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SECTION TS 13. PILES DRIVEN

SECTION TS 13. PILES DRIVEN

13.1 GENERAL

This section covers the general requirements for piled foundations constructed using driven piles.

The specific requirements for the construction of driven concrete piles is covered by Section 14 of this Specification and the relevant clauses of this Section.

Concrete shall be supplied and placed in accordance with the requirements of Section TS 3 of this Specification. Precast concrete shall be manufactured and handled in accordance with the requirements of Section TS 4 of this Specification.

Piles shall be handled and driven in the locations and to the elevations shown on the drawings, or as directed by the Engineer. The Contractor shall ensure that piles are not damaged by improperly supporting, handling or transporting. Where damage to piles results from such improper handling the piles shall be replaced or, with the consent of the Engineer, concrete piles may be repaired in accordance with the requirements of Section TS 9 of this Specification. Such repair or replacement shall be at the expense of the Contractor.

Until incorporated in the permanent works the piles shall be adequately supported at all times by the use of suitable leaders, trestles, temporary supports or other arrangements to maintain position and alignment and to prevent damage to the driven pile.

13.2 TOE ELEVATIONS

The toe elevations or depths of penetration of piles as shown on the Drawings are nominal and are subject to confirmation or alteration and the Engineer may order in writing such changes of toe levels as may be necessary to ensure a satisfactory foundation.

13.3 DRIVING SYSTEM

Piles shall be driven with a driving system which delivers sufficient energy to produce a permanent set or penetration per blow as specified below.

The Contractor shall provide details of the driving system including the make, model and rated energy of the hammer, the mass of the helmet, and the proposed cap-block and cushion materials. These details shall be submitted to the Engineer at least 14 days prior to the commencement of pile driving, together with calculations which demonstrate that the proposed driving system has sufficient energy to successfully drive the piles to the required toe elevations or the nominated driving resistances without causing damage to the piles.

Unless otherwise consented to by the Engineer, Table 13.1 below shall represent the minimum values of pile hammer weight to be used for driving the appropriate type of pile.

Vibratory or hydraulic driving systems may be used only with the consent of the Engineer.

Table 13.1 - Pile Hammer to Pile Mass Ratios

Pile Type	Hammer Type	Mass Pile	Length of Pile	Mass Hammer / Mass Pile
Steel Tube or H Section	Diesel/Steam or Air	Any	Any	> 1.0
	Drop	Any	Any	> 1.5
Concrete	Diesel/Steam or Air	Any	Any	> 0.333
	Drop	< 7.5 tonnes	< 15 m	> 1.0[1]
			15 – 20 m	> 0.75[1]
			> 20 m	> 0.667[1]
		> 7.5 tonnes	Any	> 0.5

Note (1) Minimum Mass of Hammer shall be 2.5 tonnes.

For steel piles the calculated driving energy shall not exceed 50 kilojoules unless approved by the Engineer. This energy is equivalent to a drop hammer of 2.5 tonnes weight falling a distance of 2 metres.

For concrete piles up to 7.5 tonne mass the calculated driving energy shall not exceed 50.0 kilojoules unless otherwise consented to by the Engineer. This energy is equivalent to a drop hammer of 2.5 tonnes weight falling a distance of 2.0 metres. For heavier piles the maximum allowable driving energy shall be as consented to by the Engineer.

The effective drop height shall be chosen so as to avoid injury to the pile and shall not be greater than 1.5 m for concrete piles or 2.5 m for steel piles.

13.4 DRIVING

13.4.1 General

All piles shall be driven in the presence of the Engineer and the pile driver shall not be removed from the head of a pile without his consent.

Each pile shall be driven as a continuous operation and no pile shall be left partly driven unless otherwise consented to by the Engineer.

During driving piles shall be supported in line and position with suitable leads. Leads shall be constructed in such a manner as to afford freedom of movement to the hammer and shall be held in position to ensure rigid lateral support to the pile during driving.

Except where piles are driven through water, the leads shall, unless otherwise consented to by the Engineer, be of sufficient length to make the use of a dolly or follower unnecessary and shall be so designed to allow the placing of batter piles to within the tolerances specified.

Pile helmets shall be of substantial steel construction, loose fitting on the pile head with a steel diaphragm at approximately mid-height. Between the steel diaphragm and the pile head shall be placed a suitable cushion of softwood, loaded across the grain, at least 50 mm thick. On top of the diaphragm and fitting tightly into the helmet there shall be a suitable hardwood cap block. The helmet shall preferably slide in, and be guided by, the leaders of the pile frame.

13.4.2 Site Preparation

The Contractor shall be responsible for preparing the site by excavation or other means to ensure that the required levels of toes of piles are obtained.

For piles not founded on rock where the ground level is to be permanently lowered, such as for an excavated channel, piles located in the area to be excavated shall not be driven until such excavation is complete, and where the base of the pile cap is more than 2 metres below the ground surface level existing at the time of pile driving the excavation for the pile cap shall be completed prior to driving the piles unless otherwise approved by the Engineer.

Any material forced up between the piles during driving shall be removed to the correct level before concrete for the foundation is placed. At all times care shall be taken to avoid disturbing the site by excavation below the level of the base of the pile cap.

13.4.3 Tolerances

The following tolerances shall apply to piles after driving:

1. Pile head shall finish within 75 mm of the specified position.
2. Variation from the vertical or from the specified batter shall be not more than 20 mm in 1 m.
3. In case of piers with piles capped at crosshead level, the pile at ground level shall be within 50 mm of specified position.

The Contractor shall make every effort to drive the piles within the above tolerances. Should the tolerances be exceeded such remedial measures as are considered necessary by the Engineer shall be carried out by the Contractor at his own expense.

Piles shall not be bent or sprung into place during or after driving, but shall be effectively guided to finish in the position specified herein.

The dimensions of the concrete in the pile cap shall be increased, if necessary, at the expense of the Contractor to preserve the specified edge distance shown on the Drawings.

13.4.4 Penetration Requirements

The toe elevations shown on the Drawings are for general guidance only. The final toe levels of piles shall as be determined below.

For piles which are shown on the Drawings as being founded on rock the piles shall be driven to "nominal refusal". For this Specification "nominal refusal" shall mean a penetration of not more than 25 mm from twenty successive blows with a driving energy as specified above.

For piles which are shown on the Drawings as not being founded on the rock the piles shall be driven to "nominal refusal" or "permissible set". For this Specification "permissible set" shall be attained when the pile has been driven until the last four (4) blows of the hammer, using the driving energy as specified above, produce an average penetration or set greater than the values in table 13.2 unless specified otherwise on the Drawings or directed by the Engineer.

Table 13.2 – Permissible Sets per Blow for Piles not Founded on Rock

Type of Pile	Maximum Design Load (per pile)	Permissible Set per Blow
Steel	any	5 mm
Concrete		
	Not greater than 25 kN	12 mm
	Over 250 kN and not greater than 350 kN	9 mm
	Over 350 kN and not greater than 450 kN	6 mm
	Over 450 kN and not greater than 500 kN	4 mm
	Over 500 kN	As specified on Drawings

Diesel hammers shall be driven with the throttle wide open when measurements of set or temporary compression are being taken.

When a pile does not obtain the specified driving resistance at the nominal toe elevation, it shall be driven on until the specified driving resistance is reached.

Alternatively, when requested by the Engineer, the Contractor shall stop driving, and then retest the pile in accordance with Clause 13.5.

