion of the Engineer, have been unsatisfactorily assembled and or erected in accordance with the provisions of this Specification, or are considered unsatisfactory in any other respect, shall be rectified as directed by the Engineer. Rectification may include the replacement of damaged or lost components and fixings, the straightening of bent plates, the repair of damaged surface coatings or any other measure which the Engineer deems necessary.

Rectification work instructed by the Engineer as a result of components being damaged or lost whilst in the care of the Contractor, shall entirely he at the Contractor's expense.

7.5.1.6 Maintenance of Satisfactory Erected Bridge Structures

Not withstanding the Contractor’s obligation to carry out rectification of unsatisfactory bridge components as specified in Article 7.5.1.5 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted steel bridge structures throughout the Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7

7.5.1.7 Work Scheduling

Following the issue of construction details for any steel bridge included in the scope of the Contract, the Contractor shall schedule his work program as early as possible within the Time for Completion. Full details of the sequence and timing of the erection operations for each bridge shall be incorporated into the Contractor's Construction Schedules, the revision of which shall resubmitted to the Engineer for his formal approval in accordance with the provisions of Section 1.12 of these Specifications.

7.5.1.8 Control of Traffic

Traffic control shall conform with the provisions of Section 1.8, Traffic Management and Safety, and the following additional provision:

Where the erection of a steel bridge structure is necessitated by the demolition or full closure of an existing bridge, the programmed closure shall be fully coordinated with the Engineer in order that a detour or other alternative provisions can be made to minimize disruption to traffic.

7.5.2 MATERIALS

7.5.2.1 General

All steel materials or components for the erection of steel bridge structures have been pre-purchased by the Employer and are held in stock at one or more of the Employer's various

equipment storage depots. Material for any given bridge structure may be new or may have previously been erected at other locations.

The material requirements and erection procedures for any given bridge structure may vary according to the source of the proprietary system pre-purchased by the Employer. Such systems may or may not include bridge deck components and may be erected by one of the following cantilever construction methods:

(a) Total pre-assembly of the major components of the bridge structure, including a suitable counterbalance element, on prepared temporary supports so that the assembled structure can be progressively launched from one bank to the other.

(b) Progressive assembly of the main components of the bridge structure from a previously prepared anchor frame located on one side.

7.5.2.2 Material furnished by the Employer

Material furnished by the Employer will comprise all steel members, components, fixings, bearings, tools and equipment to enable the Contractor to assemble and erect the steel bridge structures in accordance with the procedures recommended by the various manufacturers.

Material furnished for bridges to be erected by the two principal erection procedures shall include, but shall not be limited to, the following:

(a) Erection by Launching

All main truss panels including chord reinforcement when so required; all transoms, sway braces, vertical braces, racers, end posts and pin type bearings, together with all fixing brackets, lugs, connectors, link units, small assembly tools and ancillary launching components such as construction rollers, launching rollers, landing rollers, hydraulic jacking equipment and material for assembly of the counterbalance frame and launching nose.

(b) Erection by Progressive Assembly

All main truss components including chord members, diagonals, cross girders, bracing, posts, stringers, gusset plates, splice plates, hand railing and neoprene type bearings; together with all necessary connectors, link units, hydraulic jacks, small assembly tools and material for assembly of the anchor frame.

Dependent upon the proprietary design of the steel bridge structure to be erected, the Employer may also furnish materials for the construction of an all bridge deck, including all prefabricated deck units, curb units, clamps, bolts and other fixings, or may furnish all necessary steel stringers, bearers and fixings for the construction of deck framework to receive a timber running surface. Where a timber running surface is provided for, the timber planking and curbs are to be supplied by the Contractor.

7.5.2.3 Inspection, Collection, Transport and Delivery of Bridge Materials

All material to be furnished by the Employer will be made available to the Contractor at one or more designated equipment storage depots nominated in the tender documents.

The Contractor shall make all necessary arrangements for the timely hand-over safe transportation and delivery to the site of works of all such material furnished by the

Employer. The Contractor shall also inspect and check the quantity and condition of all material to be furnished by the Employer against the manufacturer's shipping lists prior to taking receipt of such material, and shall report and obtain the confirmation of the Employer's representative at the material storage depot should any damaged or missing components be discovered. The Contractor shall sign for the receipt of the consignment so inspected and recorded, and thereafter shall be responsible for the loss or damage of any material while in his care.

Material furnished by the Employer that is for temporary use only during the erection operations, such as material for anchor frames, counterbalance frames, launching nose framework, construction rollers, launching rollers, landing rollers, hydraulic jacking equipment and other erection tools, shall be inventoried separately at the time of hand over to the Contractor. The Contractor shall return all such item to the Employer in good condition after the completion of erection operations.

7.5.2.4 Handling and Storage

All material shall be stored in general compliance with Section 1.11 of these Specifications and the following additional provisions:

(a) All structural steel sections and other shapes to be stored shall be placed off the ground on skids or timber bearers over a properly drained storage or lay-down area.

(b) Structural sections of I-beam or channel profile shall be stored with webs positioned vertically so as to prevent water and dirt retention in the webs of the members.

(c) All like components shall be stored together for ease of identification and all components shall be positioned during storage such that their shipping marks can be readily located without the necessity of turning the components or moving adjacent components.

(d) All bolts and small fittings shall be stored in bins or containers in a dry location not exposed to the weather.

7.5.2.5 Replacement of Missing or Severely Damaged Components

When so directed by the Engineer, missing or severely damaged components recorded under Article 7.5.2.3 above as not having been received from the Employer shall be furnished by the Contractor. In such a case, the Contractor shall ensure that all new components supplied are of a material specification equal or better than the original manufacturer's specification, and that all fabricated components are fabricated, finished and marked strictly in accordance with the dimensions and tolerances shown on the original manufacturer's shop drawings.

The replacement components shall be subject to inspection and acceptance by the Engineer, who in addition may request the submission of material certificates or such other evidence substantiating the properties of the material supplied as he deems necessary.

7.5.2.6 Repair of Slightly Damaged Components

When so directed by the Engineer, components recorded under Article 7.5.2.3 above as being in a slightly damaged condition when received from the Employer shall be repaired by the Contractor. Repairs authorized by the Engineer shall be limited to the straightening of bent plates and other minor components, the repair of non fatigue related fractures in shop welded connections and the reinstatement of damaged surface coatings. Such repair

works shall be carried out in an approved workshop to the directions of the Engineer and the following requirements;

(a) Straightening, Bent Materials

The straightening of plates and minor components of other shapes shall be carried out by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the Engineer, in which case the heating shall not be to a higher temperature than that producing a ”dark cherry red” color.

When heating has been approved for the straightening of a bend or buckle, the metal shall be cooled as slowly as possible after the completion of the straightening operation. Following cooling the surface of the metal shall be carefully inspected for any evidence of fracture. Fractured material shall not be used in the works and must be wholly replaced to the satisfaction of the Engineer.

(b) Repair of Fractured Welds

Fractured or damaged welds within shop welded components shall be cut out, prepared and re-welded strictly in accordance with the manufacturer's specified welding standards applicable to the grade or grades of material to be welded. Welding procedures adopted for the repair work shall be so designed as to minimize any distortion to the component members being repaired in order that the manufacturer's specified fabrication tolerances are maintained.

(c) Reinstatement of Damaged Surface Coatings

Most steel components furnished by the Employer will be supplied with a hot dip galvanized finish. Where material is furnished with areas of the existing surface coating in a damaged condition, the affected areas shall be reinstated in accordance with the surface preparation and painting requirements of Article 8.5.5 of these Specifications, for the reparation of hot dip galvanized surfaces.

7.5.2.7 Supply of Timber Decking Material

When called for on the bridge manufacturer's drawings or directed by the Engineer, the Contractor shall furnish all timber materials such as deck planking, running boards and curbs.

Solid sawn timber for decking material shall generally conform to the material, storage and workmanship requirements for lumber and timber as specified in Articles 8.2.4.4, 8.2.4.5 and 8.2.4.6 of these Specifications. All timber shall be supplied precut and pre-drilled to the dimensions given on the bridge manufacturer's shop drawings. Unless directed otherwise in accordance with Article 7.5.2.5 above, bolts, nuts, washers and other connection hardware for fixing deck timbers shall not be supplied by the Contractor.

7.5.3 EXECUTION

7.5.3.1 General

The assembly and erection of steel bridge structures, either by launching or progressive assembly construction procedures, shall be carried out by the Contractor strictly in accordance with the procedures laid down in the respective bridge manufacturer's assembly and erection manuals and the general requirements specified hereunder.

At the request of the Contractor additional technical support by experienced personnel of the Employer may be provided at the site for a limited period, to instruct the Contractor's erection engineers and technicians in the principles of assembly and erection of the steel bridge structures.

The steel bridge structures furnished by the Employer are designed for assembly and erection with field bolted connections only. No field welding shall be permitted unless expressly authorized by the Engineer.

7.5.3.2 Civil Works

Civil works for abutments and piers may be of timber, stone masonry or concrete construction in accordance with the Drawings or the directions of the Engineer and shall be constructed in accordance with the relevant Sections of these Specifications or such other specifications issued by the Engineer. All civil works shall be in place and accepted by the Engineer prior to the commencement of assembly operations.

7.5.3.3 Setting Out and Temporary Works

The Contractor shall prepare and set out on one embankment an area suitable for the assembly of a counter balanced anchor frame where erection is to be by the progressive assembly method, or, where erection is to be by the launching method, the complete steel bridge structure together with a counterbalance frame and launching nose.

All temporary timber crib work supports and packing and for concrete foundations furnished by the Contractor for the installation of construction rollers, launching rollers, landing rollers or the anchorage and support of anchor frames shall be accurately set out and installed to the correct lines and levels as shown in the manufacturer's erection drawings. Particular attention shall be taken to ensure that all rollers and temporary supports are set at the correct elevations to suit the calculated launching plane and for deflection characteristics for the length of bridge span to be erected,

7.5.3.4 Setting of Bridge Bearing

Bridge bearings may be of the elastomeric bearing pad type or pin bearings set on bearing plates and grillage beams. Each type of bearing shall be set level and in exact position and shall have true and even bearing on all contact surfaces. For bridge bearings set in grout, no load shall be placed on them until the grout has set for at least 96 hours, adequate provision being made to keep the grout well moistened during this period. The grout shall consist of one part Portland cement to one part of fine grained sand.

7.5.3.5 Assembly of Steel Components

The steel components shall be accurately assembled according to the match marks shown on the bridge manufacturer's working drawings and in accordance with the correct sequence detailed in the erection procedure. During assembly the material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be allowed. Before assembly all contact surfaces shall be cleaned free of dirt, oil, loose scale, burrs, pits and other defects that would prevent solid seating of the components when assembled.

Bolted connections shall be assembled using bolts of the correct length and diameter as shown on the bridge manufacturer's bolt lists. Washers shall be placed under the element (nut or bolt head) turned in tightening. Where an outer face of the bolted parts has a slope of more than 1 : 20 with respect to a plane normal to the bolt axis, a smooth beveled washer

shall be used to compensate for the lack of parallelism. In all cases of only one non-sloping surface, the turned element shall be adjacent to this surface.

7.5.3.6 Erection Procedures

The sequence of erection shall be carried out strictly in accordance with the erection procedures given in the bridge manufacturer's erection manual. The Contractor shall perform the erection operations with due regard to all normal safety requirements and shall ensure that the bridge structure is stable at all stages of the erection process.

For bridges erected by launching procedures, the Contractor shall take all necessary precautions to ensure that during all stages of assembly the bridge structure is secured against free movement on the rollers. Movement across the rollers during launch operations shall be controlled at all times.

All counterweight material and temporary supporting steelwork or timber for the counter weight support frames shall be supplied by the Contractor. The counterweight shall be so positioned and of such a mass that the correct factor of safety for stability as assumed in the bridge manufacturer's erection calculations is achieved at all stages of assembly and erection.

Erection operations by launching or progressive assembly shall proceed until the steel bridge structure is positioned above the final bearing locations. The Contractor shall then commence jacking operations using the hydraulic jacking equipment and jacking frames furnished by the Employer. The bridge structure shall be jacked to a sufficient height to allow the removal of all temporary timber crib work, roller supports and link sets before being lowered into its final position.

Jacking operations shall be carried out strictly in accordance with the bridge manufacturer's erection procedures and the Contractor shall follow the correct sequence for the attachment and interchange of special components during such operations.

7.5.4 MEASUREMENT AND PAYMENT

7.5.4.1 Method of Measurement

(a) Erection of Steel Bridge Structures

The erection of steel bridge structures shall be measured for payment as the total number of kilograms of steel structure completed in place and accepted by the Engineer. Weights of the individual components shall be taken from the bridge manufacturer's shop drawings and parts lists.

The total weight of structure measured for payment shall be computed as the weight of all individual steel components, used in the final erected structure, including all fabricated steel sections, plates, bearings of semi permanent bridge, bolts, nuts, washers and other fastenings, and prefabricated deck units, when such units are included in the design. The weight of steel components used during erection operations which do not from part of the final structure, including components and fittings for counter balance frames, anchor frames, jacking frames, launching noses, construction rollers and the like shall not be included in the measured weight for payment.

When timber decking is specified on the construction drawings or by the Engineer, the weight of fixing hardware for the timber deck shall not be included in the measurement for erection.

(b) Transportation and Delivery of Materials

Transport and delivery of all material provided by the Employer shall be measured and paid for as the total number of kilograms. Measurement and payment of such kilograms shall constitute full compensation to the Contractor for inspection and collection of all material at one or more storage depots nominated in the tender documents, for transportation and delivery of the material to the site of works, including all loading and handling operations during transportation, and for the return in good condition of the temporary works components to an Engineer designated storage depot after erection of the steel bridge structure is complete.

(c) Supply of Replacement Components

Replacement of missing or severely damaged components, when called for by the Engineer in accordance with Article 7.5.2.5, shall not be measured for payment under this Section. Compensation for the supply of any replacement components shall be made on a Steel Structure basis in accordance with the provisions of Section 7.4 of these Specifications.

(d) Repair of Damaged Components

Repair of damaged components, when called for by the Engineer in accordance with Article 7.5.2.6, shall not be measured for payment under this Section. The Contractor shall receive compensation for any such repair works to damaged components in accordance with the measurement and payment provisions for the reinstatement of steel components as contained in Article 8.5.6 of these Specifications.

(e) Timber Decking

Timber decking, when called for on the construction drawings or directed by the Engineer, shall not be measured for payment under this Section. Compensation for the furnishing, cutting, drilling, treating, placing, fixing and finishing of timber decking shall be in accordance with the provisions of Article 8.5.6 of these Specifications.

