Fiji Electricity Authority
Wainikasou Penstock Flow Meter Chamber Construction
Technical Specifications

Revision Schedule

Rev No	Date	Description	Prepared By	Reviewed By	Approved By
A	11/11/16	Issue for tender	Nik Devlin	Greg Brown	Greg Brown

Reference Drawings

Please refer to the following schedule of Drawings that should be read in conjunction with this Technical Specification

Number	Title	Revision	Status
Z1680109-01-001-C601	Site Plan	0	For Tender
Z1680109-01-001-C602	Plans and Sections	0	For Tender
Z1680109-01-001-C603	Precast Roof Slab and Ladder Details	0	For Tender

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1110: Earthworks (General)

1 General

1.1 Scope of this Specification

a) This specification has been prepared specifically for the project and client shown on the title page and should not be relied upon for any other purpose.

b) This Specification covers the construction of earthworks including the clearing and removal of obstacles within the limit of the earthworks; excavation of all cuttings; excavation in borrow areas; benching; surface drainage facilities; the carting of the excavated fill or waste; construction of fills; shaping, trimming, grassing; and the maintaining of the works.

c) Sections 1, 2 and 3 contain generic specifications applicable to civil engineering contracts in general. Section 4 contains specifications that are specific to this Contract and takes precedence over sections 1, 2 and 3.

1.2 Applicable Codes and Standards

a) All work, materials and practices shall comply with the requirements of current New Zealand or Australasian standards for that particular class of work. The following standards shall apply specifically:

NZS 4224:1983	: Code of practice for measurement of civil engineering quantities
NZS 4402:1986	: Methods of testing soils for civil engineering purposes
NZS 4404:2010	: Land Development and subdivision engineering
NZS 4431:1989	: Code of practice for earth fill for residential development
TNZ F/1:1997	: Specification for Earthworks Construction

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

c) The documents listed above and in the clauses that follow refer to their latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

1.3 Definitions

Stripped Ground	: The lowest excavated surface after clearance, removal of topsoil and removal of any other materials deemed unsuitable by the Engineer.
Engineered Fill	: The material placed and compacted in the fill, from ground surface, in a manner and of such material(s) that provides a stable earthfill suitable for the intended purpose.
Landscape Fill	: The material placed in the fill, from ground surface after clearance and removal of topsoil (if required), in a manner that provides a stable earthfill for the intended purpose. Material shall exclude vegetation, rubbish, noxious and organic matter except as permitted in Section 4 of this Specification.
Hardstanding	: A trafficable area constructed from aggregates, including rockfill.
Drainage Blanket	: A layer of highly permeable granular or rock fill, including a geotextile above and below the fill.

1.4 Abbreviations

NZTA : New Zealand Transport Agency, (formerly TNZ)
TNZ : Transit New Zealand, (now NZTA)

2 Materials

2.1 Quality Assurance

It shall be the Contractor's responsibility to ensure that the materials comply in all respects with the Drawings and Specification.

2.2 Classification of Material

a) Material shall be classified as Type A, R1, R2, W or U as defined in Clause 8 of TNZ F/1, except as modified in Section 4 of this Specification.

b) Material shall only be classified as Type W where the material is too wet for immediate use at the time of excavation, provided such excavation is being undertaken during a permitted earthworks period as stated in Section 4 of this Specification, or unless it is identified in Section 4 of this Specification as requiring treatment to render the material suitable for use. Material rendered Type W due to the Contractor's method of working or working outside the permitted earthworks period or during wet weather will be considered to be Type A material and any treatment necessary to render the material suitable for use will be at the Contractor's cost.

c) Type H material is material unsuitable for use in construction fill due to chemical contamination or because of its hazardous nature (for example, refuse). The location, required treatment and disposal of such materials, where present or expected, are stated in Section 4 of this Specification.

2.3 Alternative Materials

Should the Contractor propose to use materials other than those in this Specification, he shall submit detailed specifications of the materials he proposes to use to the Engineer for approval. The Contractor shall not use any such materials until he has obtained written approval for their use from the Engineer.