Pile toes shall not finish above the Contract Levels without the written consent of the Engineer.

The Contractor shall use all means considered necessary, including pre-boring, jetting and preliminary excavation, to ensure the pile reaches the specified toe elevations within the accuracy of position as specified in Clause 13.4.3.

Details of the proposed work of this nature shall be submitted to the Engineer prior to implementation and no extra payment will be allowed on this account.

Whenever it is necessary to drive the head of the pile below the level of the underside of the pile cap, care shall be taken to minimise disturbance of the surrounding ground when driving or extending the pile.

13.4.5 Follower or Dolly

If during it is necessary to use a follower or dolly, driving shall be resumed within one hour of previous driving. Cushion material as consented to by the

Engineer shall be placed between the dolly and the pile head. The penetration of the pile under the last ten (10) blows before the dolly is used and the penetration the first ten (10) blows using similar driving energy with the dolly in position shall be recorded.

From these two sets of records the proportional loss of energy when using the dolly shall be calculated and the drop of the hammer adjusted accordingly to give the specified set per blow or, in the case of a diesel or steam hammer, the nominated set per blow of the hammer shall be amended accordingly.

13.4.6 Test Piles

The Engineer may order test piles to be installed to verify the number and lengths of piles required for the structure. Test piles shall be of lengths as shown on the Drawings or ordered by the Engineer. The location in which the test piles are to be driven shall be as directed by the Engineer and may be inside or outside the perimeter of the foundation.

Where ordered by the Engineer, test piles will subjected to test loading in accordance with Clause 13.7 below.

For piles not founded on rock the first pile in any group, as selected or approved by the Engineer shall be considered as a test pile unless shown otherwise on the Drawings or directed by the Engineer. For such a pile, notwithstanding that the toe of the pile shall have reached the toe elevation as shown on the Drawings, or that the specified "permissible set" shall have been obtained, driving shall be continued (by means of a dolly or follower if necessary), if required by the Engineer to "nominal refusal", or until the top of the pile is at the level required by the Drawings, whichever gives the lower toe level. If further required by the Engineer the test pile shall be driven to a still greater depth by means of a dolly or by extending the pile.

After consideration of the driving record of a test pile the Engineer will advise the Contractor of any amended toe elevations for the group of piles considered to be represented by the test pile.

13.4.7 Splicing of Piles

Splicing of piles, where required, shall be carried out immediately driving of any section has ceased and redriving shall commence as soon as the splice is completed.

Spicing shall be carried out in accordance with the requirements of Section TS 7 for concrete piles or as recommended by the manufacturer.

Steel sheet piles shall be spliced with full penetration butt welds. Where welding of steel sheet piles is required the Contractor shall submit welding procedures and procedures for qualifications of welders to the Engineer for approval.

13.4.8 Jetting, Drilling and Firing and Pre-boring

When jetting is proposed, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile and uniformly about the toe. The plant used shall have sufficient capacity to deliver at all times a pressure equivalent to at least 700

kPa (7 kg/cm^2) at two 80 mm jet nozzles. The jet pipes may, with the consent of the Engineer, be attached to the piles.

Jetting shall cease one metre above the specified toe elevation and the piles shall then be driven to the specified driving resistance.

Where piles are driven through abutment fill they shall be pre-bored to depths and hole diameter as specified on the Drawings.

Where pre-boring is used the diameter of the hole shall not be greater than the diagonal dimension of the pile less 100 mm. The actual depth of the pre-boring is to be determined by experiment and shall be such that the specified set (or less) is obtained when the pile is at the Contract Level. Pre-boring shall cease at least one metre above the Contract Level of the pile.

Firing shall only be used if shown on the Drawings or consented to by the Engineer. The procedure and charge shall be subject to the consent of the Engineer.

The amount of explosive charge (in kilograms) per hole shall not exceed 8 times D^2 where D is the distance (in metres) from the hole to the nearest structure or pile provided that at all times the peak practice velocity of the shock waves shall not exceed 50 mm/second.

In no case will firing be allowed at any pier or abutment where concrete piles have already been driven.

Any space remaining between the pile and the limits of the excavation, after the pile driving is finished, shall be backfilled with an approved granular material in accordance with the requirements of Section TS 2 of this Specification.

13.4.9 Replacement or Repair of Defective Piles

Should any pile split or crack during or become damaged in any way or become displaced from its specified position or alignment by more than the limits specified herein, the Contractor shall carry out any extra as directed by the Engineer to make good and incorporate the defective pile effectively in the structure, or to replace the pile.

A concrete pile shall be considered defective if it has a visible crack, or cracks, extending around the periphery of the pile or other defects which, in the opinion of the Engineer, will affect the strength or life of the pile.

The Engineer may order that piles to be replaced be withdrawn and replaced with a longer pile or a second pile be driven adjacent to defective pile.

Any piles forced up by the driving of adjacent piles shall be re-driven to the specified ultimate capacity and toe level.

This work shall be carried out at the expense of the Contractor.

13.4.10 Completion of Driving

On completion of driving, and filling where applicable, piles shall be cut back to the levels shown on the Drawings or as directed.

The Contractor shall carry out this operation in such a way as to avoid splitting, spalling or otherwise damaging the pile.

After driving piles the area shall be reinstated as directed by the Engineer.

13.5 RETESTING

Retesting shall be carried out not less than 24 hours after initial driving.

During retesting the pile shall be given ten consecutive blows with the energy per blow sufficient to produce a set of not less than 5 mm at the nominal driving resistance specified.

The pile will be accepted if the driving resistance calculated from the average set measured in the first 5 blows is equal to or greater than the specified driving resistance.

13.6 CAPACITY OF DRIVEN PILES

Each pile shall be driven to an ultimate capacity which shall be not less than that specified in the Drawings or as advised in writing by the Engineer.

The ultimate capacity achieved shall be calculated by the Engineer from one of the methods below or carrying out the load tests in accordance with Clause 13.7 below.

13.6.1 Ultimate Capacity based on the DANISH Formula

The ultimate may be calculated as:

$$R_u = \frac{e \times H \times W_r}{s + 0.5 \times s_o}$$

where $s_o = 1000 \times \sqrt{\frac{2 \times e \times H \times W_r \times l_p}{A \times E}}$

and :

R_u = Ultimate pile capacity in kiloNewtons

W_r = Weight of ram in Newton 9.81 x Mass of ram in kilograms

H = Height of free fall of hammer in metres

E = Modulus of Elasticity of the material of the pile (in MegaPascals)

e = Efficiency of fall of hammer

l_p[1] = Length of pile in metres

A^2 = Cross sectional area of the pile in square millimetres

E_n = W_r x H for drop hammers and is the rated hammer energy for diesel or steam hammers (in Newton metres and Joules)

s = Final set of pile in millimetres per blow using an average of 10 consecutive driving blows, or the first 5 full retest blows

s_o = Temporary compression allowance in millimetres as calculated from the above formula

The values of the coefficients e and E, which are dependent upon the type of equipment used, and the batter of piles, shall be as measured or as shown below or nominated by the Engineer:

e = 0.75 for drop hammers

e = 0.90 for steam hammers

e = 0.95 for diesel hammers

E = 21000 MPa (2.1×10^5 kg/cm^2) for concrete piles

E = 210000 MPa (2.1×10^6 kg/cm^2) for steel piles

[1] The value of l_p shall be the actual length of the pile for lengths greater than twenty times the value of the cross sectional dimension of the pile. For smaller lengths l_p shall be taken as 20 times the value of the cross sectional dimension of the pile.