7.5.4.2 Basis of Payment

The quantities for the transport and erection of steel bridge structures as determined above shall be paid for at the contract price per unit of measurement for the Pay Items listed below and in the Bill of Quantities, which price and payment shall be full compensation for inspection, collection, transportation, delivery, unloading, handling and storage of all material supplied by the Employer, for the provision and setting out of temporary works, setting of bearings of semi permanent bridge, assembly and erection of steel components for the bridge structure, disassembly and return to Employer's storage of temporary erection steelwork, rollers, jacks and special tools and for furnishing all labor, equipment, other tools and incidentals necessary or usual for the proper completion of the erection works in accordance with the requirements of this Section of the Specifications.

Pay Item No.	Description	Unit of Measurement

7.5.1	Erection of Steel Bridge Structures	Kilogram
7.5.2	Transportation of Steel Bridge Materials	Kilogram
7.5.3	Supply of galvanized, furnished steel bridge Span …..m, width …..m	Unit of Bridge

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SECTION 7.6

PILING

7.6.1 GENERAL

7.6.1.1 Description

The work described in this Section shall consist of all piling, furnished and driven, or cast in place, in accordance with these Specifications, and in accordance with the Drawings, to the penetration or depth as shown on the Drawings or as directed by the Engineer.

The following types of pile are covered in this Specification.

- Timber Piles
- Structural Steel Pile
- Steel Pipe Piles
- Precast Concrete Piles
- Precast, Prestressed Concrete Piles
- Cast-in-Place Concrete Piles
- Sheet Piles

The type of pile to be used shall be as shown on the Drawings.

7.6.1.2 Related Work Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Excavation	:	Section 3.1
(c)	Fill	:	Section 3.2
(d)	Concrete	:	Section 7.1
(e)	Prestressed Concrete	:	Section 7 2
(f)	Reinforced Steel	:	Section 7.3
(g)	Structural Steel and Steel Painting	:	Section 7.4
(h)	Demolition of Structures	:	Section 7.15

7.6.1.3 Quality Assurance

The quality of the materials supplied, workmanship and finished product shall be monitored and controlled as specified in the Reference Standards given in Sections 7.1, 7.2, 7.3 and 7.4 of these Specifications.

7.6.1.4 Tolerances

(a) Location

Piles shall be located as shown on the Drawings. Lateral displacement of the head of pile from its specified position shall not exceed 75 mm in any direction.

(b) Batter

Variations from the vertical or specified batter shall not exceed 20 mm per metre (i.e. 1 in 50).

(c) Bow

(i) The bow of a cast-in-place concrete pile shall not exceed 0.01 of the length of a pile in any direction.

(ii) The lateral bow of a steel pile shall not exceed 0.0007 of the gross length of the pile.

(d) Cast-in-Place Concrete Piles

The diameter of unlined bored hole shall be 0 to + 5 % of the nominal diameter at any position.

(e) Precast Concrete Piles

Tolerances shall be in accordance with Article 7.2.1.4.(b).

7.6.1.5 Reference Standards

AASHTO M133 - 07	:	Preservatives and Pressure Treatment Process for Timber.
AASHTO M168 - 07	:	Wood Products
AASHTO M183 - 90	:	Structural Steel.
AASHTO M202M/ M202-06	:	Steel Sheet Piling.
ASTM A252	:	Steel Pipe
ASTM D4945 - 89	:	Standard Test Method for High-Strain Dynamic Testing of Pile.

7.6.1.6 Submittals

Before commencing any piling work the Contractor shall submit to the Engineer the following:

(a) A detailed program for the piling work.

(b) Details of the proposed method of sinking the pile or shaft together with the equipment to be used.

(c) Design calculations, including driving formulae, indicating the capacity of the piles when driven using the Contractor's proposed equipment.

(d) Proposals for test loading piles. This shall include the method of applying the load, measuring the loads and settlements and the proposed presentation of the data.

The Engineer's approval in writing for the above shall be obtained prior to starting any piling work.

7.6.1.7 Storage and Protection of Materials

Cement, aggregates and reinforcing steel shall be stored as required in Sections 7.1 and 7.3 of these Specifications. Units of reinforced or prestressed concrete and steel units shall be stored clear of the ground on timber supports placed on firm ground which is not liable to subside, whether wet or dry, under the weight of the units. Where units are stacked in layers, they shall not be stacked more than 3 high with timber supports placed between each layer. Supports for each layer shall be placed above those of the preceding layer. Supports shall be placed not more than 20% of the length of the unit from each end.

7.6.1.8 Quality of Work and Rectification of Unsatisfactory Work

(a) If the tolerances given in Article 7.6.1.6 are exceeded the Contractor shall carry out, at his own expense, any remedial measures considered necessary by the Engineer.

(b) Any pile damaged by reason of internal defects or improper driving, driven out of its proper location or driven below the elevation shown on the Drawings or specified by the Engineer shall be corrected at the Contractor's expense.

(c) Rectification work, as specified by the Engineer and carried out at the Contractor's expense, shall include, but not necessarily be restricted to, the following :

(i) Withdrawal of the deficient pile and replacing it with a new or longer pile as required.

(ii) Driving a second pile alongside the defective or low pile.

(iii) Extension of the pile by splicing, as specified elsewhere in this section, to allow proper embedment of the pile head in the pile cap.

(d) Where a defective pile cannot be replaced and a new pile is required to be driven the additional cost, if any, of the additional piles and pile cap construction needed to maintain the design capacity of the foundation, shall be at the Contractor’s expense.

7.6.2 PRECAST CONCRETE PILING

7.6.2.1 Description

This work shall consist of precast reinforced concrete piling furnished and driven in accordance with these Specifications and in reasonably close conformity with the requirements on the Drawings or elsewhere in the Contract Documents.

7.6.2.2 Materials

(a) General

Precast reinforced concrete piles shall be constructed in accordance with the strength and details shown on the Drawings, mixed and placed in accordance with the provisions of Section 7.1 of these Specifications. Reinforcement shall comply with the provisions of Section 7.2 of these Specifications. Main reinforcing bars shall be supplied in one complete length and should this prove impractical separate lengths shall be effectively spliced by a method approved by the Engineer. The pile shall be so straight that a line stretched from tip to butt on any face will not be more than 1/1000 of the length of the pile from the face of the pile at any point.

(b) Formwork

Forms for precast piles shall conform to the general requirements for concrete formwork as described in Section 7.1 of these Specifications. Forms shall be accessible for compacting the concrete. Side forms may be removed at any time not less than 24 hours after completion of the placing of concrete but the entire pile shall remain supported for at least 7 days and shall not be subjected to any handling stress until the concrete has been in place for 21 days or such reduced time as the Engineer may decide as a result of tests.

(c) Reinforcement

Reinforcement shall be in accordance with the provisions set out in Section 7.3 and positioned as shown on the Drawings.

(d) Casting

The piles shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a pile free from any air pockets, honeycomb or other defect.

Concrete shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screeded off, and the top surface finished to a uniform, even texture similar to that produced by the forms.

(e) Finish

When removed from the forms piles shall present true, smooth, even surfaces free from any surface blemishes, and true to the dimensions shown on the Drawings.

(f) Curing

Concrete piles shall be covered with wet burlap immediately after placing is complete and shall be kept continuously wet for at least 7 days.

(g) Handling

When raising or transporting precast concrete piles the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile or cracking of the concrete. No concrete pile shall be lifted otherwise than by slinging from the lifting holes, the positions of which shall be submitted to and approved by the Engineer. Piles damaged in handling or driving shall be replaced. Concrete piles shall be so handled at all times to prevent breaking or chipping the edges.

Piles shall not be driven until 28 days have elapsed from the time of casting or such reduced time as the Engineer may decide as a result of tests.

7.6.2.3 Splicing

Splicing shall be avoided where possible. Where extension of piles cannot be avoided the Contractor shall submit to the Engineer for approval his method of splicing. No pile splicing is to be carried out until approval for the method is obtained in writing from the Engineer.

7.6.2.4 Extension of Pile

Extension of precast concrete piles shall be made by overlapping reinforcing steel. The concrete at the end of the pile will be cut away, leaving the reinforcement steel exposed for a length of at least 40 diameters.

Extension of the concrete pile shall be made using the same reinforcing (property and diameter) as used in the original pile. Spiral steel shall be made overlapping along two times a full circle and longitudinal reinforcement shall be overlapped by 40 diameters minimum.

If the extension is more than 1.50 m, the formwork shall be fabricated such that maximum lift of concrete is 1.50 m.

Prior to concreting, the pile head shall be cleaned of all loose materials or fragments, wetted thoroughly and covered with a thin layer of mortar. Concrete to be used shall be at least K400 concrete mix. The cement to be used shall be in the same quality with the cement used on the original piles, unless otherwise directed by the Engineer.

Formwork shall remain in place until at least 7 days after casting. Pile extension shall be maintained and protected in the same manner as the original pile. In the case that the pile will be extended after being driven and intended to be encased within the pile cap concrete work the extension of the reinforcement shall need to be as shown on the Drawings. If not specified on the Drawings the reinforcement shall be lapped for 40 bar diameters for longitudinal steel, unless otherwise directed by the Engineer.

7.6.2.5 Pile shoes

Piles shall be provided with flat or pointed co-axial shoes if they are to be driven into or through ground such as rock, coarse gravel, clay with cobbles, and other soils liable to damage the concrete at the tip of the pile. The shoes can be of steel or cast iron. In uniform clays or sands the shoes may be omitted. The area of the top of the shoe shall be such that the stress in the concrete in this part of the pile is within the safe limits as approved with the Engineer.

7.6.2.6 Stripping Pile Heads

The concrete shall be stripped to a level such that the remaining concrete shall project 50 mm to 75 mm into the pile cap. With reinforced concrete piles the exposed pile reinforcement shall be of sufficient length to be fully bonded into the pile cap as shown on the Drawings. With prestressed concrete piles, exposed prestressing wires shall extend at least 600 mm into the pile cap. These shall be supplemented, as necessary, with reinforcing bars cast into the upper part of the pile. Alternatively, bonding may be effected with mild steel reinforcement only, this being cast into the upper part of the pile during manufacture. Stripping of the pile concrete shall be done carefully to avoid shattering or otherwise damaging the pile. Any cracked or defective concrete shall be cut away and made good with new concrete properly bonded to the old. Cut-off material which, in the opinion of the Engineer, is not worth salvaging, shall be disposed of to the satisfaction of the Engineer.

7.6.2.7 Pile Driving

Refer to Article 7.6.8 of these Specifications

7.6.3 PRETENSIONED CONCRETE PILING

7.6.3.1 Description

This work shall consist of pretensioned spun concrete piling and pretensioned precast concrete piling furnished and driven in accordance with these Specifications and in

reasonably close conformity with the requirements shown on the Drawings or elsewhere in the Contract Documents.

7.6.3.2 Materials

(a) General

Pretensioned concrete piles shall be constructed in accordance with the details shown on the Drawings and to the requirement. Pretensioned spun concrete piles shall also comply with the requirement, pretensioned spun concrete piles.

The applicable provisions of Section 7.2 of these Specifications shall be read into and become part of this Section.

(b) Concrete

Concrete strength shall be as shown on the Drawings and shall be in accordance with the provisions of Section 7.1 of these Specifications.

(c) Reinforcement

Reinforcement shall comply with the provisions of Section 7.3 of these Specifications and shall be positioned as shown on the Drawings.

(d) Prestressing Steel

High tensile steel prestressing wire shall conform to the requirements of AASHTO M203M / M203 - 07.

(e) Certificate

Prior to furnishing pretensioned concrete piles the Contractor shall submit to the Engineer for approval a certificate by the manufacturer certifying that the piles comply with the specification requirements.

7.6.3.3 Pile Driving

Refer to Section 7.6.8 of these Specifications.

7.6.4 STEEL PILING

7.6.4.1 Description

This work shall consist of steel piling for structure foundations furnished and driven in accordance with these Specifications and the Drawings.

7.6.4.2 Materials

Steel pile shall be shop-fabricated and shall have the type, weight, quality and dimensions specified in ASTM A 500 (Steel Pipe Grade B), or as shown on the Drawings.

Prior to furnishing steel piles the Contractor shall submit to the Engineer for approval a certificate by the manufacturer certifying that the piles comply with the specification requirements.

7.6.4.3 Protection Against Corrosion

Where there is a possibility of corrosion of steel piles, the lengths or sections liable to corrosion shall be protected by painting with an approved protective coating and/or shall be installed with a thicker metal section when the rate of corrosion can be reasonably accurately estimated. Generally all exposed lengths of steel pile, and any lengths installed in disturbed ground above the minimum water table shall be protected against corrosion.

7.6.4.4 Pile Heads

Prior to driving, pile heads shall be cut square and a driving cap fitted to hold the axis of the pile in line with the axis of the hammer. After driving capping plates, dowel bars or cleats shall be attached to the pile cap, or a sufficient length of pile shall be embedded in the pile cap.

7.6.4.5 Joints of Steel Pile

Joints of steel pile shall be carefully constructed in accordance with the Drawings, or the instruction of the Engineer. When joints which are not specified on the Drawings are to be constructed, the Contractor shall obtain the approval of the Engineer and employ electric arc welding throughout the butt joint. Welding shall be made in accordance with requirements specified in JIS A 7201 (Standard Practice for Execution of Spun Concrete Piles).

7.6.4.6 Pile Shoes

Shoe bases where used shall consist of steel plate as shown on the Drawings

7.6.4.7 Pile Driving

Refer to Section 7.6.8 of these Specifications.

7.6.5 CAST-IN-PLACE CONCRETE PILING

7.6.5.1 Description

The work shall consist of cast-in-place concrete piles constructed by the reverse circulation drill method in accordance with these Specifications and with the requirements shown on the Drawings.

7.6.5.2 Materials

Cast-in-place concrete piles shall be constructed in accordance with the details and strength shown on the Drawings, mixed and placed in accordance with the provisions of Section 7.1 of these Specifications.

Reinforcement shall comply with the provisions of Section 7.3 of these Specifications.

7.6.5.3 Construction

(a) Drilled Holes

All holes for concrete piles cast in drilled holes shall be drilled to the tips of piles. The length of piles shall be instructed by the Engineer. The drilling machine shall be such that the hole can be maintained exactly vertical during drilling operations.

Completed piles and existing structures very close to the drilling area shall be protected from the influence of piling and the Contractor's proposals for this shall be submitted to, and approved by, the Engineer before the start of piling.

Drilled holes shall be protected from collapse by a water surcharge, by providing a steel casing (i.e. stand casing pipe). The stand casing pipe shall be rigid and project at least 50 cm above ground level.