3 Execution

3.1 General

a) Earthworks construction shall be as required by TNZ F/1, as modified and extended by this Specification. Where any conflict arises, this Specification shall take precedence.

b) Unless specifically detailed in Section 4 of this Specification, the Contractor shall make his own arrangements for stockpiling of acceptable material, unacceptable materials and reusable items (including topsoil), and for the provision of sites for the purpose. The Contractor shall also be responsible for the removal of surplus materials and restoration of the stockpile sites upon completion of the Contract Work.

c) The Contractor shall ensure that the stability of excavations and fills are not adversely affected by construction activities, or by the location of stockpiling materials or plant, or by the siting of temporary buildings or structures.

3.2 Demolition and Site Clearance

No demolition shall be required for this project.

Site clearance is limited to removal and storage for reuse of top soil of existing grassed area where the Works shall take place.

3.3 Hazardous Waste and Contaminated Soils

Hazardous waste and contaminated soils (Type H materials) encountered during the progress of the Works shall be treated and/or disposed of as stated in Section 4 of this Specification.

3.4 Removal of Topsoil

a) Topsoil shall be removed in accordance with Clause 4 of TNZ F/1 and stockpiled to provide for subsequent replacement. Topsoil shall be as defined in Clause 2.12 of TNZ F/1.

b) The nominal depth to be stripped varies but shall be confirmed on site, depending on the actual depths available. If required in Section 4 of this Specification, the Contractor shall take photographs of the topsoil depth at 100 metre intervals longitudinally along the earthworks and at 50 metre intervals transverse to the earthworks. Photographs shall be submitted to the Engineer and labelled to clearly show the depth of topsoil with tape measure (or similar) date and location. Photos may be used for the purposes of quantity calculation and progress payments.

c) Topsoil shall wherever practicable be used immediately after stripping, or otherwise shall be stored in stockpiles of height not exceeding 2m or other heights stated in Section 4 of this Specification. Stockpiles shall not be surcharged or otherwise loaded.

3.5 Classified and Erodible Soils

a) The Contractor shall immediately advise the Engineer if Type R2, U or H materials are unexpectedly encountered in order that quantities may be determined prior to the excavation of the material. The Contractor shall take photographs of all areas where a change in material is located. These shall be submitted to the Engineer and clearly labelled to show the date and location of the photograph.

b) Where soils are stated in Section 4 as being erodible, the Contractor shall ensure that all exposed surfaces are well compacted at all times to minimise erosion issues. An erosion control plan shall be developed, agreed with the Engineer, and implemented to not only minimise the risk of erosion, but to also mitigate the impact of any erosion that occurs within the site of works as a result of the Contract Works or construction activities.

3.6 Site Drainage

a) Surface drainage shall be in accordance with Clause 5 of TNZ F/1 and the following requirements.

b) During construction, all areas of earthworks shall be kept free from water as much as possible. Using drains or other means, surface water shall be kept from flowing from the surrounding country on to the excavations or areas of fill. The Contractor shall ensure that there is adequate drainage at all times. Temporary side and cross drains shall be provided as necessary and the excavation shall always be cambered and any loose material compacted to prevent absorption and to facilitate surface drainage.

c) Particular care shall be taken to ensure that surface water does not wet embankments or fill material that has yet to be compacted. Crossfalls of 7% from the earthworks centreline shall be maintained to facilitate surface drainage during periods of wet weather and during any period outside of the permitted earthworks season stated in Section 4 of this Specification. Any remedial work required as a consequence of the Contractor's failure to keep the site drained, shall be at the Contractor's expense.

3.7 Excavations

a) Excavations shall be in accordance with Clause 9 of TNZ F/1 and modified by the following requirements.

b) The Contractor shall be responsible for all required temporary works to ensure the safety of workers and the public, including any adjacent buildings and infrastructure.

c) Excavation shall be carried out in a manner to produce neat cut faces to the batters shown on the drawings and to the lines and levels where shown on the drawings or as stated in Section 4, including the use of any required slope or excavation support. All excavation shall be done in a manner which ensures the cut surfaces will be adequately drained at all times.

d) Except where otherwise stated in Section 4 of this Specification, the excavation of cuttings shall be halted 400mm above formation level or final subgrade level to provide weather protection and left in place until construction of the formation or final subgrade level. At no time shall the formation or final subgrade level be left exposed to the weather to the detriment of the in-situ materials (including hot dry weather).

e) Dump areas will not be permitted immediately adjacent to engineered fills.

f) Benching shall be undertaken on any slope steeper than 2H:1V. Bench widths shall be of earthworks machinery width and not exceeding 1m high unless otherwise stated in Section 4 of this Specification.