[2] A for a steel pipe is the area of the steel.

13.6.2 Ultimate Capacity based on Wave Equation Methods

If the Contractor wishes to use the wave equation method to predict the ultimate capacity of the pile or wishes to instrument the pile with the dynamic testing equipment a detailed proposal in writing shall be submitted to the Engineer not less than four weeks prior to the date the Contractor proposes to commence driving.

Pile driving shall not commence without the consent of the Engineer.

13.7 TEST LOADING

13.7.1 General

Where required by the Engineer the bearing capacity of the piles shall be checked by test loading on pile, and by measurement of settlement of the pile and of the adjacent piles in the pile group, which shall remain unloaded during the testing operation.

Test loading shall be carried out as described in this Clause and in general accordance with ASTM D 1143.

The test piles shall be the first piles at driven at each footing or distinct group of piles.

Loading of the test pile shall be achieved by jacking against kentledge. Adjacent piles shall not be used as jacking restraints.

The Contractor shall provide, at his own expense, all materials, equipment and labour required for the test loading of piles, including the provision of kentledge (together with any horizontal restraints required), the placing of kentledge and jacks in position, and all such work and material as may be incidental to the conduct of the test loading procedure as specified.

The method of test loading, and the loading and measurement procedures followed shall be subject to the consent of the Engineer.

Suitable, apparatus for determining the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of three times of 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 the possibility of disturbance. All pile load settlement shall be measured by adequate devices, such as gauges, and shall be checked by means of a levelling instrument.

13.7.2 Procedure

The test loading procedure shall comply with the following requirements:

1. The initial loadings, and the subsequent increments and decrements of loading shall be achieved instantaneously or as nearly so as may be practicable.

2. Settlements shall be measured to an accuracy of 0.5 mm, and shall be recorded at the following intervals of time for a period of at least one hour, and until the rate of settlement shall have reduced to not more than 0.5 mm per hour:

   15 seconds

   30 seconds

   1 minute

   2 minutes

   3 minutes

   4 minutes

   5 minutes

   30 minutes

   1 hour

   and at intervals of one hour thereafter as required.

3. Test loading shall follow the sequence set out hereunder, unless otherwise directed by the Engineer:

   a) An initial load of the magnitude shown on the Drawings shall be applied to the test pile and shall be maintained as long as may be necessary to satisfy the requirements of 2. above.

   b) The initial load shall be removed and the recovery of the test pile shall be measured not less than 10 minutes after removal of the load.

   c) Recovery shall be measured to an accuracy of 0.5 mm.

   d) The initial load shall then be reapplied, and the load shall be increased subsequently by increments of an amount as shown on the Drawings to a maximum of not less than the maximum value shown on the Drawings on directed by the Engineer.

e) Settlements shall be measured in accordance with the provisions of this Clause following re-application of the initial load and each subsequent increment of load.

f) The maximum test load shall be maintained for at least 24 hours or until the rate of settlement reduce to 0.5 mm per hour (whichever is the loner) or as the Engineer may direct.

g) The test load shall then be removed from the test pile in successive decrements until the load is reduced to the minimum value shown on the Drawings when the remainder of the load shall removed.

h) The recovery of the test pile shall be measured during the unloading process in accordance with the provisions of 2. above.

i) Measurements of settlement and recovery of adjacent unloaded piles shall be taken concurrently of the loaded pile at each stage of the testing procedure.

13.7.3 Report

The Contractor shall prepare a report on each load test as outlined below and shall submit a report to the Engineer within four (4) days of completion of the rest.

The report shall include at least the following information:

- Pile Construction and installation.

  A description of the pile type, length as driven, length as tested, length embedded, will thickness, head and tip details and dimensions, date pile was driven and pile mass.

  A description of the forming or driving of the pile including details of concreting, driving records and description of drilling.

- Test Layout and Equipment

  Sketches and if possible photographs showing location and size of reaction and loading equipment, deflection measuring equipment, test pile and cap and position of reference level marks.

  An assessment of the accuracy of the deflection measurement and results of calibrations of the load measuring apparatus.

- Test Procedure and Results

  A tabulation of the readings during and unloading of the pile together with the relevant times and dates.

  A graphical representation of the test results in the form of load-settlement and time-settlement curves (together with all necessary corrections for calibration, movement of datum pints and other influences).

  An assessment of the effect of the reaction system on the deflections and the ultimate bearing capacity.

13.7.4 Acceptance

The criterion for acceptance of the pile shall be total settlement of the test pile under the maximum test load shall not exceed the value shown on the Drawings when the rate of settlement has reduced to not more than 0.5 mm per hour.

Where not shown on the Drawings this settlement may be taken as 6 mm at a maximum test load of 150 % of the maximum pile load shown on the Drawings.

The settlement of adjacent pile shall be within limits acceptable to the Engineer.

Should the test fail to comply with this criterion, tow additional piles shall be tested.

If both of the additional piles subsequently comply with the test criterion, all piles shall be deemed acceptable.

Should either of two piles subsequently tested fail to pass the test, the Contractor shall construct such additional piles as the Engineer may deem to be necessary to provide the required load capacity.

13.8 MEASUREMENT AND PAYMENT

Measurement and Payment for Piles Driven will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates and lump sum prices entered in the priced Bill of Quantities for works which incorporate the requirements of this section of the Technical Specification. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.

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SECTION TS 14. PILES DRIVEN CONCRETE

SECTION TS 14. PILES DRIVEN CONCRETE

14.1 GENERAL

This Section covers the driving of precast reinforced or prestressed concrete piles.

The manufacture, handling, transport and storage of precast concrete piles shall be generally in accordance with the requirements of Section TS 4 of this Specification.

The general principles of driving piles shall be in accordance with the requirements of Section TS 13 of this Specification.

14.2 MANUFACTURE

14.2.1 Supply by Contractor

Unless otherwise shown on the Drawings or in the Special Specifications, all piles shall be supplied by the Contractor and the provisions of this Specification shall apply.

14.2.2 Dimensions

Piles shall be manufactured to the dimensions shown on the Drawings.

If a test pile is ordered, only the test pile shall be manufactured to the length shown on the Drawings. After driving the test pile, all other piles shall be manufactured to the lengths, sectional dimensions, and with reinforcement to conform to the toe levels authorised by the Engineer.

If no test piles are shown on the Drawings, or specified, all piles may be cast to lengths to suit the levels shown on the Drawings. As the work proceeds and further information is obtained the Engineer may amend the toe levels, and the dimensions of all piles required to piles not already cast shall be amended accordingly. If any additional length is required to piles already cast, the Engineer will determine at what stage such extensions are to be made.

Where the authorised length of piles is more than 1.5 metres in excess of the length shown on the Drawings, the Engineer may direct that reinforcement of a larger diameter, and/or a greater number of bars, and/or a larger size of pile than shown on the Drawings, shall be used.

The Contractor may propose to use high early strength cement, to employ steam curing, or to give special treatment to piles. Details of such proposals shall be submitted in writing to the Engineer, and his consent obtained before the special construction method is introduced. Once obtained no alteration shall be made unless consented to by the Engineer. No extra payment will be allowed for any such special type of construction.