The water level of the inside of the drilled hole shall be always kept approximately 2m higher than the natural ground water level. Water supplied from a municipal water supply system or a river is allowed for this purpose.

All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed by air lift or suction pump before placing concrete.

(b) Reinforcement

Reinforcement shall be positioned as shown on the Drawings. The connecting portions of main bars with hoops shall generally be welded by arc fillet welding.

During the placing of the reinforcement in the hole, the verticality and position of the reinforcement shall be carefully controlled to prevent collapse of the drilled hole or damage to the walls.

(c) Casting

Concrete shall be placed in one continuous operation from tip to cut-off elevation by tremie tubes and shall be carried out in such a manner as to avoid segregation. The tip of the tremie shall generally be 2 m lower than the fresh concrete surface.

The Contractor at his own expense shall initially cast an additional length of pile above the finished level of the top of the pile and subsequently remove any defective concrete to ensure satisfactory bonding of the pile head to the footing structure.

(d) Reporting

The Contractor shall furnish the Engineer daily with a detailed record of the construction of piles.

(e) Test Loading

The Engineer may instruct the load testing of cast-in-place concrete piles.

7.6.6 SHEET PILES

7.6.6.1 General

Generally the requirements governing the installation of bearing piles shall apply to sheet piles. The type of pile to be used shall be as indicated on the Drawings or as directed by the Engineer.

7.6.6.2 Timber Sheet Piles

Timber piles shall be of the dimensions shown on the Drawings either cut from the solid material or made by building up the piles of three planks securely fastened together. The piles shall be drift sharpened at their lower ends so as to wedge adjacent piles tightly together. The tops of the piles shall be cut off to a straight line at the elevation indicated and shall be braced with walling strips, properly lapped and jointed at all splices and corners. The walls shall preferably be in one length between comers and shall be bolted near the tops of the piles.

7.6.6.3 Concrete Sheet Piles

Concrete sheet pile walls shall be constructed in accordance with the Drawings.

7.6.6.4 Steel Sheet Piles

Steel sheet piles shall be of the type and weight indicated on the Drawings. The piles, when in place in the completed structure, shall be practically watertight at the joints.

The painting of steel sheet pile shall subject to Article 8.5.5.

7.6.7 TIMBER PILES

7.6.7.1 General

All timber piles shall be inspected prior to driving to ensure that they comply with the requirements for materials and tolerances.

7.6.7.2 Preservative

All softwoods used for piles require preservative treatment which shall be carried out in accordance with AASHTO M133 - 07 using pressure impregnation plant. In Areas where such plant is not available hot and cold open tank treatment shall be used. Some hardwoods may be used without preservative treatment but, in general, the need to treat hardwoods depends upon the timber species and the severity of the service conditions.

The Engineer's approval in writing shall be obtained before driving untreated piles.

7.6.7.3 Pile Heads

Before driving, precautions to prevent “brooming” shall be taken. This may be done by trimming the head of the pile to a round cross section at right angles to the length and fitting it with a tight steel or iron ring or by an alternative method shown to be effective.

After driving, the heads of the piles shall be cut off square to sound wood and treated with preservative before capping.

Where softwood piles form the foundation of a permanent structure and are to be cut off below ground level, care shall to be taken to ensure that they are cut off at or below the lowest anticipated groundwater level.

If concrete caps are provided, the piles shall be embedded for a depth sufficient to ensure transmission of the load. The concrete shall be at least 150 mm thick around the piles and shall be suitably reinforced to prevent splitting.

7.6.7.4 Pile Shoes

A pile shall be provided with a suitable shoe for protecting the point of the pile during driving, unless the driving is wholly in soft soils. The shoe shall be truly concentric and firmly bedded on to the end of the pile. The contact area between shoe and timber shall be sufficient to avoid overstressing during driving.

7.6.7.5 Driving

Hard driving likely to broom the pile butt, crush the 'tip and cause cracking shall be avoided by limiting the hammer drop and the number of blows to the pile. Generally the weight of the hammer shall be equal to the weight of the pile for easy driving. Care shall be taken during driving to ensure that the head of the pile is always central to the hammer and normal to the length of the pile and that the pile stays in position relative to the leaders.

7.6.7.6 Splicing

When it is necessary to employ piles formed from two or more lengths, the butting surfaces shall be cut square to ensure contact over the whole cross section of the pile. With sawn piles the joint shall be secured by timber or steel splice plates, or by steel sections such as channels or angles welded together to form a box designed to develop the necessary strength and stiffness. Round piles shall be secured with tubes. Splices near points of maximum bending stress shall be avoided.

7.6.8 PILE DRIVING

7.6.8.1 Preparation for Driving

(a) Caps

The heads of all concrete piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design having a suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. No pile head will be held so firmly that the slight rotation of the pile normally occurring while the pile is being driven will be prevented.

(b) Joints

Joints of pretensioned concrete piles shall be carefully constructed in accordance with the Drawings or the instruction of the Engineer. Welding shall be made in accordance with the requirements specified in JIS A 7201 (Standard Practice for Execution of Spun Concrete Piles).

(c) Pile Shoes

Shoe bases shall consist of steel plate as shown on the Drawings.

7.6.8.2 Handling, Pitching and Driving

(a) General

When raising or transporting piles the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile.

The main setting out for the piles is to be completed prior to commencement of driving. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned. All main setting out points, lines and stations are to be maintained safe and undisturbed until the work is complete.

Piles shall be pitched accurately in the positions and driven to the lines shown on the Drawings or fixed by the Engineer. Piles deflected from the vertical or proper line shall, where ordered by the Engineer, be withdrawn and repitched until the proper line is obtained.

No forcible method of correction of the position or line of any pile will be permitted. Any pile damaged by reason of improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question :

- The pile shall be withdrawn and replaced by a new and if necessary longer pile. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving takes place; or

- A second pile shall be driven adjacent to the defective pile.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven again.

(b) Batter Piles

Batter piles shall be driven accurately to the batter shown on the Drawings. The pile frame employed for the driving of the batter piles shall have leads capable of adjustment to the required angle. When piles have to be driven below the level of the bottom of the leads, extension leads shall be provided except where the use of a follower is specifically permitted by the Engineer.

(c) Driving Equipment

Before any piling work is commenced the Contractor shall submit to the Engineer full details of the pile driving equipment and the method of carrying out the work he intends to use. All piles shall be provided with caps for driving as specified in Article 7.6.9.1.(a).(i) above. For special types of piling, driving head mandrels, or other devices in accordance with these requirements shall be provided so that piles may be driven without damage.

Piles shall be driven with steam, air or diesel hammers, a combination of hammers with water jets or gravity hammers. When diesel hammers are used, they shall be calibrated by a load test if necessary.

The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure in the manner specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge, and another gauge shall be supplied at the hammer intake.

When gravity hammers are used for driving concrete piles, the drop of the hammer shall not exceed 2.5 metres and the hammer shall have a weight of not less than half the weight of the pile. The fall shall be regulated so as to prevent injury to the pile.

(d) Driving

Piles shall be supported in line and position with leads while being driven. Pile drive leads shall be constructed so as to afford freedom of movement of the hammer, and they shall be held firmly in position to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit the proper placing of batter piles. If the condition at the site requires the necessity of a follower, the Contractor shall not use it without approval of the Engineer.

When water jets are considered by the Engineer to be necessary, the number of jets and the nozzle volume and pressure shall be sufficient to erode freely the material adjacent to the piling. The plant shall have at all times a pressure of at least seven (7) kilogrammes per square centimetre at two (2) centimetre jet nozzles. Before the required penetration is reached, the jets shall be shut off and the piles driven by hammer to final penetration.

A detailed accurate record of the driving of all piles shall be kept by the Engineer and the Contractor shall give every assistance to the Engineer to help him keep this record which will include the following : pile numbers, positions, types, sizes, actual lengths, dates driven, lengths in footings, penetration under final blows of the hammer, striking energy of the hammer, lengths extended, length cut off, and final pay lengths.

No piles shall be driven near freshly placed concrete.

(e) Bearing Values

Piles shall be driven to a bearing value of not less than that shown on the Drawings. The Engineer will specify the penetration and the Contractor shall drive the piles to the penetration specified, but if the Engineer is not satisfied that the desired bearing

value has been attained the Contractor shall carry on driving until such desired bearing value is attained.

(f) Cut off and Extension

Piles shall be cut off at such elevation that they will extend into the cap or footing as indicated on the Drawings.

The extended length of a pile shall be sufficient to reach the elevation of the bottom of the cap and shall be of the same section as the pile itself or as shown on the Drawings. After piles have been lengthened driving shall not be resumed until the approval of the Engineer has been given.

Unless otherwise specified, pile cut-off length shall become the property of the Contractor and shall be disposed of beyond Government property limits and outside the limit of view from the roadway to the satisfaction of the Engineer.

(g) Connection with Footing

All piles shall be connected to footings as shown on the Drawings or directed by the Engineer.

7.6.9 TEST PILES

The Engineer may order the execution of test piles as he may consider necessary to ascertain the type of the foundation or the length of pile for the project. The Contractor shall furnish and execute test piling at the locations designated by the Engineer.

The lengths of the piles shown on the Drawings are based on information obtained from previous site investigations. However, piles of different lengths may be required and as ordered by the Engineer.

Before pile lengths are finally settled, the Contractor shall construct to the lengths shown on the Drawings such test piles as may be found necessary and these piles shall be driven in the positions specified by the Engineer who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily with a detailed record of the driving of test piles throughout the full depth of driving.

After attaining the approved set, driving shall be continued until the Engineer directs that it shall cease. Driving of test piles beyond the point at which the approved set is obtained will be called for to demonstrate that driving resistance continues to increase. The Contractor shall then furnish the remainder of the piles in the structure. In determining the lengths of piles the Contractor shall base his list on the lengths assumed to remain in the completed structure.

Test piles shall be used as foundation piles only on the written agreement of the Engineer.

The Contractor at his own expense may increase the lengths to provide for fresh heading and or such lengths as may be necessary to suit his method of operation.

7.6.10 TEST LOADING

The static and dynamic load tests shall be made by the methods approved by the Engineer. The Contractor shall submit to the Engineer for approval detailed drawings of the loading apparatus he intends to use.

7.6.10.1 Static Load Test

The apparatus of static load tests shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles.

If the approved method requires the use of tension (anchor) piles, such tension piles shall be of the same type and diameter as the permanent piles and shall be executed in the location of permanent piles. Pipe and shell piles whose walls are not of adequate strength to sustain the test loading when empty shall have the required reinforcement and concrete placed before loading. Loads for the load tests shall not be applied until the concrete has attained a minimum compressive strength of 95 percent of the design 28 day compressive strength. If he so elects, the Contractor may use high early strength cement, type III or III A, in the concrete of the load test piles and the tension piles.

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

The apparatus shall have a working capacity of three times the design load shown on the Drawings for the pile being tested. Reference points for measuring pile settlement shall be sufficiently removed from the test pile to preclude all possibility of disturbance. All pile load settlement shall be measured by adequate devices, such as gauges, and shall be checked by means of an Engineer's level.

Increments of deflection shall be read just after each load increment is applied and at 15 minute intervals thereafter. The safe allowable load shall be considered as 50% of the load which, after 48 hours of continuous application, has caused not more than 6.5 mm of permanent settlement, measured at the top of the pile. The test load shall be twice the design load shown on the Drawings.

The first increment of load to be applied to the test pile shall be the pile design load. The load on the pile shall be increased to twice the design load by applying additional loads in three equal increments. A minimum period of 2 hours shall intervene between the application of each increment, except that no increment shall be added until a settlement of less than 0.12 mm is observed in a 15 minute interval under the previously applied increment. If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by 50 percent, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted. The full test load shall remain on the test pile not less than 48 hours. The full test load shall then be removed and the permanent settlement read. When requested by the Engineer, loading shall then continue beyond the double design load in 10 ton increments until the pile fails or the capacity of the loading apparatus is reached, whichever is the lesser. The pile may be considered to have failed when the total settlement under load exceeds 2.5 cm or the permanent settlement exceeds 6.5 mm.

After the completion of loading tests, the load used shall be removed and the piles, including tension piles, shall be utilized in the structure if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilized similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for utilization in the

structure, it shall be removed if so ordered by the Engineer or shall be cut off below the ground line or footings, whichever is applicable.

7.6.10.2 Dynamic Load Test

Dynamic Load Test shall be in accordance with ASTM D4945-89 Standard Test Method for High-Strain Dynamic Testing of Pile. The dynamic load test covers the procedure for testing vertical or batter piles individually to determine the force and velocity response of the pile to an impact force applied axially by pile driving hammer to the top of pile. This is applicable to deep foundation piles.

This method is used to provide data on strain or force and acceleration, velocity or displacement of a pile under impact force. The data will be used to estimate the bearing capacity, pile integrity, as well as hammer performance, pile stresses, and soil dynamic characteristics.

The apparatus for applying impact force is pile driving hammer or similar device which is capable of generating a net measurable pile penetration, or an estimated mobilized static resistance in the bearing stratum.

The apparatus for obtaining dynamic measurement shall consist of force or strain transducers and velocity or displacement transducers. The first transducers shall be capable of independently measuring strain and acceleration versus time at a specific location along the pile axis during the impact event. The second transducers shall be placed at equal radial distances on the diametrically opposite side of the pile to where the first transducers were placed. Both of the transducers shall be placed securely so that they do not slip. Velocity data shall be obtained with the second transducers or accelerometers, provided the signal can be processed by integration in the apparatus for reducing data. The accelerometers shall have a minimum of two accelerometers with a resonant frequency above 7500 Hz.

The signals from the transducers during the impact event shall be transmitted to the apparatus for recording, reducing and displaying data to allow determination of the force and velocity versus time. It may be desirable to also determine the acceleration and displacement of the pile head, and the energy transfer to the pile. This apparatus shall include an oscilloscope or oscillograph for displaying the force and velocity traces, a tape recorder or equivalent for obtaining a record for future analysis, and a means to reduce data. The apparatus shall have the capability of making internal calibration check of strain, acceleration, and time scales. No error shall exceed 2% of the maximum signal expected.

The number and location of the piles to be submitted to static or dynamic load testing shall be decided by the Engineer. This number, for piles over 600 mm in diameter, shall be not less than one and not more than three for each bridge. For piles up to and including 600 mm in diameter it shall be not less than one for every 30 piles.