3.8 Filling and Compaction

a) Filling and compaction shall be in accordance with Clause 10 of TNZ F/1 and modified by the following requirements.

b) Filling shall be undertaken to the line and levels shown on the drawings or as stated in Section 4, including the use of any required slope support. The Contractor shall be responsible for all required temporary works to ensure the safety of workers and the public, and to prevent damage to adjacent buildings, infrastructure and utilities.

c) Fill placed over areas with a high groundwater table or liable to be inundated by water during flood events, shall be constructed upon a drainage blanket as required and specified in Section 4 of this Specification.

d) Fill shall be placed in a systematic manner, with near-horizontal layers of uniform thickness of material each being deposited progressively across the fill area to bring up, as far as is possible, the whole surface at an even rate. If for any reason the filling cannot be constructed by placing uniform and approximately horizontal layers of fill, the Contractor shall propose a methodology for approval by the Engineer.

e) The uncompacted thickness of each fill layer shall be limited to 230mm unless the Contractor can demonstrate that the specified compaction is achieved for the full depth of the proposed layer thickness. A trial filling section will be required, which, subject to achieving the required degree of compaction, may be accepted as part of the permanent works.

f) Where an engineered fill is used as a haul road or trafficked other than to construct the fill, a 400mm sacrificial layer will be required over the engineered fill. Where this is not provided, the uppermost 400mm of placed fill shall, prior to placement of the next embankment fill lift or completion of the earthfill and placement of any pavement or other construction, be removed and replaced with compacted engineered fill at the Contractor's expense.

g) Abandoned watercourses within the footprint of any fill shall be cleaned out including the removal of all vegetation, vegetable matter and all alluvial deposits within and adjacent to the watercourse. Unless stated otherwise in Section 4 of this Specification, the resulting hole shall be filled with Type A material.

h) Except where otherwise stated in Section 4 of this Specification, compaction shall be in accordance with Clause 10 of TNZ F/1.

i) Landscape fill shall be well compacted for stability by tracking with earthworks plant.

3.9 Slips

a) This section replaces Clause 12 of TNZ F/1.

b) Known slips shall be treated as detailed in Section 4 of this Specification.

c) Any area affected by slips during the works shall be identified, photographed and reported to the Engineer without delay. Any resulting hazard to the public shall be promptly and appropriately fenced off.

d) Work associated with the remediation of any slip shall be treated as a variation provided the slip did not occur as a direct consequence of the Contractor's method of working or failure to comply with the Specification or the requirements of this Contract.

3.10 Shaping, Topsoiling, Grassing and Batter Protection

a) Except where otherwise stated in Section 4 of this Specification, shaping and topsoiling shall comply with Clause 14 of TNZ F/1.

b) Except where otherwise stated in Section 4 of this Specification, grassing and batter slope protection shall comply with Clause 15 of TNZ F/1.

3.11 Tolerances

Unless otherwise stated in Section 4 of this Specification, earthworks shall be constructed to the following tolerances:

	Permissible Deviation
Excavations for Structural Foundations and Floor Slabs:	
Position on plan	± 35 mm
Dimensions on plan	± 50 mm
Level of surface trimmed to receive concrete other than floor slabs	± 50 mm
Level of surface trimmed to receive concrete floor slabs	± 15 mm
Terraces and Embankments:	
Position of top edge of terrace from designated position	± 300 mm
Alignment of top edge of terrace from a line joining any two points 30m apart on top edge of terrace	± 100 mm
Finished levels	± 50 mm
Slopes of top surfaces from direction of slope	Nil
Slopes of top surfaces from rate of fall:	
i. 1 in 100 to 1 in 300	± 10 %
ii. Flatter than 1 in 300	± 5 %

3.12 Inspection and Testing

3.12.1 General

All acceptance tests shall be carried out in the presence of the Engineer during normal working hours. The Contractor shall give the Engineer 24 hours notice that the test will be carried out.

3.12.2 Testing of Borrow Sources

a) Before filling commences, the Contractor shall take samples from each proposed borrow source and conduct compaction tests to determine the maximum dry density and optimum moisture content in accordance with Test 4.1.1 or 4.1.2 of NZS 4402. Section 4 of this Specification sets out the required test methods and the minimum number of tests required per borrow source.

b) Should the materials from a borrow source appear to change from that tested, the above testing shall be repeated upon request by the Engineer.