A completed pile shall be straight within a tolerance of 0.06 percent of its length.

14.2.3 Specifications

Piles manufactured (together with any extensions) shall comply with the requirements of:

Section TS 3 – Concrete
Section TS 4 – Precast Concrete
Section TS 5 – Prestressed Concrete
Section TS 6 – Pretensioned Prestressed Concrete

14.2.4 Designation and Strength of Piles

Precast, Prestressed Concrete Cylindrical Piles

Precast, Prestressed Concrete Cylindrical Piles furnished under this contract shall comply with the type of pile designated shown on the Drawings. For the purposes of this contract the designations shall have the minimum strengths as shown in the following table.

Outside Diameter (mm)	600	500	500	450	450	400	350
Pile Type Designation	A	A	B	A	B	A	A
Cracking Bending Moment (tf m)	17.0	10.5	15.0	7.5	11.0	5.5	3.5
Concrete Compressive Strength (kgf/cm^2)	500	500	500	500	500	500	500
Effective Prestress (kgf/cm^2)	40.0	40.0	80.0	40.0	80.0	40.0	40.0

Precast Prestressed Concrete Sheet Piles

All materials and workmanship shall comply with the general requirements specified in section TS 3,4,5 and 6.

Concrete shall be Class A-1 in accordance with Section TS 3 of this specification.

Prestressing tendons shall comply with the requirements of Section TS 5 of this specification.

Piles shall measure 500 mm x 200 mm in cross section with male and female shaping of the edges to permit jointing between adjacent installed piles and shall be manufactured to the required lengths as shown on the Drawings.

The bending moment capacity shall be equal or greater than 5.90 tf.m (cracking bending moment).

14.2.5 Pile Shoes

The shoe as shown on the Drawings shall be firmly bonded to the pile, located centrally and in line with the pile axis. Manufacture of the pile shoe shall be in accordance with the manufacturer's recommendations and to the Engineer's approval.

14.2.6 Marking

Each pile segment shall have on its side, within 300 mm from the head, the length of pile, the date of casting and identification number. The marking shall be in indelible paint which is not injurious to the concrete, and the letters shall be at least 75 mm high. Alternatively, the markings may be cast into the concrete not deeper than 5 mm if consented to by the Engineer.

In addition, commencing at 5 metres from the toe, and thereafter at every metre up to the head, each pile shall be marked by a lightly-scribed line across the full width of one face of the pile or a minimum of one third of the circumference, and square to its length. Just above each line, on the side further from the toe, the distance of each such line from the toe shall be lightly scribed.

14.3 HANDLING, TRANSPORT AND STORAGE

14.3.1 General

Handling, transport and storage of piles shall be in accordance with the requirements of Section TS 4 of this Specification except as modified below.

14.3.2 Handling

a. General

Piles shall be lifted by means of a suitable bridle or slings using lifting points located at the one-fifth point of their length unless otherwise shown on the Drawings or directed by the Engineer.
In no case shall piles be moved by dragging across the ground.
The method of support for piles being pitched shall be subject to the consent of the Engineer.

b. Reinforced Concrete Piles

The entire length of each pile shall be supported during curing and shall not be lifted or handled until the concrete has attained sufficient strength to support the weight of the pile without damage.

c. Prestressed Piles

Prestressed piles shall not be handled or lifted until fully stressed.
The entire length of each pile shall be supported and remain stationary, and the pile shall not be handled, until after the specified curing period has expired, that is at least seven days for concrete made with normal cement and moisture cured, or otherwise as directed by the Engineer for special methods of manufacture and/or curing. Piles shall be handled and supported at the one-fifth points of their length, except that piles up to 10 meters long may be lifted at a point one third of the length of the pile from the end.

14.3.3 Transport

During transport piles shall be supported at lifting points as consented to by the Engineer.

Timber packers shall be used between the sides of individual piles to prevent contact.

14.3.4 Storage

For the stacking of piles, heavy sill logs shall be well bedded and flattened to give a bearing width not less than 200 mm and minimum clearance of 300 mm above ground. Piles may be stacked on top of each other up to six layers with the consent of the Engineer.

Each layer shall be separated from the next layer by timber bearers, each 100 mm wide and 75 mm high. The bearers shall be placed centrally above the still logs, and above one another, so that no additional bending is

induced in any pile in the stack. The bearers shall support the piles over their full width.

Piles when stacked shall be supported at lifting points as consented to by the Engineer.

14.4 DRIVING OF PILES

14.4.1 General

Piles shall be driven generally in accordance with the requirements of Section TS 13 of this Specification except as modified below.

Only piles which have been inspected and passed by the Engineer shall be driven. Any pile which shows any defect which, in the opinion of the Engineer, would affect the driveability or durability of the pile will be rejected and shall not be used anywhere in the work.

14.4.2 Minimum Age of Piles Before Driving

Piles shall not be driven until the least 14 days after the specified 28 days strength has been achieved and in no case shall piles be driven until the least 21 days after casting.

These minimum ages before driving shall also apply to any concrete extensions and splices.

14.4.3 Test Piles

When shown on the Drawings or in the Special Specifications or ordered by the Engineer, test piles shall be driven at locations designated by the Engineer and, if accepted, may form part of the permanent works.

The Contractor shall not cast the remaining piles until the test piles have been driven. Following the driving of the piles the Engineer will determine any variations to the casting lengths obtained from the Contract Levels shown on the Drawings and shall not notify the Contractor of such variations in writing.

Where piles are manufactured by a specialised and reputable pile manufacturer, approved by the Engineer, the Contractor may, at his own risk, order remaining pile segments without awaiting driving of test piles.

14.4.4 Driving Procedure

To prevent damage to the pile from the tension caused by shock wave action, driving shall commence by tapping the pile very lightly with blows of the order of 0.2 to 0.3 metre-tonne intensity (that is with a driving energy between 2 to 3 kilojoules), so that the penetration does not exceed 50 mm per blow, or such figure as may be directed by the Engineer. The driving energy shall be increased gradually as the resistance to the movement of the pile increases, until the full energy specified in Section TS 13 can be applied without producing a penetration exceeding 50 mm per blow.

To avoid damage by bending the piles shall be driven from a fixed frame having sufficient rigidity to ensure accuracy of driving and freedom from bending of the pile under all conditions of tides, stream flow, hammer action or other disturbances which may occur during the driving.

The force of the hammer shall be directed centrally and axially into the head of pile.

The Contractor shall ensure that no torsional stresses are induced into the pile by any restraint against rotation about the vertical axis within the helmet.

14.4.5 Pile capacity

The capacity of driven piles shall be calculated in accordance with the requirements of Section TS 13 of this Specification.

14.4.6 Severe Driving

Unless otherwise consented to by Engineer, severe driving where the average penetration per blow is less than that for nominal refusal shall not be permitted.

14.4.7 Acceptance of Driven Piles (other than Test Piles)

The "permissible set" is the criterion for accepting driven piles (other than test piles) when the finished toe level is at or lower than amended toe levels.

When "nominal refusal" or "permissible set" is achieved before the toe of the pile reaches the amended to levels, the Engineer may authorise the acceptance of the pile provided adequate penetration below the existing surface has been achieved.

Piles which contain additional bonding bars cast into the head end must be driven until a minimum length equal to one and a half times the bond length of these bars remains in the pile below the level to the which the pile is stripped back. The pile shall not be cut off without this bond length remaining unless written consent is obtained from the Engineer.