7.6.10.3 Reporting

A report shall be prepared by the Contractor on each load test. This report shall include the following documents :

- Plan of the foundation;
- Stratification of the soil;
- Calibrating curve of the gauges;
- Drawing of the jack diameter of the piston;

- Graph of the test, having for abscissa the loads (tons) and for ordinates the settlements in fractions of mm;
- Tables showing, as a function of the times (date and hour), the readings of the gauge in atmospheres, the loads in tons, the settlements and average of the settlement.

When the safe bearing capacity of any pile is found by test to be less than the design load, longer piles or additional piles shall be installed as directed by the Engineer.

7.6.11 DYNAMIC FORMULA FOR ESTIMATING PILE CAPACITY

The pile load capacity of driven piles may be estimated using the following dynamic formula (Hiley). The Contractor may propose another formula for the Engineer's approval.

$$P_u = \frac{e_f W H}{S + (C_1 + C_2 + C_3)/2} \times \frac{W + n^2 W_p}{W + P}$$

Where :

P_u : ultimate load capacity (ton)
P_a : permissible load capacity (ton)
e_f : hammer efficiency
e_f = 1.00 for diesel hammer
e_f = 0.75 for drop hammer actuated by rope and friction winch
W : weight of hammer or ram (ton)
W_p: weight of pile (ton)
n : coefficient of restitution
n = 0.25 for concrete pile
H : drop of hammer (m)
H = 2H' for diesel hammer (H' : drop of ram)
S : pile penetration for last blow, or "set" (m)
C_1 : temporary compression allowance for pile head and cap (m)
C_2 : temporary compression allowance for elastic deformation of pile shaft (m)
C_3 : temporary compression allowance for quake of ground (m)
N : safety factor

Value of $C_1 + C_2 + C_3$ shall be measured during driving.

7.6.12 MEASUREMENT AND PAYMENT

7.6.12.1 Measurement

(a) Timber Piles

Timber Piles shall be measured for payment in number of linear metres for furnishing and driving of mini pile in conformity with lines and levels shown on the Drawings or as directed by the Engineer.

(b) Sheet Piling

Permanent timber, steel or concrete sheet pile walls shall be measured as the number of square metres of completed structure placed to the lines and levels shown on the Drawings or as directed by the Engineer. The area shall be the product of the length

of piles measured from the pile toes to cut-off levels multiplied by the length of the structure measured at cut-off level. Tie rods, anchor piles or blocks, walling etc. shown on the Drawings shall not be measured for payment.

Temporary sheet piling, in any materials, for cofferdams, drainage control, support of excavation or any other non-permanent application shall not be measured or paid for, but shall be assumed to be covered by the various items for excavation, drainage structure etc.

(c) Driven Piles - Furnishing

The unit of measurement for payment for furnishing timber (treated and untreated) and precast concrete piles (reinforced or prestressed) shall be the linera metre of various length and each size and type of pile furnished. Steel piles furnished shall be measured in kilograms of the various lengths of each size and type of pile furnished. In either case the types and lengths measured shall be those as directed by the Engineer, furnished in compliance with the material requirements of these Specifications and stockpiled in good condition at the site of the work by the Contractor, and accepted by the Engineer. Quantities in linear metres, or kilograms, to be paid for shall include the lengths of test and tension piles directed by the Engineer but not the lengths of those furnished by the Contractor at his option.

No allowance shall be made for the piles, including test piles, furnished by the Contractor to replace piles previously accepted by the Engineer that are subsequently lost or those that are damaged prior to completion of the Contract while in stockpile, or during handling or driving, and are ordered by the Engineer to be removed from the site of work or disposed of otherwise.

Should extensions of piles be necessary, the extension length will be included in the linear metres, or kilograms, measured for payment.

Reinforcing steel, fittings, shoes and splices if required, and falsework shall not be measured for payment.

If the Contractor casts the precast concrete piles longer than necessary, such as the full length of the reinforcement bars to facilitate driving, no measurement shall be made for the portion where concrete must be removed in order that bars may project into the overlying structure.

(d) Driven Piles - Driving

Timber, steel and concrete piles shall be measured for driving as the number of linear metres of pile as accepted and remaining in the completed structure. The length of individual piles shall be measured from the toe of pile to the under-side of pile cap for the piles totally penetrated in ground, or from the toe of pile to the ground level whichever is lower for the piles partly penetrated in ground.

(e) Cast-in-Place Concrete Piles

The measurement for cast-in-place piles shall be the actual number of linear metres of pile constructed completely and accepted in a structure. The lengths for payment shall be measured from the toe of the pile as constructed or otherwise approved by the Engineer to the cut-off as shown on the Drawings or as designated by the Engineer.

(f) Piles Executed in Water Stream

Measurement for additional payment for piles constructed under water shall be calculated by linear metre. No additional payment will be made if the depth of water is less than 50 cm. The additional payment will be based on the linear metre measurement of the depth of water, based on the elevation difference between the river bed and normal water level for each individual pile.

(g) Cofferdam and Dewatering Works

In the case where the top of piles and under side of piers are under water level, cofferdam and dewatering works may be applied whenever included as a Pay Item in the Bill of Quantities. These works shall be measured for the payment as lump sum price in accordance with Article 3.1.3.3 of Specifications.

(h) Test Piles

Test piles shall be measured by the same method, for furnishing and driving, as described in Article of 7.6.9.1.(c) and 7.6.9.1.(d) above.

7.6.12.2 Payment

The quantities determined as provided above, shall be paid for at the Contract Price per unit of measurement, for the Pay Items listed below and shown in the Bill of Quantities, which price and payment shall be full compensation for furnishing, handling, driving, joining, extending, pile head cutting, painting, curing, testing, reinforcing steel or prestressed steel in concrete, explosion using, boring or other necessary equipment for penetration, including loss of casing, all labors and any other necessary equipment and all other costs to complete the works properly as described in this Section.

Pay Item No.	Description	Unit of Measurement
7.6.1	Grouping of Mini Timber Piles (Cerucuk), furnished and driven	Linear Metre
7.6.2	Untreated Timber Sheet Pile	Square Metre
7.6.3	Treated Timber Sheet Pile	Square Metre
7.6.4	Structural Steel Sheet Pile	Square Metre
7.6.5	Precast Concrete Sheet Pile	Square Metre
7.6.6	Untreated Timber Pile, furnished	Linear Metre
7.6.7	Treated Timber Pile, furnished	Linear Metre
7.6.8a	Steel Pipe Pile, D= …cm, t= …mm, furnished	Linear Metre
7.6.9a	Precast Reinforced Concrete Pile, 35 cm x 35 cm Square, furnished	Linear Metre
7.6.9b	Precast Reinforced Concrete Pile,	

	40 cm x 40 cm Square, furnished	Linear Metre
7.6.9c	Precast Reinforced Concrete Pile, 45 cm x 45 cm Square, furnished	Linear Metre
7.6.9d	Precast Reinforced Concrete Pile, 50 cm x 50 cm Square, furnished	Linear Metre
7.6.10a	Precast Prestressed Concrete Pile, 35 cm Diameter , furnished	Linear Metre
7.6.10b	Precast Prestressed Concrete Pile, 40 cm Diameter , furnished	Linear Metre
7.6.10c	Precast Prestressed Concrete Pile, 45 cm Diameter , furnished	Linear Metre
7.6.10d	Precast Prestressed Concrete Pile, 50 cm Diameter , furnished	Linear Metre
7.6.11	Timber Pile, driven	Linear Metre
7.6.12	Steel Pipe Pile, 40 cm diameter, driven	Linear Metre
7.6.13	Steel Pipe Pile, 50 cm diameter, driven	Linear Metre
7.6.14	Steel Pipe Pile, 60 cm diameter, driven	Linear Metre
7.6.14a	Steel Pipe Pile ,…. Cm diameter, driven	Linear Metre
7.6.15	Precast Concrete Pile, 35 cm x 35 cm square or 35 cm diameter, driven	Linear Metre
7.6.16a	Precast Concrete Pile, 40 cm x 40 cm square or 40 cm diameter, driven	Linear Metre
7.6.16b	Precast Concrete Pile, 45 cm x 45 cm square or 45 cm diameter, driven	Linear Metre
7.6.17	Precast Concrete Pile, 50 cm x 50 cm square, or 50 cm diameter, driven	Linear Metre
7.6.18	Cast in place Concrete Pile, 60 cm diameter	Linear Metre
7.6.19	Cast in place Concrete Pile, 80 cm diameter	Linear Metre
7.6.20	Cast in place Concrete Pile 100 cm diameter	Linear Metre
7.6.21	Cast in place Concrete Pile 120 cm diameter	Linear Metre

7.6.22	Cast in place Concrete Pile 150 cm diameter	Linear Metre
7.6.23	Additional Price to Prices Nos. 7.6.11 ~ 7.6.17 when the Pile is executed in the Water Stream	Linear Metre
7.6.24	Additional Price to Prices Nos. 7.6.18 ~ 7.6.22 when the Pile is executed in the Water Stream	Linear Metre
7.6.25	Static Load Test for diameter pile of up to 600 mm	Each
7.6.26	Static Load Test for diameter pile of more than 600 mm	Each
7.6.27	Pile Integrity Test (PIT)	Each
7.6.28	Dynamic Load Test (DLT) for diameter pile of up to 600 mm	Each
7.6.29	Dynamic Load Test (DLT) for diameter pile of more than 600 mm	Each
7.6.30	Cofferdam and Dewatering Works	Lump Sum

SECTION 7.7

OPEN CAISSON FOUNDATION

7.7.1 GENERAL

7.7.1.1 Description

This work shall consist of sinking concrete shafts cast in place, or sinking precast concrete shafts composed of precast concrete units, in accordance with these Specifications and as shown on the Drawings, or directed by the Engineer. Types of open caissons to be used and dimensions shall be shown on the Drawings.

7.7.1.2 Construction Details

Construction details of reinforced concrete open caisson foundations which are not included in the Contract Documents will be prepared by the Engineer and issued to the Contractor after field survey has been accomplished in accordance with Section 1.9 of these Specification.

7.7.1.3 Related Work Specified Elsewhere

(a)	Field Engineering	:	Section 1.9
(b)	Environmental Safeguards	:	Section 1.17
(c)	Excavation	:	Section 3.1
(d)	Concrete	:	Section 7.1
(e)	Reinforcing Steel	:	Section 7.3

7.7.1.4 Tolerance

Open caisson foundation work shall comply with the tolerance criteria in Article 7.1.1.4 of these Specifications.

7.7.1.5 Reference Standards

Reference Standard shall be in accordance with Article 7.1.1.6.

7.7.1.6 Submittal

Submittals shall be in accordance with Sections 7.1 and 7.3.

7.7.1.7 Storage and Protection of Material

Storage and protection of material shall be in accordance with Sections 7.1 and 7.3.

7.7.1.8 Work Conditions

Work conditions shall be in accordance with Sections 7.1 and 7.3.

7.7.2 MATERIAL

Material to be used shall be as shown on the Drawings. Caisson shafts shall be made from reinforced concrete. The concrete work and reinforcing steel shall be in accordance with the requirements described in Articles 7.1.2 and 7.3.2. Unless otherwise specified on the Drawings, the concrete to be used shall be grade K250 for both cast in place and precast construction and steel shall be Class U-24. Unless otherwise specified on the Drawings, caisson foundation filler shall be cyclopean concrete which shall be in accordance with the requirements of Section 7.1.

7.7.3 CONSTRUCTION

The caisson shall be constructed so as to satisfy the dimensional and functional requirements, taking into consideration the given construction conditions.

7.7.3.1 Precast Concrete Units

The precast concrete units shall be cast on a properly casting platform constructed of concrete. The forms shall be true to line and built of metal. Forms shall be watertight and shall not be removed for at least 3 days after casting. The completed precast concrete unit shall be free from stone pockets, honeycombs or other defects and shall be true to the dimensions specified.

Precast concrete units shall not be moved for at least 7 days after concrete casting, or until tests indicate a compressive strength of 70 percent of the design 28 day's compressive strength has been reached.

Precast concrete units shall not be transported or installed until they have set at least 14 days after casting, or until tests indicate a compressive strength of 85 percent of the design strength has been reached.

7.7.3.2 Shafts Composed of Precast Concrete Units

The leading precast concrete unit shall be installed as the first operation. When the leading precast concrete unit has been sunk, the next precast concrete unit shall be placed and properly jointed to it with cement mortar to provide the required rigidity and stability. Sinking can proceed 24 hours after completion of jointing.

7.7.3.3 Shafts cast in place

Forms for cast in place shafts shall be true to line, watertight and shall not be removed until at least 3 day's after casting. The concrete shall be cast and cured in accordance with requirements of these Specifications. Sinking shall not start at least 7 days after concrete casting or until tests indicate a compressive strength of 70 percent of the design 28 days compressive strength has been reached.

7.7.3.4 Excavation and Sinking

When carrying out the excavation and sinking of the caisson the following shall be carried out:

(a) All the jobs shall be performed safely, strictly adhering to the occupational safety and health law, explosive control law, etc.

(b) The excavation shall be carried on while properly correcting the sinking chart due to the construction and soil conditions. It is necessary to avoid tipping, shifting. and gyrating of the caisson during excavation.

(c) The caisson shall be generally sunk by means of its own weight, by application of superimposed loads, and the reduction of frictional resistance, etc.

(d) Methods of reducing frictional resistance

Where much frictional resistance is predicted when sinking a caisson, it is advisable to take appropriate measures for reducing such friction between the outside surfaces of the caisson and the surrounding ground

(e) Bottom Plug

In constructing the bottom plug:

(i) Casting concrete under water shall generally be carried out by using tremie or concrete pumps after making sure that there is no fluctuation of water level within the caisson.

(ii) The water in the caisson shall not generally be removed after casting the concrete for the bottom plug.

(f) Filling of the Shaft

The caissons shall be filled with Class 175 Cyclopean Concrete to a level of one metre below the underside of the footing. The remaining one metre of the caisson shall be filled, with Class K250 concrete, or as shown on the Drawings.

(g) Cut-off Wall Work

The cut-off wall shall be watertight and shall be able to withstand external forces such as earth and water pressure exerted during the caisson sinking process, and shall be withdrawn after completion of the caisson construction work.

(h) Demolition of Upper Part of Open Caisson

The upper part of installed concrete caissons which project above the underside of footings shall be demolished. The demolition shall be carried out only by use of pneumatic breakers. Explosives shall not be used under any circumstances.

The reinforcing steel projecting into the footings shall at least 40 times the diameter of steel.

(i) Safety Control

In carrying out the construction work of caisson foundation, high standards of safety shall be adopted in the work methods to ensure the safety of the work force by strictly adhering to the related laws and regulations.