3.12.3 Testing of Fill Placement

The Contractor shall provide certification from an independent soils testing laboratory, approved by the Engineer, that the filling and construction of all compacted fill is in accordance with this Specification. The testing laboratory shall supply a description of the type and frequency of all tests making up the testing regime for the earthworks to the Engineer for his approval before commencing any filling work. Section 4 of this Specification sets out the minimum testing requirements and frequency of testing.

4 Project Specification

This section contains project specific schedules and specifications, and takes precedence over sections 1, 2 and 3 above.

4.1 General

Not used

4.2 Materials

4.2.1 Material Classifications

There are no changes to the material classifications given above.

4.2.2 Type H Materials

It is expected that there are no Type H materials within the Site. Upon discovery of suspected Type H materials, the Contractor shall stop work and inform the Engineer of the discovery and await instruction.

4.2.3 Fill Material

The excavated material shall be cut to fill if it satisfies the criteria of either Type A, R1, R2 or W materials. Should the excavated materials be unsatisfactory, the Contractor shall inform the engineer and await instruction.

4.2.4 Erodible Soils

The material on the site is expected to be highly erodible.

4.3 Execution

4.3.1 Stockpiling of excavated materials

The Contractor shall agree the location within the powerhouse site of the stockpile with the Employer's representative prior to commencement of work.

4.3.2 Minimum testing and frequency

Testing shall be in accordance with Clause 10, TNZ F/1, with one test per layer.

4.3.3 Extent of filling and topsoil

The extent of filling shall to return to existing ground level. The Contractor shall undertake a level survey of the area to be excavated and submited to the Engineer five (5) Days before excavation works commence.

The top 400mm of fill shall be top soil, after storage and reuse in accordance with Section 3.4 above.

4.3.4 Grassing

Grassing shall not be required.

4.3.5 Minimum Benching height

The minimum benching height specified above shall not apply to R1 and R2 materials.

1130: Concrete (Structural)

1 General

1.1 Scope of this Specification

a) This specification has been prepared specifically for the project and client shown on the title page and should not be relied upon for any other purpose.

b) This specification covers the requirements for structural concrete (plain, reinforced and pre-stressed) and includes specific clauses for hydraulic structures.

c) Sections 1, 2 and 3 contain generic specification clauses applicable to all contracts. Section 4 contains specification clauses that are specific to this Contract and takes precedence over sections 1, 2 and 3.

1.2 Applicable Codes and Standards

a) All work, materials and practices shall comply with the requirements of current legislation, standards and codes for that particular class of work. The following standards shall apply specifically:

AS 1478.1:2000	: Chemical admixtures for concrete, mortar and grout – admixtures for concrete
AS 3610:1995	: Formwork for concrete
AS 3799:1998	: Liquid membrane forming curing compounds for concrete
BS 4486:1980	: Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
AS/NZS 1554.1:2014	: Structural Steel Welding - Welding of Steel Structures
AS/NZS 1554.3:2014	: Structural Steel Welding - Welding of Reinforcing Steel
AS/NZS 1170 Set	: Structural Design Actions Set
AS/NZS 2980:2007	: Qualification of welders for fusion welding of steels
AS/NZS 4671:2001	: Steel Reinforcing Materials
AS/NZS 4672.1:2007	: Steel prestressing materials – General requirements
ASTM C309-11	: Standard Specification for Liquid membrane-forming compounds for curing concrete
NZS 3101:2006	: Concrete Structures Standard
NZS 3104:2003	: Specification for Concrete Production
NZS 3106:2009	: Concrete Structures for the storage of Liquid
NZS 3109:1997	: Concrete Construction
NZS 3111:1986	: Methods of Test – water and aggregate
NZS 3112:1986	: Method of Tests for Concrete
NZS 3114:1987	: Specification for Concrete Surface Finishes
NZS 3121:2015	: Specification for Water and Aggregate for Concrete
NZS 3122:2009	: Specification for Portland and Blended Cements (General and Special Purpose)
NZS 3123:2009	: Specification for Pozzolan for use with Portland and Blended Cement
NZS 3124:1987	: Specification for Concrete Construction for Minor Works
NZS 3125:1991	: Specification for Portland–Limestone filler Cement
NZS 4702:1982	: Metal-arc welding of Grade 275 Reinforcing Bar