14.4.8 Driving Precast Prestressed Concrete Sheet Piles

Prestressed concrete sheet piles be pitched and driven accurately in the positions shown on the Drawings and to the required depths as directed by the Engineer.

The piles shall be pitched inside a braced template and carefully aligned and positioned before driving. The piles shall then be driven to the required penetration in such a manner as to ensure that the vertically of the piles is maintained. In the event of any misalignment developed during driving, the Contractor shall take appropriate action to correct the condition during driving.

Piles driven in excess of 10 mm, per meter of pile length or damaged during driving may be rejected, if, in the opinion of the Engineer, the improperly aligned or damaged pile adversely affects the structure. The Contractor shall propose the corrective measures to be taken for approval by the Engineer. All corrective measures shall be at the Contractor's own expense. Rejected piles shall be expected, re-driven or placed or cut-off at all a level approved by the Engineer.

14.5 CUTTING OFF AND STRIPPING OF PILE HEAD

After driving the excess portion of the pile shall be cut off and the top section remaining shall be stripped over the length as shown on the Drawings to

expose longitudinal reinforcement for bonding into the pile cap. The concrete in the pile head after stripping shall be embedded into the pile cap the distance shown on the Drawings.

In order to prevent spalling of the adjacent concrete stripping of a pile shall be preceded by cutting a circumferential notch, approximately 30 mm deep, at the level above which the concrete is to be removed.

The Contractor shall ensure that longitudinal reinforcement and prestressing strands are not damaged in any way during the stripping operations.

Explosives shall not be used except with the consent of the Engineer.

Where cut-off elevation is above the level of the head of the pile it shall be extended in accordance with Clause 14.6.6 below.

When a pile is cut off and stripped and the projecting steel is longer than is required for joining to the structure, the Engineer will direct whether the steel is to be cut off or bent. No extra payment will be made for cutting off or bending.

14.6 EXTENSIONS OF PILES

14.6.1 General

Should a pile fail to achieve the specified set after being driven to the limit of its cast length it shall continue to be driven as far as practicable by first extending the leaders and then using a suitable dolly as specified in Section TS 13.

14.6.2 Splicing Piles by Lapping of Steel

Unless otherwise specified the end of the pile shall be stripped to expose the longitudinal reinforcing steel for a length equal to:

- 40 diameters of the steel for deformed bars up to U 24 grade (2400 kg/cm^2)
- 50 diameters of the steel for deformed bars above U 24 grade (2400 kg/cm^2)
- 50 diameters of the steel for plain bars
- 60 diameters of the steel for prestressing strand or wire

Where bars or strands of different diameters are used the stripped length shall be equal to the longest of the individual requirements.

Reinforcement similar to that used in the original end of the pile shall then be spliced to the projecting steel, spiral steel being for two complete turns and the straight steel for a length as specified above.

14.6.3 Splicing by Welding of Steel

Splicing of steel by welding shall only be used with the express consent of the Engineer.

The concrete at the top of the pile shall be cut away, leaving the reinforcing steel exposed for such length as may be required for the splice as directed by the Engineer.

Welds shall fully develop the strength of the bars, all bars being fully butt welded, or joined by means of lapped bar filled welded joints.

No welding shall approach closer than 150 mm to a concrete surface.

In the case of fillet welds fillets not less than 6 mm shall generally be used, and the lapped length on each end of each bar to be spliced shall not be less than twelve diameters of the spliced bar, or six diameters if two splice bars and four lines of fillet weld are used for each pile bar spiced.

All welding shall be in accordance with procedures and by welders approved by the Engineer.

14.6.4 Splicing with Precast Lengths of Pile

If consented to by the Engineer, lengthening of piles may be carried out by splicing on a length of precast pile, prior to driving, during driving or after driving ceases. Splices may be made in concrete, epoxy mortar or epoxy with a suitable steel sleeve.

Details of the proposed splice shall be submitted to the Engineer and his consent obtained prior to the splice being made and/or prior to the commencement of driving.

14.6.5 Pile Extensions in Reinforced Concrete

The extended reinforcement shall provide an ultimate flexural strength of the pile equivalent to that of the original pile.

The extended bars shall be secured in position and held by circumferential ties or spirals consisting of 6.4 mm wire at 150 mm pitch or equivalent. In the case of reinforced concrete piles, should any pile need to be driven after it has been extended, the tie reinforcement at the end of the pile shall be similar to that at the driving end of the original pile.

Unless otherwise directed by the Engineer in writing the extension shall be formed to the same cross sectional profile and fillet concrete of the same strength as that specified for the original pile.

14.6.6 Pile Extensions which are not Driven

In the case of extensions to piles already fully driven, the necessary length of steel for bonding to work above the pile shown on the Drawings shall project above the extended portion of the pile.

14.6.7 Pile Extensions of Prestressed Concrete Piles

Extensions of prestressed concrete piles will be permitted only where a recognised standard proprietary welded steel splice recommended by the manufacturer and approved by the Engineer, is used conforming to the requirements of Japanese Standard JIS A 7201 (Standard Practice for Execution of Spun Concrete Piles)

With the consent of the Engineer, and only after driving has been completed, extensions may be made in accordance with Clause 14.6.6 above.

Welding of tendons will not be permitted and tendons must be adequately protected during any welding operations adjacent to them.

14.6.8 Miscellaneous Works Associated with Piling

14.6.8.1 Concrete Filling

Where shown on the Drawings, the Contractor shall fill concrete into the hollow cores of precast prestressed concrete piles after driving as shown on the Drawings or as directed by the Engineer. Concrete shall be type D in accordance with the requirements of Section TS 3, Concrete Works.

14.6.8.2 Pile Head Treatment

Where shown on the Drawings reinforced concrete shall be placed in the upper portion of prestressed concrete piles for the purposes of tying into pile caps. Materials shall be Concrete type C1 and steel reinforcement shall be deformed reinforcing bars in accordance with Section TS 3 of the Technical Specification. Refer to Section TS 3 for measurement and payment of this item.

14.6.8.3 Sand Filling

Where shown on the Drawings or directed by the Engineer the Contractor shall fill sand into the hollow core of precast prestressed concrete piles after driving as shown.. Filling and compaction of sand shall be performed with the appropriate equipment approved by the Engineer.

(Note this item is deleted from this contract)

14.7 MEASUREMENT AND PAYMENT

14.7.1 Prestressed Concrete Test Piling

This clause refers to the precast, prestressed concrete piles for test piling as described in Section TS 14 and other referenced sections of the Technical Specification.

Measurement for payment, of each test pile size, shall be based on the total number of linear metres supplied, marked accordingly, and placed in storage at the site of the works and accepted by the Engineer.

The measurement for payment shall be made for such piles whether driven or used only as undriven extensions, in linear metres (m), measured along the pile axis from the pile toe, as actually driven, to the head of the pile prior to stripping back for joining into the pile cap.

Apart from partial payments for certain materials delivered to site, as provided for below, payment shall not be made for test piles until they have been driven, test loaded and accepted in accordance with the Drawings and this Technical Specification or as directed by the Engineer.