7.7.4 MEASUREMENT AND PAYMENT

7.7.4.1 Method of Measurement

The quantity of caisson furnished in compliance with the material requirements of these Specifications measured for payment, shall be the sum of the lengths of the total number of caissons shown on the Drawings and directed in writing by the Engineer. The unit of measurement for the sinking of caissons shall be the total number of linear metres sunk and accepted as measured between the toe of the caisson and the underside of the footing.

No separate measurement for payment shall be made for excavation, pumping, form-work and any other incidental work to construct the caissons, as those items are deemed to be included in the measurement and payment of the caisson.

7.7.4.2 Basis of Payment

Payment for the above shall be made at the Contract Unit Price under the Pay Items listed below and shown in the Bill of Quantities, which price and payment shall be full compensation for furnishing all labor, materials, equipment, tools, excavation for sinking including disposal or removal of excavated materials, demolition (if required) of portions of the concrete caisson to attain required elevation, connections, joints and all incidentals and temporary works necessary to complete these works.

Pay Item No.	Description	Unit of Measurement
7.7.1	Caisson 250 cm diameter, furnished	Linear Metre
7.7.2	Caisson 300 cm diameter, furnished	Linear Metre
7.7.3	Caisson 350 cm diameter, furnished	Linear Metre
7.7.4	Caisson 400 cm diameter, furnished	Linear Metre
7.7.5	Caisson 250 cm diameter, sunk	Linear Metre
7.7.6	Caisson 300 cm diameter, sunk	Linear Metre
7.7.7	Caisson 350 cm diameter, sunk	Linear Metre
7.7.8	Caisson 400 cm diameter, sunk	Linear Metre

SECTION 7.8

CEMENT MORTAR

7.8.1 GENERAL

7.8.1.1 Description

This work shall consist of producing and applying mortar for use in the various work items and as a surface finish to stone masonry or other structures in accordance with these Specifications.

7.8.1.2 Related Work Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Mortared Stonework	:	Section 2.2
(c)	Culverts and Concrete Drains	:	Section 2.3
(d)	Concrete Work	:	Section 7.1
(e)	Stone Masonry	:	Section 7.9
(f)	Grouted Rip Rap and Gabion	:	Section 7.10

7.8.1.3 Reference Standards

AASHTO M45 - 91 (2004)	:	Aggregate for Masonry Mortar
AASHTO M85 - 07	:	Portland Cement
ASTM C207	:	Hydrated Lime
ASTM C476	:	Mortar and Grout for Reinforcement of Masonry

7.8.2 MATERIALS AND MIXES

7.8.2.1 Materials

(a) Cement shall conform to the requirements of AASHTO M85.

(b) Fine aggregate shall conform to the requirements of AASHTO M45.

(c) Hydrated lime shall meet the requirements for residue, popping and pitting, and water retention shown for Type N Lime in ASTM C207.

(d) Water shall conform to the requirements of Article 7.1.2.2 of these Specifications.

7.8.2.2 Mixes

(a) Cement Mortar

Mortar to be used for finishing or repairing defects in concrete work, in accordance with the relevant Articles of these Specifications, shall be composed of cement and fine sand mixes in the same proportions as in the concrete being finished or repaired. The mortar so prepared shall have a compressive strength meeting the specified requirements for the concrete to which the mortar is applied.

(b) Masonry Mortar

Unless directed otherwise by the Engineer, masonry mortar shall have a compressive strength of at least 50 kg/cm^2 at 28 days. Hydrated lime may be added in an amount equal to 10 percent of the cement by weight

7.8.3 MIXING AND PLACING

7.8.3.1 Mixing

(a) All the materials except the water shall be mixed, either in a tight box or in an approved mortar mixer, until the mixture assumes a uniform color, after which time the water shall be added and the mixing continued for a five to ten minute period. The quantity of water shall be such as to produce a mortar of the required consistency but shall be no more than 70 percent of the weight of the cement used.

(b) Mortar shall be mixed only in those quantities required for immediate use. If necessary, the mortar may be re-tempered with water within 30 minutes from the time of the initial mixing process. Re-tempering shall not be carried out after this time.

(c) Mortar that is not used within 45 minutes after the water has been added, shall be discarded.

7.8.3.2 Placing

(a) Surfaces to receive mortar shall be cleaned of oil or clay or other contaminants and thoroughly saturated before the mortar is applied. Free surface water shall be removed, however, before application of the mortar.

(b) When used as a surface finish, mortar shall be applied to clean damp surfaces in sufficient quantity to provide a minimum thickness of mortar of 1.5 centimetres, and shall be troweled to a smooth and even surface.

7.8.4 BASIS OF PAYMENT

Cement mortar shall not be measured for separate payment. The work shall be deemed to be incidental to various other items of work prescribed in these Specifications and the cost of the work shall be deemed to be included in the Contract Prices entered for the various Pay Items. Cement mortar shall be measured and payment will be made only for an existing slope protection, stone masonry or non-structural repairs.

Pay Item No.	Description	Unit of Measurement
7.8	Cement Mortar	Cubic Metre

SECTION 7.9

STONE MASONRY

7.9.1 GENERAL

7.9.1.1 Description

(a) This work shall consist of the construction of those structures shown on the Drawings or as directed by the Engineer to be made in stone masonry. The Work shall include supplying all materials, and all work necessary to complete the structure in accordance with these Specifications and in conformity with the lines, grades, sections and dimensions as shown on the Drawings or as required in writing by the Engineer.

(b) Generally, Stone Masonry shall be used only for those structures such as retaining walls, slab culvert and large culvert head walls in which the stone-work is intended to resist structurally significant externally imposed loads. Where the primary function is scour resistance rather than load bearing, as for waterway linings, catch pits, culvert spillway aprons or other protective works on slopes or around culvert ends, lower quality stonework may be used, such as Mortared Stonework or Grouted Rip Rap as specified in these Specifications in Section 2.2 and 7.10 respectively.

7.9.1.2 Issue of Construction Details

Construction details for Stone Masonry not included in the Contract Documents at the time of tender will be furnished by the Engineer after the field survey has been completed in accordance with Section 1.9 of these Specifications.

7.9.1.3 Related Work Specified Elsewhere

(a)	Field Engineering	:	Section 1.9
(b)	Environmental Safeguards	:	Section 1.17
(c)	Ditches and Waterways	:	Section 2.1
(d)	Mortared Stonework	:	Section 2.2
(e)	Culverts and Concrete Drains	:	Section 2.3
(f)	Porous Drainage	:	Section 2.4
(g)	Excavation	:	Section 3.1
(h)	Fill	:	Section 3.2
(i)	Concrete Work	:	Section 7.1
(j)	Cement Mortar	:	Section 7.8
(k)	Rip Rap and Gabions	:	Section 7.10
(l)	Routine Maintenance of Pavement, Shoulders,		
(m)	Drainage, Road Furniture and Bridges	:	Section 10.1

7.9.1.4 Dimensional Tolerances, Submittals, Approvals, Work Scheduling. Work Site Conditions and Rectification of Unsatisfactory or Failed Work and Maintenance of Accepted Work

The Provisions specified for Mortared Stonework in Section 2.2 of these Specifications shall apply.

7.9.2 MATERIALS

7.9.2.1 Stone

(a) The stone shall be clean, hard, without weak seams or cracks and shall be of a type known to be durable. If necessary, stones shall be dressed to remove any thin or weak portions.

(b) The stones shall be flat, wedge or oval shaped and able to be closely interlocked when placed together.

(c) Unless otherwise directed by the Engineer, stones shall have a thickness of not less than 15 cm, a width of not less than one and a half times their respective thickness, and a length of not less than one and a half times their respective width.

7.9.2.2 Mortar

Mortar shall be Cement Mortar conforming to the requirements of Section 7.8 of these Specifications.

7.9.2.3 Porous Drainage

Materials for forming bedding weep holes or filter pockets for Mortared Stonework shall conform to the requirements of Section 2.4 of these Specifications.

7.9.3 CONSTRUCTION OF STONE MASONRY

7.9.3.1 Preparation of Foundations

(a) Foundations for Stone Masonry structures shall be prepared in accordance with the Provisions of Section 3.1, Excavation.

(b) Unless otherwise specified or shown on the Drawings, foundation bases for retaining wall structures shall be normal to, or in steps normal to, the face of wall. For other structures, the foundation base shall be horizontal or stepped in horizontal sections.

(c) Permeable bedding layers and filter pocket recesses shall be provided where specified in accordance with the provisions of Section 2.4, Porous Drainage.

(d) Where shown on the Drawings, or otherwise directed by the Engineer, a concrete foundation footing may be required. Concrete used shall conform to the requirements of Section 7.1 of these Specifications.

7.9.3.2 Placing of Stones

(a) A bedding of fresh mortar at least 3 cm thick shall be placed on the prepared foundation immediately before placing each stone in the first course. Large selected stones shall be used for the bottom courses and in the corners. Care shall be taken to avoid groupings of stones of the same size.

(b) Stones shall be laid with their longest face horizontal and the exposed face of individual stones shall be set parallel to the face of the wall in which the stones are set.

(c) The stones shall be handled so not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those which can be handled by two men. Stones shall not be rolled or turned on the already placed work.

7.9.3.3 Placing of Mortar

(a) Prior to being laid, the stones shall be cleaned and thoroughly wetted, ample time being allowed for the absorption of water to near saturation. The bed that is to receive each stone shall also be moistened and then a mortar bedding layer shall be spread on the sides of stones adjacent to the one being placed.

(b) The thickness of the mortar bed shall be in the range 2 cm to 5 cm and shall be the minimum necessary to ensure all voids between the placed stones are completely filled.

(c) The extent of the mortar bedding placed at any one time shall be limited so that stones are placed only in fresh, unset mortar. If a stone is loosened after the mortar has taken initial set it shall be removed, the mortar cleaned off, and the stone re-laid with fresh mortar.

7.9.3.4 Provision of Weep holes and Expansion Joints

(a) Walls of stone masonry shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be spaced at not more than 2 metres center to center and shall be 50 mm in diameter.

(b) In continuous long structures such as retaining walls, expansion joints shall be formed at a maximum spacing of 20 metres. Joints shall be 30 mm in width and shall extend through the complete wall. Stones used for joint forming shall be selected so as to form a clean vertical joint of the dimension specified above.

(c) Backfill behind expansion joints shall be well graded granular Porous Drainage material selected so that the retained earth fill cannot wash through it, nor through the expansion joint.

7.9.3.5 Finishing Stone Masonry

(a) Face joints between stones shall be finished almost flush with the surface of the work, but not covering the stones, as work proceeds.

(b) Unless otherwise specified the top horizontal surface of all Stone Masonry shall be finished with the addition of a 2 cm. thick weathering layer of mortar, finished to an even surface with a cross fall that will ensure shedding of rainwater and with a clean chamfered edge. The weathering layer shall be included inside the specified dimensions of the structure,

(c) Immediately after being laid, and while the mortar is still fresh, all face stones shall be thoroughly cleaned of mortar stains.

(d) Finished surfaces shall be cured as specified for Concrete Work in Article 7.1.5.4 of these Specifications.

(e) When the Stone Masonry is sufficiently strong, and no sooner than 14 days following completion of the placing work, backfill shall be placed as specified, or as

directed by the Engineer, in accordance with the relevant provisions of Section 3.2, Fill, or Section 2.4, Porous Drainage.

(f) Adjacent slopes and shoulders shall be trimmed and finished to ensure a tight smooth interface with the Mortared Stonework that will allow unobstructed drainage and prevent scour at the edges of the work.

7.9.4 MEASUREMENT AND PAYMENT

7.9.4.1 Measurement for Payment

(a) Stone Masonry shall be measured for payment in cubic metres as the normal volume of completed and accepted work, calculated as the theoretical volume defined by the specified or approved lines and cross-sections.

(b) Any materials placed in excess of the approved theoretical volume shall not be measured or paid for.

(c) Permeable bedding, porous backfill or granular filter pocket material shall be measured and paid for as Porous Drainage, as set out in Article 2.4.4 of these specifications. No separate measurement or payment shall be made for the provision or installation of weep hole forms or pipes or for any other formwork or excavation or backfill required.

7.9.4.2 Basis of Payment

The quantities, determined as provided above, shall be paid for at the Contract Price per unit of measurement for the Pay Item listed below and shown in the Bill of Quantities, which prices and payment shall be full compensation for furnishing and placing all materials, for construction of weep holes and construction joints, for dewatering the works, for finishing, and for all other works or costs necessary or usual for the proper completion of the work prescribed in this Article.

Pay Item No.	Description	Unit of Measurement
7.9	Stone Masonry	Cubic Metre

SECTION 7.10

RIP RAP AND GABIONS

7.10.1 GENERAL

7.9.4.3 Description

This work shall consist of providing either stone-filled wire mesh baskets (gabions) or approved stone rip rap on an approved bed in accordance with the details shown on the Drawings and in this Specification.

Installation shall be carried out on stream banks, embankment slopes, cut slopes and other surfaces composed of erodable material where scour protection is desired. The locations will be directed by the Engineer on site or shown on the Drawings.

7.9.4.4 Issue of Construction Details

Construction details for Rip Rap and Gabions not included in the Contract Documents at the time of tender will be furnished by the Engineer after the initial design review or design revision has been completed in accordance with Section 1.9 of these Specifications.

7.9.4.5 Related Work Specified Elsewhere

(a)	Field Engineering	:	Section 1.9
(b)	Environmental Safeguards	:	Section 1.17
(c)	Ditches and Waterways	:	Section 2.1
(d)	Porous Drainage	:	Section 2.4
(e)	Excavation	:	Section 3.1
(f)	Fill	:	Section 3.2

7.9.4.6 Reference Standards

Standar Nasional Indonesia (SNI) :

SNI 03-2417-1991 (AASHTO T96 - 02 (2006))	:	Cara Uji Keausan Agregat dengan Mesin Abrasi Los Angeles.

AASHTO :

AASHTO M 279 - 03	:	Zinc Coated Wire Fencing
ASTM A 239	:	Uniformity of Coating, Dreece Test
ASTM B 117	:	Salt Spray Exposure Test

7.9.4.7 Submittals

(a) Two rocks samples for rip rap with attached results of tests as required under Article 7.10.2.2 below.

(b) Sample of wire basket with manufacturer's certificate if any.

7.10.2 MATERIALS

7.10.2.1 Gabion Wire

(a) Galvanized steel conforming to AASHTO M279 Class I, and ASTM A239. Galvanizing to have a minimum coating of 0.26 kg/m^2.