Payment will be made at the rates entered in the priced Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs. In particular rates for test piles shall be deemed to include, but not be limited to the following:

1) Supplying precast prestressed concrete piles, taking delivery and handling

2) Preparing, handling and pitching precast prestressed concrete piles

3) Driving precast prestressed concrete piles including pre-boring and the like

4) Driving additional pile lengths

5) Dollying piles below ground or water level

6) Moving pile frames to re-test piles or re-drive lengthened piles

7) Extension of pile

8) Test loading of piles

9) Cutting off and stripping of pile heads and incorporation into cap

10) Extension of pile

11) Splicing of pile including welding consumables and equipment

12) Any excavation, dewatering and the like

No payment shall be made for lengthening of test piles carried out by the Contractor to make up test piles from shorter lengths than the lengths shown on the Drawings or directed by the Engineer or for any lengthening of test piles which is carried out by the Contractor for his own convenience.

For the purposes on payment for materials on site, payment may be made at 50 % of the rates entered in the priced Bill of Quantities following delivery and the Engineer deeming the piles acceptable. The remaining 50% may be paid following testing and acceptance by the Engineer.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Furnishing and Driving PC Test Pile, Dia. 500mm, Type A	m

14.7.2 Prestressed Concrete Piles

This clause refers to the precast, prestressed concrete piles as described in Section TS 14 and other referenced sections of the Technical Specification.

Measurement for payment, of each pile size, shall be based on the lengths of piles as instructed in writing by the Engineer.

The measurement for payment shall be made for such piles whether driven or used only as undriven extensions, in linear metres (m), measured along the pile axis from the pile toe, as actually driven, to the head of the pile prior to stripping back for joining into the pile cap.

Apart from partial payments for certain materials delivered to site, as provided for below, payment shall not be made for test piles until they have been driven and accepted in accordance with the Drawings and this Technical Specification or as directed by the Engineer.

Payment will be made at the rates entered in the priced Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs. In particular rates for test piles shall be deemed to include, but not be limited to, the following:

1) Supplying precast prestressed concrete piles, taking delivery and handling

2) Preparing, handling and pitching precast prestressed concrete piles

3) Driving precast prestressed concrete piles including pre-boring and the like

4) Driving additional pile lengths

5) Dollying piles below ground or water level

6) Moving pile frames to re-test piles or re-drive lengthened piles

7) Extension of pile

8) Splicing of pile including welding consumables and equipment

9) Any excavation, dewatering and the like

No payment shall be made for lengthening of piles carried out by the Contractor to make up piles from shorter lengths than the lengths shown on the Drawings or directed by the Engineer or for any lengthening of piles which is carried out by the Contractor for his own convenience.

For the purposes on payment for materials on site, payment may be made at 50 % of the rates entered in the priced Bill of Quantities following delivery and the Engineer deeming the piles acceptable. The remaining 50% may be paid following driving and acceptance by the Engineer.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Furnishing and Driving PC Piles, Dia. 500 mm, Type A	m

14.7.3 Prestressed Concrete Sheet Piles

Measurement shall be made of the length of prestressed concrete sheet piles in place and accepted by the Engineer.

Payment for prestressed concrete sheet piles will be made at the rate entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including furnishing, handling, pitching, driving and cutting and all other items for completing the work in accordance with the specification.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Furnishing and Driving PC Sheet Pile (t=220 mm)	m

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SECTION TS 15. STEEL SHEET PILES

SECTION TS 15. STEEL SHEET PILES

15.1 GENERAL

This section covers the supply and driving of steel sheet piles

The handling and driving of steel sheet piles shall be in accordance with the requirements of Section TS 13 of this Specification except as modified hereunder.

The steel sheet piles to be furnished and driven in this contract are for seepage control and are not required to be driven to criteria based on bearing capacity.

15.2 MATERIALS

Steel sheet pile shall be of U-shape type with a yield point strength of 30 kgf/mm^2 or more as specified in JIS A5528 or equivalent approved by the Engineer. Type and sectional properties of steel sheet pile shall be as tabulated below. The material used for sheet pile shall be Type II as shown on the Drawings or directed by the Engineer.

Type of Steel Sheet Pile

Type	Width (mm)	Height (mm)	Thickness (mm)	Section Modules (cm^3)
Type I	400	85	8.0	88
Type II	400	100	10.5	152
Type III	400	125	13.0	223
Type IV	400	170	15.5	362
Type V	400	200	24.3	520

All piles shall be supplied by the Contractor

15.3 HANDLING, TRANSPORT AND STORAGE

Handling, transport and storage shall be as specified in Section TS 13

15.4 DRIVING OF PILES

15.4.1 General

Piles shall be driven generally in accordance with the requirements of Section TS 13 of this Specification except as modified below.

Only piles which have been inspected and passed by the Engineer shall be driven. Any pile which shows any defect which, in the opinion of the Engineer, would affect the driveability or durability of the pile will be rejected and shall not be used anywhere in the work.

15.4.2 Test Piles

Test piles are not required for steel sheet piles.

15.4.3 Driving Steel Sheet Piles

Steel sheet piles be pitched and driven accurately in the positions shown on the Drawings and to the required depths as directed by the Engineer.

The piles shall be pitched inside a braced template and carefully aligned and positioned before driving. Particular care shall be taken to ensure the interlocking of adjacent sheet piles. The piles shall then be driven to the required penetration in such a manner as to ensure that the vertically of the piles is maintained. In the event of any misalignment developed during driving, the Contractor shall take appropriate action to correct the condition during driving.

Piles driven in excess of 10 mm, per meter of pile length or damaged during driving may be rejected, if, in the opinion of the Engineer, the improperly aligned or damaged pile adversely affects the structure. The Contractor shall propose the corrective measures to be taken for approval by the Engineer. All corrective measures shall be at the Contractor's own expense. Rejected piles shall be expected, re-driven or placed or cut-off at all a level approved by the Engineer.

Pile shall be extended by full penetration butt welds in accordance with clause 13.4.7 of the Technical Specification.

15.5 MEASUREMENT AND PAYMENT

Measurement shall be made of the length of steel sheet piles in place and accepted by the Engineer. The length measured shall include the length of any portion cut off as the result of the specified length of pile not being driven to the toe elevation as shown on the Drawings following a directive of the Engineer to cease driving for whatsoever reason.

Payment for steel sheet piles will be made at the rate entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including furnishing, handling, pitching, driving and cutting and all other items for completing the work in accordance with the specification.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Furnishing and Driving Steel Sheet Pile, Type II	m

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SECTION TS 16. TIMBER PILES

SECTION TS 16. TIMBER PILES

16.1 GENERAL

This section covers the requirements for timber log piles to be driven as part of foundations in various parts of the Works.

16.2 MATERIALS

Timber piles shall be cylindrical logs cut from timber with recognised qualities of durability and suitability for installation as piles in wet conditions. The Contractor shall propose timber of a type or species for the Engineer's approval prior to procuring timber pile material. Logs shall be straight to a tolerance of 20 mm over their full length and shall be free of branches. The diameter of the thinnest part of any pile shall not be less than 150 mm and not shorter than the length specified on the drawings. All logs shall be treated with creosote using a method subject to the Engineer's approval. Any log not complying with the above requirements shall be removed from the site.

16.2 HANDLING

Timber piles shall be kept in neat stacks on site until ready for use. Handling shall be conducted in such a manner so as not to damage the integrity and strength of the piles.

16.3 DRIVING

Timber piles shall be pitched and driven accurately in the position and at the location shown on the Drawings and to the required depths as directed by the Engineer. During driving operations, timber pile heads shall be protected and held in position by use of a combination creation-driving head and pilot.

Timber piles shall be fresh-head and square and, when directed by the Engineer, the pile heads shall be protected by means of heavy steel or wrought iron rings. The driving head shall closely fit the top of the timber pile and shall extend down the sides of the pile at least 75 mm. During driving operations, each pile shall be restrained from lateral movement and the pile shall be kept moving by continuous operation of the hammer. If the specified penetration has not yet been reached when the energy required to continue driving is endangering the pile integrity the driving may be discontinued with the approval of the Engineer. Piles driven materially out of line and position as indicated on the Drawing shall be pulled and replaced. Deviations in the excess of 200 mm out of position and 2 percent out of plumbness or batter indicated on the Drawings shall be cause for rejection.

Cutting off and trimming of timber piles shall be done at the designated elevations. Splicing of timber piles shall not be permitted except when approved by the Engineer in writing. Piles inaccurately cut off shall be replaced. The sawn heads of all treated piles which are not embedded in concrete shall be brush-coated with 3 applications of hot creosote and covered with hot roofing pitch. The sawn heads of all treated piles to be encased in concrete need not to be treated further.

16.4 MEASUREMENT AND PAYMENT

A count shall be made of the number of timber piles of each designated length, in place and installed in accordance with the specification then that total multiplied by the nominal length of pile specified on the Drawings.

Payment for timber piles will be made at the rates entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including furnishing, handling, pitching, driving and cutting and all other items for completing the work in accordance with the Specification.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Log Pile, Dia. 150 mm L=2.0 m	m
Log Pile, Dia.150 mm, L=3.0m	m

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SECTION TS 17. STONE MASONRY

SECTION 17. STONE MASONRY

17.1 GENERAL

This section covers the general and specific requirements for the construction of the following type of masonry work:

- Wet stone masonry in flood walls, revetment construction of various types, retaining walls, ground sills, channels, dikes, drainage structures, stairways and other structures included in the Works and in places where shown on the Drawings or directed in writing by the Engineer.
- Stone facing in revetments.

17.2 MATERIALS

17.2.1 Stone

Stone for all classes of masonry shall be clean, hard, and durable. Adobe blocks shall not be used unless specified or consented to by the Engineer.

Samples of stone proposed for use in masonry construction shall be submitted to the Engineer for his consent.

Stones shall be of the sizes shown on the Drawings or appropriate for the particular application. Unless otherwise shown on the Drawings, stones shall have thickness of not less than 150 mm, widths of not less than one and a half times their respective thicknesses, and lengths of not less than one and a half times their respective widths. Each stone shall be free of depressions and projections that would prevent it from being properly bedded.

Stone to be used in wet stone masonry revetments shall be regular is size and their thickness shall be approximately 200 mm.

Stone shall be dressed to remove any thin or weak portions. Face stone shall be dressed to provide bed and joints lines that do not vary more than 20 mm from true lines and to ensure the meeting of bed and joints lines without the rounding of the corners of the stones in excess of 30 mm in radius. Bed surfaces of face stones shall be normal to the faces of the stones for 80 mm and from this point may depart from a normal plane by an angle which is not to exceed 50 mm in 300 mm.

Face stones shall be pitched to line along all beds and joints. The maximum projections of rock faces beyond the pitch lines shall not be more than 50 mm.

Stones shall increase in thickness from bottom to top of wall.

17.2.2 Mortar

Cement mortar shall be composed of one part of cement to three parts of fine aggregate by volume, or such other proportions as shall be directed by the Engineer, or as shown on the Drawings mixed with water so that the water-cement ratio does not exceed 0.45 by weight.

Hydrated lime may be added in an amount not exceeding ten (10) percent of the cement by weight. The hydrated lime shall comply with the requirements for type "N" lime in ASTM C 207 "Hydrated Lime".

17.3 CONSTRUCTION

17.3.1 Wet Stone Masonry Walls

17.2.1.1 General

This clause refers to the construction of wet stone masonry walls including, but not limited to, retaining walls, parapet walls, flood walls and leaning walls.

17.2.1.2 Selection and Placing

When the masonry is to be placed on a prepared foundation bed, the bed shall be firm and normal to, or in steps normal to, the face of the wall, and shall have been approved by the Engineer before any stone is placed.

Care shall be taken to prevent the bunching of small stones or stones of the same size large stones shall be used for the bottom courses and large, selected stones shall be used in the corners.

All stones shall be cleaned thoroughly and wetted immediately before being set, and the bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joint shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set.

The stones shall be so handled as not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. Rolling or turning stones on the walls will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar.

17.2.1.3 Beds and Joints

Beds for face stones may vary from 20 mm and to 50 mm in thickness. They shall not extend in an unbroken line through more than five stones. Joints may vary from 20 mm to 50 mm in thickness. They shall not extend in unbroken line through than two stones. They may be at angles with the vertical from 0 to 45 degrees. Face stone shall bond at least 150 mm longitudinally and 50 mm vertically. At no place shall corners of four stones be adjacent to each other.

Beds for vertical faced walls shall be level, and battered walls may vary from level to normal to the batter line of the face of the wall.

17.2.1.4 Headers

Headers shall be distributed uniformly throughout the walls of structures so as to form at least one fifth of the exposed faces. They shall be of such lengths as to extend from the front face of the wall into the backing at least 300 m. When a wall is 450 mm or less in thickness, the headers shall extend entirely from front to back face.

17.2.1.5 Backing

The backing shall be built with greater than 75 percent of stones having a minimum dimension of 200 mm. The individual stones composing the

backing and hearting shall be well bonded with the stones in the face wall and with each other. All openings and interstices in the backing shall be filled completely with mortar or with spalls surrounded completely by mortar.

17.2.1.6 Pointing

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar. The mortar shall be well driven into the joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done and in hot or dry weather the pointed masonry shall be protected from the sun and kept wet for a period of at least 3 days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

17.2.1.7 Plastering

Plaster, if called for, shall of the same mix proportions as for mortar. Before plastering commences the surface to be plastered shall be cleaned of any dirt, grease, organic matter or any other deleterious substance. The surface shall then be wet with water. Plaster shall be applied so as to firmly key into the surface being treated. The finished surface shall be uniform in texture and regular in appearance. Flat surface shall be flat to a tolerance of 10 mm measured with a 2 m long straight edge.

17.2.1.8 Coping

Copings, if called for, shall be as shown on the Drawings. Where copings are not called for, the top of the wall shall be finished with stones wide enough to cover the top of the wall from 450 mm to 1 metre in length, and of random heights, with a minimum height of 150 mm. Stone shall be laid in such a manner that the top course is an integral part of the wall. The tops of the top courses of stone shall be pitched to line in both vertical and horizontal planes.

17.2.1.9 Weep Holes

All walls and abutments shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets for water can be obtained and shall be spaced not more than 2 metres centre to centre.

Weep holes shall be constructed in accordance with the requirements of Section 18 of the Technical Specification, Weep Holes.

17.2.1.10 Cleaning Exposed Faces

Immediately after being laid, and while the mortar is fresh, all faces stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

17.2.1.11 Curing

The masonry shall be satisfactorily protected from the sun and shall be kept wet for a period of at least three days after completion.

17.3.2 Wet Stone Masonry for Revetment Facing

17.3.2.1 General

This clause refers to the use of wet stone masonry for surface protection construction in revetments or where otherwise required to complete the Works.