(b) Wire Characteristics shall be:

▪ Selvedge	5 mm Diameter	6 SWG
▪ Netting	4 mm Diameter	8 SWG
▪ Binding	2.1 mm Diameter	14 SWG
▪ Tensile Strength	4200 kg/cm^2	
▪ Elongation	10 % (min)	

(c) The fabric shall be uniform hexagonal wire mesh woven in a triple twist pattern with openings approximately 80 mm x 60 mm fabricated in such a manner that it is non-raveling and designed to provide the required flexibility and strength. The perimeter edges of the wire mesh shall be securely bound so that the joints formed by tying the selvedge shall have the same strength as the body of the mesh.

(d) Baskets shall be of single unit construction, provided to the dimensions specified on the Drawings and so fabricated that they may be transported to the site before filling with boulders.

7.10.2.2 Stone

Stone for rip rap and gabions shall consist of hard durable rock pieces with the following properties:

(a) Los Angeles Abrasion test value of less than 35 %

(b) Specific Gravity greater than 2.30

(c) Water absorption no greater than 4 %.

(d) Soundness by Sodium or Magnesium Sulphate test less than 10% weight loss after 5 cycles.

Stone for rip rap shall be angular, weigh not less than 40 kg and have minimum dimensions of 300 mm. The Engineer may direct that a larger stone size be used if stream velocities are high.

7.10.2.3 Bedding

Bedding shall be porous backfill material as specified in Article 2.4.2.1, with a grading selected so that the foundation soils cannot wash out through the bedding nor the bedding through the rip rap or gabions.

7.10.2.4 Grout

Grout for grouted rip rap shall be Class KI75 concrete as specified in Section 7.1 of these Specifications.

7.10.3 EXECUTION

7.10.3.1 Preparation

Excavation shall conform to the requirements of Section 3.1 Excavation, including required toe keys for rip rap and gabions. Bedding shall be placed in accordance with Article 2.4.3 of these Specifications. All prepared surfaces are to be approved by the Engineer before placement of rip rap or gabions.

7.10.3.2 Gabion Placement

(a) Gabion baskets shall be firmly stretched to obtain the correct shape and position using a crowbar or small winch before filling with stone. The joints between baskets shall be as strong as the fabric itself. Each hexagon shall receive at least two turns of binding wire and the selvedge between edge hexagons at least one. At least 15 cm of binding wire should be left after the last turn and bent into the baskets.

(b) Stones should be placed individually so that maximum density and minimum voids are attained. When each gabion is filled to half height, two horizontal bracing wires from front to back shall be placed; the basket should be slightly over filled to allow for settlement. Outside stones adjacent to any wire shall have their flat surface bearing against the basket fabric.

(c) After filling, the hinged lid shall be stretched by crowbar or winch over the top surface and tied down,

(d) When baskets are laid on top of each other the vertical joint shall be staggered.

7.10.3.3 Placing Rip Rap

Unless laid to form a flat apron, placing of rip rap shall be commenced by laying the first course of the largest rocks in a cut off trench below the toe of the slope. Rocks shall be placed by crane or by hand to the required length, thickness and depth. Rocks shall then be set on the slope so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of the wall. No shaping of rocks will be necessary if they are angular, but placing shall ensure as dense a structure as is possible and that the largest stones are below the high water level. Larger stones should also be placed on the outside of the finished rip rap surface.

7.10.3.4 Backfill

As per requirements of Section 3.2 Fill.

7.10.3.5 Placing Grouted Rip Rap

Stones shall be thoroughly clean and saturated with water before being placed. Concrete grout shall be applied to the previously placed stone against which a new stone is to be placed. Stones shall be firmly bedded into the slope and tamped into close contact with adjacent stones to form the required thickness of rip rap.

The interstices between stones may be partly filled with spills or small stones after which all remaining voids shall be solidly filled with concrete and neatly pointed to within not more than 10 millimeters of the surface of the stones.

Weep holes shall be constructed as directed by the Engineer.

The work shall be kept shaded and damp for not less than 3 days after completion.

7.10.4 MEASUREMENT AND PAYMENT

7.10.4.1 Method of Measurement

The quantity to be measured for payment shall be the number of cubic metres of gabions or rip rap complete in place and accepted. The dimensions to be used in calculating this quantity shall be the nominal dimensions of each gabion basket or rip rap protection as prescribed in the Drawings or as directed by the Engineer.

7.10.4.2 Basis of Payment

The quantity, determined as provided above, shall be paid for at the Contract Price per unit of measurement, for the Pay Items listed below and shown in the Bill of Quantities, which price and payment shall be full compensation for all necessary excavation and backfill, for supplying, fabricating and placing all materials, wire, basket, including all labor, equipment, tools, testing and other work necessary for the satisfactory completion of the work as prescribed in the Drawings and this Specification.

Pay Items	Description	Unit of Measurement
7.10.1	Grouted Rip Rap	Cubic Metre
7.10.2	Non-grouted Rip Rap	Cubic Metre
7.10.3	Gabions	Cubic Metre

SECTION 7.11

EXPANSION JOINTS

7.11.1 GENERAL

7.11.1.1 Description

This work shall consist of the supply and installation of metallic or elastometric deck joints, and any fillers and sealers, in joints to structures in accordance with the Drawings and as instructed by the Engineer. The guarantee period for the supply and installation of the expansion joints shall be at least 30 months from the date of completion of works irrespective of Defect Notification Period specified elsewhere in the tender document. The contactor shall furnish the guarantee bond as directed by Engineer.

7.11.1.2 Related Work Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Concrete	:	Section 7.1
(c)	Prestressed Concrete	:	Section 7.2
(d)	Structural Steelwork and Steel Painting	:	Section 7.4

7.11.1.3 Quality Assurance

The quality of materials supplied, workmanship and final products shall be monitored and controlled as specified in the Reference Standards in Article 7.11.1.4.

7.11.1.4 Reference Standards

AASHTO M120 - 05	:	Steel for Expansion Joint Class A.
AASHTO M153 - 06	:	Preformed Sponge Rubber Expansion Joint Fillers for Concrete Paving and Structural Construction.
AASHTO M173 - 84	:	Concrete Joint Sealer, Hot Poured Elastic Type.
AASHTO M213 - 01 (2005)	:	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (non-extruding and resilient bituminous type)
AASHTO M220 - 84 (2003)	:	Preformed Elastomeric Compression Joint Seals for Concrete.

7.11.1.5 Submittals

(a) The Contractor shall submit for the approval of the Engineer, details of all joint fillers and sealers he proposes to use.

(b) When proprietary joints are proposed, the Contractor shall submit for the approval of the Engineer full details of the joint, including working drawings and manufacturer's certificates for the product and materials used therein. Details of any modifications to the structural work shall also be submitted.

7.11.1.6 Rectification of Unsatisfactory Work

(a) Joint filler that does not fully fill the width of a joint immediately prior to sealing shall be removed and replaced with filler of the correct width.

(b) Sealer that fails to set, runs or bubbles shall be removed and replaced.

(c) Proprietary joints that are damaged prior to, during or after installation due to negligence in handling, storage, installation or subsequent site operations shall be removed and replaced. All such joints shall be inspected on arrival on site and any damage reported to the Engineer in writing. The Contractor is, however, responsible for protecting and safe keeping such joints throughout the Time for Completion.

7.11.1.7 Maintenance of Accepted Work

Not withstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 7.11.1.6 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted expansion joint work throughout the Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7

7.11.2 MATERIALS

7.11.2.1 Expansion Joint Structures

The type of expansion joint structure shall depend upon the amount of deck movement required and as indicated on the Drawings. Steel angle/plate joints, steel finger joints and tube modular neoprene sealing joints shall be of a form approved by the Engineer. Steel parts and holding down bolts shall be in accordance with AASHTO M120, Class A. Metal parts shall be protected against corrosion.

7.11.2.2 Joint Filler

Joint filler shall be of the premoulded non-extruding resilient type in accordance with AASHTO M135 - 84 or AASHTO M213 - 01 (2005).

7.11.2.3 Joint Sealer

Material for sealing horizontal joints shall be in accordance with AASHTO Ml73-74, Hot-poured Elastic Joint Sealer. Alternatively hot-poured rubber-bitumen sealer such as Expandite Plastic Grade 99 or similar may be used with the approval of the Engineer. Vertical and inclined joints shall be sealed with Expandite Plastic Joint bituminous putty, Thioflex 600 two part polysulphide compound, or similar material as approved by the Engineer.

Joint priming compound shall be as recommended by the manufacturer of the sealer selected to be used.

Materials for joint primer and sealer shall be mixed and used in accordance with the manufacturer's recommendations.

7.11.2.4 Waterstops

The type and material of waterstops shall be as detailed on the Drawings or as approved by the Engineer.

7.11.2.5 Miscellaneous Materials

All other materials required for use in joints shall be in accordance with the Drawings and subject to the approval of the Engineer.

7.11.3 CONSTRUCTION

7.11.3.1 Storage of Materials

Joint material delivered to the bridge site shall be stored, under cover, on platforms above the surface or the ground. It shall be protected at all times from damage and when placed it shall be free from dirt, oil, grease or other foreign substances.

7.11.3.2 Premoulded Joint Filler and Elastic Joint Sealing

Joints in decks, walls, etc. shall be accurately formed to the lines and levels as shown on the Drawings or as approved by the Engineer. Joint filler shall be used in as large pieces as possible. Small areas of 0.25 square metres or less shall be made of one piece. The material shall be cut with sharp tools to give clean edges. Rough or ragged edges shall not be permitted. The material shall be placed so that it will be securely fixed in the form and well-fastened to one face of the concrete, using copper nails as necessary, to ensure that it is not dislodged during subsequent construction operations or movements of the structure. The joint filler shall not extend into the space to be filled with sealer except where a separate piece of filler is used as a form. In the case of expansion joints, the size of the gap shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with arrangements approved with the Engineer. Joint sealer shall be flush or slightly recessed from the surface of the joint on setting. It shall be tooled to a smooth finish using a spatula or similar tool. Mixing, application and curing of all proprietary materials shall comply with the manufacturer's requirements.

7.11.3.3 Expansion Joint Structures

Joints shall be shock and sound absorbing, watertight structures. Expansion joint structures shall be installed in accordance with the Drawings and the manufacturer's requirements. The size of the gap shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with arrangements approved with the Engineer. The position of all bolts cast into concrete or holes drilled into concrete shall be accurately determined from templates. Screw threads shall be kept clean and free from rust. Ramps shall be provided and maintained to protect all expansion joints from vehicular loading until the joints are accepted and the Engineer approves their removal. Vehicles shall cross the joints only by means of the ramps until such time.

7.11.4 MEASUREMENT AND PAYMENT

7.11.4.1 Measurement

The units of measurement of expansion joint structures shall be the number of linear metres of joints installed and accepted. Waterstops, premoulded expansion joint fillers, premoulded joint sealers, and poured elastic joint sealing shall not be measured unless specified as separate items in the Bill of Quantities.

The joint filler for construction joint at widening deck slab shall be measured and paid for separately as Pay Item No. 7.11.6.

7.11.4.2 Payment

The work measured as provided above shall be paid for at Contract price for the Pay Items shown below and listed in the Bill of Quantities. The prices and payment shall be deemed

full compensation for furnishing and placing all materials, all labor, tools, equipment and incidentals necessary to complete the work prescribed. All other types of joints shall be paid for by being included in the unit price for other items into which they are constructed or to which they are connected and shall not be paid for under separate items.

Item No.	Description	Unit of Measurement
7.11.1	Expansion Joint Asphaltic Fixed Type	Linear Metre
7.11.2	Expansion Joint Asphaltic Movable Type	Linear Metre
7.11.3	Expansion Joint Seal Rubber Type 1 (Gap 21 - 41 mm)	Linear Metre
7.11.4	Expansion Joint Seal Rubber Type 2 (Gap 32 - 62 mm)	Linear Metre
7.11.5	Expansion Joint Seal Rubber Type 3 (Gap 42 - 82 mm)	Linear Metre
7.11.6	Joint Filler for Construction Joint	Linear Metre
7.11.7	Expansion Joint Steel Angle Type	Linear Metre

SECTION 7.12

BEARINGS

7.12.1. GENERAL

7.12.1.1. Description

This work shall consist of the furnishing and erecting of metal or elastomeric bearings to support deck beams and slabs all as indicated on the Drawings and required in these Specifications. For the work of bearings replacement, it may require an existing bridge lifting.

7.12.1.2. Related Work Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Concrete	:	Section 7.1
(c)	Prestressed Concrete	:	Section 7.2
(d)	Structural Steelwork and Steel Painting	:	Section 7.4

7.12.1.3. Quality Assurance

The quality of materials supplied, workmanship and final products shall be in accordance with the Reference Standards in Article 7.12.1.5 below.

7.12.1.4. Tolerances

(a) Setting of Bearings

Bearings, locating bolts and fixing dowels shall be located so that their centerlines are within ± 3 mm of their correct position. The level of single bearing or the mean levels of more than one bearing at any support shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding ± 5 mm.

(b) Concrete Surfaces

Concrete surfaces for the direct setting of bearings shall not vary from a flat plane by more than 1 in 200 within the plan area of the bearing and local irregularities shall not exceed 1 mm in height.

(c) Bedding

Bearings shall be bedded over their whole area as shown on the Drawings or approved by the Engineer. After installation there shall be no voids or hard spots.

The bedding material shall be capable of transmitting the applied load to the structure without damage. Surfaces to receive bedding mortar shall be adequately prepared to a state compatible with the mortar chosen. The top surface of any extension of the bedding beyond the bearing shall have a slope away from the bearing.

(d) Threaded Fixings

Threaded fixings shall be tightened uniformly to avoid overstressing any part of the bearing. Where significant vibration may occur, fasteners shall be of a vibration resistant type.

(e) Overall Size

Dimensional tolerances of bearing shall conform to Table 7.12.1.(1).

Table 7.12.1.1 Allowable Overall Dimensional Tolerances of Bearing

Type of bearing	Tolerance of size	
	Overall plan dimensions	Overall thickness or height
Elastomeric up to 200 mm thickness or height	+ 6 mm - 3 mm	± 1 mm
Elastomeric above 200 mm thickness or height	+ 6 mm - 3 mm	± 5 %
other than Elastomeric	± 3 mm	± 3 mm

(f) Parallelism of Outer Surfaces

When designed to be parallel, the tolerance on parallelism of the upper surface of the bearing, as datum, shall be 0.2 % of the diameter for surfaces circular in plan and 0.2 % of the longer side for surfaces rectangular in plan.

(g) Roller Bearings

(i) General

The tolerance of flatness for roller plates measured in any direction shall be 0.025 mm for lengths up to and including 250 mm and 0.01% of the length, in the direction of measurement, for lengths above 250 mm. The surface roughness of rolling surfaces shall not exceed 0.8 microns.