17.3.2.2 Preparation

The gravel bed shall be completed to the approval of the Engineer prior to placing wet stone masonry.

All concrete work around the perimeter of the intended wet stone masonry work shall be completed to the satisfaction of the Engineer prior to commencing wet stone masonry.

17.3.2.3 Selection and Placing

All stones shall be cleaned thoroughly and wetted immediately before being set, and the gravel bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joint shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the revetment face in which the stones are set and the pattern shall be regular.

The stones shall be so handled as not to jar or displace the stones already set.

17.3.2.4 Beds and Joints

Beds for stones may vary from 20 mm and to 50 mm in thickness. At no place shall corners of four stones be adjacent to each other.

17.3.2.5 Pointing

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar. The mortar shall be well driven into gaps between stones with a pointing tool. Stones shall be proud of the pointed mortar by approximately 30 mm. The wall shall be kept wet while pointing is being done and in hot or dry weather the pointed masonry shall be protected from the sun and kept wet for a period of at least 3 days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

17.3.2.6 Weep Holes

Weep holes shall be constructed at the locations as shown on the Drawings or as directed by the Engineer in accordance with the requirements of Section 18, Weep Holes.

17.3.2.7 Cleaning Exposed Faces

Immediately after being laid, and while the mortar is fresh, all faces stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

17.3.2.8 Curing

The masonry shall be satisfactorily protected from the sun and shall be kept wet for a period of at least three days after completion.

17.3.3 Chipping of Existing Masonry

17.3.3.1 General

This clause refers to the chipping back of the surface of existing plastered masonry walls in order to prepare them for joining new masonry to the old.

17.3.3.2 Method of Execution

All plastering shall be chipped back as shown on the Drawings in order to expose clean stonework of the existing masonry structure.

The chipped surfaces of existing masonry against which new masonry is to be placed shall be brushed clean, and wetted with water . New masonry shall not be placed until the prepared surface of the existing masonry has been inspected and approved by the Engineer.

Masonry extensions to prepared surfaces shall be laid in accordance with the specification for new stone masonry above.

17.4 MEASUREMENT AND PAYMENT

Wet Stone Masonry

Measurement will be made of the volume of stone masonry complete in place and accepted. Projections extending beyond the faces of the walls will not be included. In computing the quantity for payment, the dimensions used shall be those shown on the Drawings or ordered in writing by the Engineer. No deductions shall be made for weep holes, drain pipe, pipe, or other openings of less than 0.01 square metres in area.

Payment will be made at the unit price entered in the priced Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of stone masonry.

Pointing

Measurement will be made of the area of the surface of wet stone masonry in which the mortar has been pointed and accepted. The area measured will be the gross area which includes stone and pointed mortar. No deduction shall be made for the areas occupied by stone, weep holes or openings less than 0.01 square metres.

Payment will be made at the unit price entered in the priced Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of pointing.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Wet Stone Masonry	m3
Pointing	m2

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SECTION TS 18. GABIONS AND MATTRESSES

SECTION 18. GABIONS AND MATTRESSES

18.1 GENERAL

This section of the Technical Specification covers the requirements for Gabions and Gabion Mattresses (also known as reno mattresses).

Gabions shall be flexible galvanised wire boxes of the size stated in the Drawings, fabricated of wire mesh of the type and size, and selvedged as specified as specified below. Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 mm except in the case of reno mattresses where the diaphragms shall have a maximum spacing of 600mm.

18.2 MATERIAL REQUIREMENTS

18.2.1 Gabion Wire Mesh Baskets

Wire

Wire used in the fabrication of gabions and in the wiring operations during construction shall conform to AASHTO M 279 (ASTM A 116) having a tensile strength of not less than 350 MPa (3500 kg/cm^2). The minimum weight of zinc coating shall be 250 g/m^2.

The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns around a mandrel of four times the diameter of the wire, it shall not crack to such an extent that any zinc can be removed by rubbing with the bare fingers.

Where shown in the Drawings or shown in the Bill of Quantities, wire, galvanized as specified above, shall be coated with PVC in accordance with the manufacturer's recommendations.

Manufacture

The mesh shall be hexagonal woven mesh wherein the joints are formed by twisting each pair of wires through three half turns. The diameter of the wire shall be as shown on the drawings but not less than 3 mm for body wire, 3.9 mm for perimeter wire and 2.4 mm for tying and connecting wire.

The undisturbed size of the mesh shall be as shown on the drawings but shall not be greater than 80 mm by 100 mm. The tightness of the twisted joints shall be such that a force of not less than 1.75 kN pulling on one wire is required to separate it from the other wire when each wire is prevented from turning and the wires and the applied force are in the same plane.

The wire mesh shall have elastic properties sufficient to permit elongation of the mesh equivalent to a minimum of 10% of the length of the section of mesh under test without reducing the gauge or tensile strength of individual wire strands to values less than those for a similar wire one gauge smaller in diameter.

All edges of the gabions, diaphragms and end-panels except as stated below shall be selvedged with a wire of which the diameter is 25% greater than that of the wire used to form the mesh. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it shall be attached by binding the cut ends of the mesh, so that a force of not less that 8.5 kN applied in the same plane as the mesh, at a

point on the selvedge of a mesh sample of length one (1) metre is required to separate it from the mesh.

The diaphragms and end-panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by twisting the cut ends of the mesh at the bottom of the panel about the selvedge on the base of the gabions. Similarly, the diaphragms shall be attached by twisting the cut ends of the mesh to the twisted joins of the mesh of the gabions. In each case the force required to separate the panels from the base shall not be less than that required to break the mesh over the same length.

Sufficient binding and connecting wire shall be supplied with the gabions to perform all the wiring operations to be carried out in the construction of the gabion work as stated below. The diameter of the binding wire shall not be less than 2.20 mm.

Tolerances

A tolerance on the diameters of all wire of + or – 2.5 % shall be permitted. The length of the gabions is subject to a tolerance of + or – 3 % and the width of gabions to a tolerance of + or – 25 mm. All other gabion dimensions are subject to a tolerance of + or – 3% of the sizes shown on the Drawings.

18.2.2 Stone Fill

Stone fill material shall consist of hard, durable stone of minimum dimension 100 mm and maximum dimension of 250 mm.

18.3 CONSTRUCTION

Gabions and Gabion Mattresses

Prior to constructing gabions the bed on which they are to be placed shall be cut to the lines and profiles as shown on the Drawings.

The placement of the gabion boxes shall be carried out in an orderly manner so that a face of incomplete work is maintained.

At least two rows of empty boxes shall be wired together at the face of uncompleted work prior to filling the box closest to the completed work. Prior to filling any box, one end or side of the box shall be secured to completed works or to stakes driven into the ground at the corners or in any other approved manner and the opposite end, side or corner shall be stretched with crow bars and secured to and bottom in a suitable manner.

Stone fill material shall be placed carefully in order to ensure that it is tightly packed with a minimum of voids. The boxes shall be filled to between 25 mm and 50 mm above their tops. The top layer of material shall consist of selected small stone not less than 100 mm minimum dimension.

18.4 MEASUREMENT AND PAYMENT

Gabion Mattresses

Measurement shall be made of the volume of gabion mattresses in place and accepted by the Engineer.

Payment shall be made at the rate entered it the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Drawings, the Specification and instructions by the Engineer.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Gabion Mattress t=500mm (Galvanized)	m^3