(ii) Cylindrical rollers

The tolerance on cylindricity shall be 0.025 mm. The tolerance on size of single rollers with respect to their nominal diameter shall be + 0.5 mm and - 0.0 mm. The tolerance on size of multiple rollers with respect to their nominal diameter shall be + 0.08 mm and - 0.0 mm.

(iii) Non- cylindrical rollers

Curved surfaces shall have a profile or surface tolerance of 0.3% of the intended radii. The tolerance on size with respect to the height at the centerline of the bearing shall be + 0.5 mm and - 0.0 mm. The tolerance on parallelism between the chord line joining the ends of the bottom rolling surface as datum shall be 1 mm. The tolerance on squareness between the plane passing through the centers of the rolling surfaces as datum and the top and bottom chord lines joining the ends of the rolling surfaces shall be 1 mm.

(h) Rocker bearings

Tolerances for flatness of plates mating with rockers shall be 0.075 mm for lengths up to and including 250 mm, and 0.03 % of the length for lengths above 250 mm. The profile or surface tolerance for the length of the surface over which contact can occur shall be 0.025 mm. The surface roughness of rocking surfaces shall not exceed 0.8 microns.

(i) Knuckle Bearings

Cylindrical and spherical knuckle bearings: The tolerance of flatness and profile of surface for cylindrical knuckle bearings and tolerance on profile of surface for cylindrical knuckle bearings and tolerance on profile of surface for spherical knuckle bearings shall be 0.0002 x h mm or 0.24 mm, whichever is the greater, where x is the length of the chord (in mm) between the ends of the *poly tetra fluor ethylene* (PTFE) surface in the direction of rotation and h is the projection of the PTFE (in mm) above the top of the confining recess, for confined PTFE, or the thickness (in mm) for bonded PTFE. The tolerance on size with respect to the radius of the curved surface on the furnished bearing shall be 3 % of the intended radius. The surfaces roughness of metal curved sliding surfaces shall not exceed 0.5 microns. Where PTFE forms one of the contact surfaces it shall comply with the appropriate requirements given in (j).

(j) Plane Sliding Bearings

The tolerance of flatness of PTFE sheet shall be 0.2 mm where the diameter or diagonal is less than 800 mm and 0.025 % of the diameter or diagonal where this dimension is greater than or equal to 800 mm. On PTFE surfaces made up of more than one piece of PTFE the above conditions shall apply to the diameter of diagonal dimension of the inscribed circle or rectangle around the PTFE.

The dimensional tolerances on PTFE sheet given in Table 7.12.1.2 :

Table 7.12.1.2 The Limits of Dimensional Tolerances on PTFE Sheet

Diameter or diagonal	Tolerance on plan dimension	Tolerance on Thickness	
		Recessed PTFE	Bonded PTFE
(mm)	(mm)	(mm)	(mm)
< 600	± 1.0	+ 0.5 - 0	+ 0.1 - 0
> 600 & < 1200	± 1.5	+ 0.6 - 0	+ 0.2 - 0
> 1200	± 2.0	+ 0.7 - 0	Not applicable

The gap between the edge of the PTFE sheet and the edge of the recess in which it is confined shall not anywhere exceed 0.5 mm 0.1 % the corresponding plan dimensions of the PTFE sheet, in the direction measured, whichever is the greater.

The profile tolerance on the specified projection of PTFE above it confining recess shall conform to Table 7.12.1.3 below :

Table 7.12.1.3 Profile Tolerances

Maximum dimension of PTFE (diameter or diagonal) (mm)	Tolerance on specified projection above recess (mm)
< 600	+ 0.5 - 0
> 600 and < 1200	+ 0.6 - 0
> 1200 and < 1500	+ 0.8 - 0

All measurements on PTFE sheet shall be made a temperature range of 20°C to 25° C.

Mating surfaces

For surfaces mating with PTFE, the flatness tolerance in all directions shall be 0.0002 Lh mm. Where L is the length (in mm) of the PTFE surface in the direction measured and h is the projection of the PTFE (in mm) above the top of the confining recess, for confined PTFE, or the thickness (in mm) for Bonded PTFE.

The surface roughness of lane metal sliding surfaces shall not exceed 0.15 microns.

(k) Elastomeric Bearings

(i) Parallelism

The tolerance on parallelism for the axes of reinforcing plates with respect to the base of the bearing as datum shall be 1 % of the diameter for plates circular in plan, or 1 % of the shorter side for plates rectangular in plan.

(ii) Size

The tolerance on size with respect to the plan dimensions of plates for reinforcing elastomeric bearings shall be + 3 mm and - 1 mm. The tolerance on size with respect to the thickness of the top and bottom covers for laminated elastomeric bearings shall be between + 20 % and – 0 % of the nominal thickness, or 1 mm whichever is the less. The tolerance on size with respect to the thickness of an individual inner layer of elastomeric laminated elastomeric bearing shall be ± 20 % of its nominal thickness value, or 3 mm, whichever is the less. The tolerance on size with respect to the thickness of the side cover for a laminated elastomeric bearing shall be + 3 mm and - 0 mm.

(1) Pot bearings

The tolerance of fit between the piston and pot shall be + 0.75 mm to + 1.25 mm.

Guides the surface roughness of metal sliding surfaces shall not exceed 0.5 microns.

Fixing holes in bearing plates. Where required tolerances on the position for centers of fixing holes shall be as specified or approved by the Engineer.

7.12.1.5. Reference Standards

Standar Nasional Indonesia (SNI):

SNI 03-4801-1998	:	Spesifikasi Bantalan Elastomer Tipe Polos dan Tipe Berlapis untuk Perletakan Jembatan.
SNI 03-4816-1998 (AASHTO M251 - 06)	:	Spesifikasi Bantalan Karet Untuk Perletakan Jembatan
SNI 06-3042-1992	:	Bantalan Karet Jembatan
SNI 03-3967-2002	:	Metode Pengujian Regangan Tekan dan Tegangan Geser Bantalan Karet Jembatan.
AASHTO and ASTM	:	
AASHTO M102 - 06	:	Carbon Steel forging or General Industrial Use.
AASHTO M105 - 07	:	Gray Iron Castings.
AASHTO M163M/ M163-07	:	Corrosion-resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel-based Castings for General Application.
AASHTO M169 - 06	:	Cold-finished Carbon Steel Bars and Shafting.
AASHTO M183 - 90	:	Structural Steel.
AASHTO M192 - 86	:	Steel Castings for Highway Bridges.
ASTM A47	:	Mild Castings (Grade No 35019).
ASTM D3183	:	Elastomeric Bearings.

7.12.1.6. Submittals

(a) The Contractor shall submit details of the type of bearing he proposes to use, together with manufacturer's certificates stating that the materials used conform with the requirements of these specifications. If these are approved by the Engineer the Contractor shall produce working drawings indicating erection and installation technique, taking account of the tolerance and temperature of installation requirements. Details shall also indicate any alterations to the details for the substructure and deck to which the bearing is to be attached, necessary to locate and fix the bearing.

(b) The Contractor shall submit samples of the proposed material to the Engineer for approval. Material supplied will be compared with the approved materials. Any change in quality, shape or physical properties from the approved material will result in rejection of the bearing materials.

7.12.1.7. Storage and Protection of Material

Upon delivery to site the bearings shall be checked to ensure they conform with the required units and have suffered no damage during delivery and handling. Damage to bearings shall be immediately notified to the Engineer in writing.

At site, bearings shall be stored in a waterproof shed above ground level and shall at all times be protected from atmospheric and physical damage and accumulation of dust, dirt, oil, grease, moisture or other objectionable substances.

Because of the risk of electrolytic action, it is important to prevent the contact of dissimilar materials. In this context, mild steel and stainless steel are dissimilar. In particular, direct contact between copper, nickel and their alloys (e.g. brass and bronzes) with aluminum, and aluminum with steel should be avoided. Copper may be affected by direct contact with concrete.

7.12.1.8. Rectification of Unsatisfactory Work

(a) Bearings not conforming to the dimensional tolerances shall not be installed in the works unless it can be shown by test and calculation, to the satisfaction of the Engineer, that the operation of the bearing is not impaired by being out of tolerance and that no additional loads are imposed on the deck or substructure of the bridge. Where this cannot be proved bearings not conforming with dimensional tolerances shall be removed from site and replaced.

(b) Bearings which have not been correctly installed in accordance with the installation tolerances, taking into account temperature effects, shall be removed and if undamaged, re-installed to the approval of the Engineer.

(c) Bearings damaged during handling, erection, including dismounting and re-erection in accordance with (b) above, or during subsequent operations, shall be removed from site and replaced.

7.12.1.9. Maintenance of Accepted Work

Not withstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 7.12.1.8 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted bearings throughout the Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7

7.12.2. MATERIALS

7.12.2.1. Steel for Bearings

(a) Steel Plate Laminations

The reinforcing steel plate laminations for bearing pads shall conform to AASHTO M183 - 90. Edges of plates shall be carefully treated to prevent notching. Plates shall be fully enclosed in elastomer to prevent corrosion.

(b) Metal Bearings

Metal bearings shall be pot, sliding, roller, knuckle, rocker, fixed or other bearings as indicated on the Drawings and approved by the Engineer. Materials shall comply with the relevant AASHTO specification.

7.12.2.2. Elastomer for Bearings

Elastomer used in the manufacturer of bridge bearings shall contain either natural rubber or chloroprene rubber as the raw polymer. No reclaimed or ground vulcanized rubber shall be used. Elastomer, as determined from test specimens, shall conform to the Table 7.12.2.(1) :

Table 7.12.2.1 Elastomer Materials Requirements

Test	ASTM Designation	Requirement
Tensile strength	D 412	169 kg/cm^2.min
Elongation at break	D 412	350%.min
Compression set, 22 hrs at 67°C	D 395 (Method B)	25%.max
Tear strength	D 624 (Die C)	13 kg/cm^2.min
Hardness (Shore A)	D 2240	65 ± 5
Ozone resistance 20% strain 100 hrs at 38 °C ± 10 °C	D 1149 (except 100 ± 20 parts per 100,000,000)	No cracks
Low temperature stiffness, young's Modulus at – 35 °C	D 797	350 kg/cm^2.max
Low temperature brittleness 5 hrs at – 40 °C	D 736	Passed

After accelerated aging in accordance with ASTM D573 for hours at 100 °C, the elastomer shall not show deterioration changes in excess of the Table 7.12.2.2 :

Table 7.12.2.2 Deterioration of Elastomer After Accelerated Aging

Tensile strength	max. 15%
Elongation at break	50% (but not less than 300% total elongation of the material)
Hardness	max. 10 points

The bond between elastomer and metal shall be such that, when a sample is tested for separation, failure shall not occur within the elastomer and between the elastomer and metal. The sole polymer in the elastomeric compound shall be neoprene and shall be not less than 60 percent by volume of the total bearing.

7.12.3. INSTALLATION

7.12.3.1. General

Bearings shall be clearly marked with their type and place of installation when received on site. Suitable handling devices shall be provided as required. Temporary clamping devices shall be used to maintain the correct orientation of the parts but shall not be used for slinging or suspending bearings unless specifically designed for this purpose.

In order that moving surfaces are not contaminated, bearings shall not normally be dismantled after leaving the manufacturer's works. However if for any reason a bearing requires to be dismantled, then this shall only be done under expert supervision and the manufacturer's assistance shall be sought. Laminated bearings shall not be dismantled.

Transfer of superstructure weight on to the bearings shall not be allowed until sufficient strength has development in the bedding to resist the applied load. Temporary clamping services shall be removed at the appropriate time before the bearings are required to accommodate movement. Consideration shall be given to any treatment required to holes exposed on the removal of temporary transit clamps.

Where re-use of these fixing holes may be required, the material selected to fill them shall not only give protection against deterioration but shall also be easily removable without damaging any threads.

Where necessary, suitable arrangements shall be made to accommodate thermal movement and elastic deformation of the incomplete superstructure. When provided, temporary supports under bearing base plates shall be compressible under design loading or removed once the bedding material has reached the required strength. Any voids left as a consequence of their removal shall be made good using material similar to the bedding material.

Steel folding wedges and rubber pads are suitable for temporary supp6rts under bearing base plates.

To accommodate creep and shrinkage of the concrete plus the temperature movements of the superstructure, the bearings shall be pre-adjusted as directed by the Engineer.

7.12.3.2. Bedding

The choice of the bedding material shall depend on the method of installing the bearings, the size of the gap to be filled, the strength required and the required setting time. When selecting the bedding materials, the following factors shall be considered: type of bearing; size of bearing; loading on bearing; construction sequence and timing; early loading; friction requirements; doweling arrangements; access around the bearing; thickness of material required; design and condition of surfaces in the bearing area; shrinkage of the bedding material.

The composition and workability of the bedding material shall be designed on the basis of the tests with the above factors in mind. In some cases it may be necessary to carry out trials to ascertain the most suitable material. Commonly used materials are cementitious or chemical resin mortar, grout and dry packing. The use of materials such as lead, which tend to flow under load, leaving hard spots shall be avoided.

To ensure even loading of bearings and their supporting structures, it is essential that any bedding material, whether above or below the bearing, extends over the whole area of the bearing.

7.12.3.3. Fixing of Bearing other than Elastometric

To cater for vibration and accidental impact, fixing shall be provided. Shear keys or holding down bolts shall be accurately set into recesses cast into the structure using templates and the remaining voids in the recesses shall be filled with a material capable of withstanding the loads involved. Close tolerance bolts shall be set using the bearings as templates. In this case special precautions shall be taken to prevent contamination of the bearings during bolt installation.

Bearings that are to be installed on temporary supports shall be firmly fixed to the structure by the holding-down bolts or other means to prevent disturbance during subsequent operations. The method of bolt tightening shall be such as not to deform the bearings. Finally voids beneath the bearings shall be completely filled with bedding material.

Hard spots shall be avoided, e.g. temporary packing shims shall be removed and resilient washers used. Alternatively bearings may be fixed directly to metal bedding plates cast into or bedded on top of the supporting structure. Only a thin layer of bedding mortar shall be used and when other than synthetic resin mortar is used for this purpose it should be housed in a recess suitably reinforced on all sides.

If the substructure is of steel the bearings may be bolted directly to it. In such cases provision shall be made to ensure that the line and level are within the tolerances.

If bearings are to be preset the manufacturer shall be notified at the time of ordering so that due provision can be made for the movement of the relevant parts. Wherever possible, presetting of bearings shall be avoided.

7.12.3.4. Fixing of Elastomeric Bearings

Elastomeric bearings may be laid directly on concrete, provided it is within the specified tolerance for flatness and smoothness. Alternatively, they shall be laid on a layer of bedding material.

7.12.3.5. Bearings Supporting In-situ Concrete Deck

Where bearings are installed prior to forming an in-situ concrete deck, formwork around bearings shall be carefully sealed to prevent grout leakage. The bearings, and particularly the working surfaces, shall be fully protected during concreting operations. Sliding plates shall be fully supported and care shall be taken to prevent tilting, displacement or distortion of the bearings under the weight of wet concrete. Any mortar contaminating the bearings shall be completely removed before it sets.

7.12.3.6. Bearing Supporting Precast Concrete or Steel Units

A thin layer of synthetic resin mortar shall be used between bearings and beams. Alternatively, bearings with outer bearing plates may be bolted to anchor plates, to sockets embedded in precast elements, or to machined sole plates on steel elements.

7.12.4. MEASUREMENT AND PAYMENT

7.12.4.1. Measurement

The quantity of metal bearing shall be the number of each type of bearing placed and accepted.

The quantity of bearings pads shall be the number of each type, size and thickness of pad completed in place and accepted. Bearing strips shall be measured as the number of linear metres completed in place and accepted.

7.12.4.2. Payment

This work measured as provided above for the particular items specified shall be paid for at the Contract unit price for the Pay Items shown below and listed in the Bill of Quantities. The prices and payment shall be full compensation for existing bridge lifting in the case of replacement of bearings, furnishing and placing all materials including steel shim plates, concrete plinths, mortar beds, epoxy gluing layers, dowels, anchor bars, all labor, tools, equipment, incidentals and other works necessary or usual for the satisfactory completion of the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
7.12.1	Metal Bearing	Each
7.12.2	Elastomeric Bearing Type 1	Each
7.12.3	Elastomeric Bearing Type 2	Each

7.12.4	Elastomeric Bearing Type 3	Each
7.12.5	Elastomeric Bearing Type 4	Each
7.12.6	Strip Bearing	Linear Metre
7.12.7	Bearing Replacement, furnished and placed	Each

SECTION 7.13

STEEL BRIDGE RAILINGS

7.13.1 GENERAL

7.13.1.1 Description

This work shall consists of furnishing, fabricating and erecting steel railings for bridges and incidental structures including galvanizing, painting, posts, base plates, holding down bolts, etc., as shown on the Drawings, as required by these Specifications and as directed by the Engineer.

7.13.1.2 Related Works Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Concrete Work	:	Section 7.1
(c)	Structural Steelwork and Steel Painting	:	Section 7.4
(d)	Cement Mortar	:	Section 7.8

7.13.1.3 Quality Assurance

The quality of materials supplied, workmanship and finished products shall be monitored and controlled as specified in the Reference Standards in Article 7.13.1.5.

7.13.1.4 Tolerances

Diameter of holes	:	+ 1 mm, - 0,4 mm
Posts	:	to be erected line to line and grade. They shall be vertical within a tolerance not exceeding 3 mm per metre of height.
Rails	:	adjacent railing panels shall align with each other within 3 mm.
Curvature	:	railings shall conform to the bridge curvature. This may be formed by means of a series of short chords between posts
Appearance	:	railings shall present a smooth, uniform appearance when in their final positions.

7.13.1.5 Reference Standards

AASHTO M111M/ M111-04	:	Galvanizing.
AASHTO M160M/ M160-07	:	General Requirement for Delivery of Structural Steel.
AASHTO M183 - 90	:	Structural Steel.
ASTM A307	:	Mild Steel Nuts and Dolts.
AWS D210	:	Welded Highway and Steel Bridges.

7.13.1.6 Submittals

(a) The Contractor shall furnish for the approval of the Engineer working drawings for each particular type of railing to be installed. The fabrication shall not start before the working drawings have been approved.

(b) The Contractor shall submit manufacturer's certificates indicating quality of steel, welding etc.

7.13.1.7 Storage and Handling of Materials

Steel parts shall be carefully handled and stored on blocks, racks or platforms, shall not be in contact with the ground and shall be protected from corrosion. Materials shall be kept free from dirt, oil, grease and other foreign matter. Surfaces to be painted shall be carefully protected both in the shop and in the field. Threads shall be carefully protected from injury.

7.13.1.8 Rectification of Unsatisfactory Work

(a) During transportation, storage, handling or erection any railing suffering major damage, such as bending or crushing of pipe rail, shall be replaced. Railing suffering damage to welds shall be returned to the workshop to have the welds renewed and be re-galvanized.

(b) Railings suffering damage to galvanizing or painting shall be returned to the workshop and the finish made good. Minor damage to paintwork may be made good on site, to the satisfaction of the Engineer.

7.13.1.9 Maintenance of Accepted Work

Not withstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 7.13.1.8 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted steel bridge railings throughout the Time for Completion. Such routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7

7.13.2 MATERIALS

7.13.2.1 Steel

Material for bridge rail shall be rolled steel with a yield point of 2,800 kg/cm^2 conforming to AASHTO M183 - 90 or other standard approved by the Engineer. The Contractor, on the instruction of the Engineer, shall have samples of steel tested at an approved testing institution, should manufacturers certificates be inadequate.

7.13.2.2 Holding Down Bolts

Holding down bolts shall be 25 mm diameter U-bolts conforming to ASTM A307 or, if approved by the Engineer, equivalent epoxy bonded stud anchor bolts. Expansion type stud anchors are not allowed. All holding down bolts shall be rust proofed or galvanized.

7.13.3 FABRICATION

7.13.3.1 General

Fabrication shall generally be carried out in accordance with the requirements of Section 7.4, Structural Steelwork and Steel Painting. Railings shall be fabricated at an approved workshop. Joints in adjacent panels shall be match-marked for erection purposes.

7.13.3.2 Welding

Welding shall be carried out by skilled operatives, in an expert manner, taking full consideration of material properties. Exposed seams shall be chipped, ground, filed and

cleaned to give a neat appearance ready for galvanizing. Base plates shall be welded to posts to take account of any gradient given on the Drawings and in such a way that the posts are vertical when in their final positions

7.13.3.3 Galvanizing

All steel members shall be galvanized in accordance with AASHTO M111M/ M111-07 Galvanizing, except that galvanizing shall have a minimum thickness of 80 microns. Drilling and welding work shall be complete prior to galvanizing. In order that condensation moisture can run off after fabrication prior to galvanizing, tubes shall be provided with holes as shown on the Drawings. Any additional holes necessary to drain tubes or required for galvanizing shall be positioned so as not to be visible and not reduce the load bearing capability of the tube. Tubes shall be completely galvanized including the insides. After the galvanizing of the railing members no welding or boring of holes shall take place without permission of the Engineer. Repair of the galvanizing, shall then be made (after fully removing any light rust, moisture, loose galvanizing, oil and other foreign matter) with three coats of high quality, durable, zinc dust priming paint as approved by the Engineer.

7.13.4 ERECTION

Erection shall be in accordance with Section 7.4 Structural Steelwork and Steel Painting. Railings shall be carefully erected to the lines and levels indicated on the Drawings. Railings shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, correct alignment and camber throughout their length. The approval of the Engineer shall be obtained before final fixing of the railing. The Contractor shall notify the Engineer when inspection and approval is required.

7.13.5 MEASUREMENT AND PAYMENT

7.13.5.1 Measurement

Steel bridge railings shall be measured for payment as the number of linear metres of railing of each type specified on the Drawings, complete in and place accepted in the works. Measurement shall be made along the top rail member between centers of end posts and shall include all intermediate posts, rail supports, and end elements. No separate measurement shall be made for base plates, holding down bolts, infill panels and any other fittings necessary, to complete the railings. On staircases the measurement in linear metres shall be taken along the top of the hand rail.

7.13.5.2 Payment

The quantities of steel bridge railing measured as provided above shall be paid for at the Contract Price per linear metre of railing for the Pay Item listed below and shown in the Bill of Quantities. Such price and payment shall be deemed full compensation for finishing all rails, end and intermediate posts, rail supports, base plates, holding down bolts, infill panels, end panels and fittings, plus delivery, erection, surface treatment and furnishing together with all labor, equipment, tools and incidentals necessary' or usual for the proper completion of the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
7.13	Steel Bridge Railing	Linear Metre

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SECTION 7.14

BRIDGE NAME PLATE

7.14.1 GENERAL

7.14.1.1 Description

The meaning of bridge name plate referenced in these Specifications is the board which provides the information including the name, number and location of bridge and is installed at the parapet of bridge.

This work consist of furnishing and installing the bridge name plate in the shape and dimension as shown on the Drawings.

7.14.1.2 Specified Elsewhere

(a)	Environmental Safeguards	:	Section 1.17
(b)	Cement Mortar	:	Section 7.8
(c)	Stone Masonry	:	Section 7.9

7.14.2 MATERIAL AND CARVING

The material to be used is marble stone which shall be carved to include the Public Works symbol and written, in approved characters, the name, reference number and the location of the bridge with the information approved by the Engineer.

7.14.3 EQUIPMENT

The equipment for installing the bridge name plate shall be approved by the Engineer.

7.14.4 MEASUREMENT AND PAYMENT

7.14.4.1 Measurement

The quantities to be paid shall be the actual number of installed furnished name plate and accepted by the Engineer.

7.14.4.2 Basis of Payment

The quantities determined as provided above shall be paid for at the contract price per unit of measurement, which price and payment shall be full compensation for furnishing and installing all material, labor and tool as required in these Specifications.

Pay Item No.	Description	Unit of Measurement
7.14	Bridge Name Plate	Each

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SECTION 7.15

DEMOLITION OF EXISTING STRUCTURES

7.15.1 GENERAL

7.15.1.1 Description

(a) This work shall consist of the removal, wholly or in part, and the satisfactory disposal of, existing bridges, culverts, head walls and aprons, buildings, walls and other structures required to be removed to enable the construction or extension of repair of structures which have the same intended function as the old structures (or parts of structures) which are to be demolished.

(b) The works shall also include the satisfactory disposal of materials demolished under Article 7.15.1.1.(a) above, including either wasting or salvaging, handling, transporting, storing and preserving from damage designated materials as directed by the Engineer.

7.15.1.2 Related Work Specified Elsewhere

(a)	Traffic Management and Safety	:	Section 1.8
(b)	Field Engineering	:	Section 1.9
(c)	Environmental Safeguards	:	Section 1.17
(d)	Concrete Work	:	Section 7.1
(e)	Stone Masonry	:	Section 7.9
(f)	Reinstatement of Existing Bridge Structures	:	Section 8.5

7.15.1.3 Submittals

All demolished materials designated by the Engineer to be salvaged shall be measured immediately following the demolition work and a written record giving the original location, nature, condition and quantity of the material shall be submitted to the Engineer.

7.15.1.4 Contractor's Liability for Salvaged Materials and Existing Structures

Where the widening, extension, reinstatement or other improvement to a bridge or culvert requires the removal of decking, girders, head wall, or other structural part, such removal shall be carried out without unnecessary damage to the parts of the structures that are to remain.

Any damage to or, loss of, salvaged or temporarily dismantled parts, or any damage to a part of a structure that is to remain which is caused by the Contractor's carelessness, shall be made good at the Contractor's expense.

7.15.1.5 Waste Disposal Arrangements

The Contractor shall make all necessary arrangements with property owners, and bear all costs, for obtaining suitable locations for permanent disposal of waste materials and for temporary storage of salvaged materials.

7.15.1.6 Arrangements for Traffic

Bridges, culverts and other structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate the traffic in accordance with Section 1.8. Traffic Management and Safety.

7.15.2 DEMOLITION PROCEDURES

7.15.2.1 Dismantling Structures

(a) Steel bridges and wooden bridges, when specified by the Engineer to be salvaged, shall be carefully dismantled without damage.

(b) Timber bridges of span greater than 2.2 m or parts thereof which are required to be adjusted or interfered with because of the Works shall be carefully dismantled to the extent necessary and reconstructed with the original materials. Simply supported timber structures of spans less than 2.2 m which obtrude upon the Works shall be carefully removed and handed to the owner or otherwise disposed of as directed by the Engineer.

7.15.2.2 Removal of Structures

(a) Unless otherwise directed, the substructures of existing structures shall be removed down to the natural stream bottom and those parts not located in a stream shall be removed down to at least 30 cm below the natural ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure and any resulting holes and cavities shall be back filled and solidly compacted to the satisfaction of the Engineer.

(b) Blasting or other operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing any new work in the vicinity, unless other wise directed by the Engineer.

7.15.3 DISPOSAL OF DEMOLISHED MATERIALS

7.15.3.1 Salvaged Materials

(a) All salvaged materials remain the property of their legal owner before the demolition work was carried out. No demolished materials become the property of the Contractor.

(b) All salvaged materials shall be stored as requested by the Engineer.

(c) Unless waived in writing by the Engineer, all concrete removed that is of suitable size for rip rap and not needed for such use on the project, shall be stockpiled at locations indicated by the Engineer.

7.15.3.2 Waste Materials

Materials and debris not designated to remain or be salvaged may be burned of buried or otherwise disposed of as approved by the Engineer.

7.15.4 MEASUREMENT AND PAYMENT

7.15.4.1 Measurement and Payment of Demolition Work

The quantity of demolition shall be measured for payment in cubic metres for all pay item except demolition of the following: demolition of building; demolition of steel truss; demolition of timber deck; and for demolition of timber bridge in square metres and for demolition of steel girder/stinger and bridge railing in linear metres.

For haulage for disposal in excess of 5 kilometers shall be paid per cubic metre per kilometer.

7.15.4.2 Basis of Payment

The quantity, determined as provided above, shall be paid for at the Contract Price per unit of measurement, for the Pay Items listed below and shown in the Bill of Quantities, which price and payment shall be full compensation for all labors, equipments, tolls, testing and other work necessary for the satisfactory completion of the work as prescribed in this Section.

Pay Items	Description	Unit of Measurement
7.15.1	Demolition of Stone Masonry	Cubic Metre
7.15.2	Demolition of Concrete	Cubic Metre
7.15.3	Demolition of Prestressed Concrete	Cubic Metre
7.15.4	Demolition of Building	Square Metre
7.15.5	Demolition of Steel Truss	Square Metre
7.15.6	Demolition of Steel Girder/Stringer	Linear Metre
7.15.7	Demolition of Bridge Railing	Linear Metre
7.15.8	Demolition of Timber Deck	Square Metre
7.15.9	Demolition of Timber Bridge	Square Metre
7.15.10	Haulage in excess of 5 km.	Cubic Metre per km
7.15.11	Demolition of Gabions	Cubic Metre