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

c) The documents listed above and in the clauses that follow refer to the latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

1.2.1 Other Publications

Other publications applicable to this specification are:

i. Building Industry Authority: New Zealand Building Code Handbook and Approved Documents, 1992.

ii. Cement and Concrete Association of New Zealand, TR 3, 1991: Alkali aggregate reaction-minimizing the risk of damage to concrete.

iii. Cement and Concrete Association of New Zealand, TR 11, 2003: Properties of New Zealand Concrete Aggregates

iv. Cement and Concrete Association of New Zealand/ SANZ, New Zealand Guide to Concrete Construction

v. New Zealand Transport Agency TNZ Standards.

vi. WorkSafe Guides and approved Codes of Practice.

vii Relevant Territorial Authority's Codes of Practice.

viii Cement and Concrete Association of New Zealand, Code of Practice for weathertight concrete and concrete masonry construction

1.3 Definitions and Abbreviations

a) The term "hydraulic structure" used in this specification means environmental engineering concrete structures for the containment, treatment, or transmission of water, wastewater, or other fluids.

b) In accordance with NZS 3104 and 3109 there are 3 types of specification methods for concrete mixes
   i. P Prescribed concrete
   ii. N Normal concrete
   iii. S Special concrete

c) "Construction reviewer": the role assigned to the construction reviewer by NZS 3109 has been ascribed below to the one of the following parties – designer, the main contractor or the subcontractor. Where NZS 3109 specifies a role for the construction reviewer this specification clarifies which of these 3 parties assumes that responsibility.

1.4 Existing Structures

When matching new concrete work to existing structures and where stated in this Specification, the Contractor shall verify specified dimensions against site measurements prior to fabrication and report discrepancies to the Engineer.

1.5 Shop Drawings and Contractor Designed Items

1.5.1 General

a) The Contractor shall allow for:

i. preparation of shop drawings, and

ii. preparation of designs and specifications for those portions of the Contract Works which the Contract Documents specify as being designed by the Contractor (if any),

and for submission of such documentation for review by the Engineer.

b) The Contractor shall submit the required documentation for review to the Engineer in due time to ensure conformance with the programme and not less than the periods stated in 1.5.2 and 1.5.3 below. The Contractor shall make due allowance in the programme for the design work, review and re-review, prior to the time required for ordering Materials and commencing fabrication.

c) The status of documents submitted by the Contractor and reviewed by the Engineer or Principal shall be in accordance with the following:

   i. Review of shop drawings or Contractor-designed items shall not relieve the Contractor of responsibility for the correctness of its shop drawings, designs and site dimensions, or for ensuring the Contract Works are performed in compliance with the Contract Documents.

   ii. Review merely establishes whether the Engineer or Principal has any objection to the documentation and indicates only that it has been reviewed without the need for further modification, other than the corrections indicated by the Engineer.

   iii. Reviewed documentation which contains comments or notations indicating where the documents are at variance with the Contract Documents shall be modified and resubmitted to the Engineer for re-review.

   iv. Unless otherwise specified, the shop drawings and Contractor-designed items shall comply with the stated requirements, details and specifications of the manufacturers and suppliers of individual equipment components and Materials.

   v. Review shall not be construed as authorising any variation from the requirements of this Contract, except where explicitly stated.

c) Refer to NZS 3910 clause 2.9 [*Documents prepared by the Contractor*] for the method of processing documents prepared by the Contractor; such provisions shall apply except as modified in 1.5.2 and 1.5.3 below.

d) The periods for review stated in 1.5.2 and 1.5.3 below are subject to change in response to the quantity and complexity of designs under review by the Engineer at any one time.

e) The periods for review in 1.5.2 and 1.5.3 below shall be calculated from the date on which the Engineer receives the Contractor's submission for review to the date on which the Engineer issues notice of the outcome of its review.

f) The Contractor shall provide final shop drawings, and final Contractor designs (if any), including modifications required by the Engineer, before proceeding with procurement, fabrication or erection. Any works executed in advance of final review of such documents shall be at the Contractor's risk.

1.5.2 Shop Drawings

a) Shop drawings in this section refer to drawings developed by the Contractor from Drawings, designs and descriptions of the Contract Works prepared by the Engineer or Principal.

b) Prior to submitting shop drawings for review, the Contractor shall ensure that:

   i. Site measurements have been performed and documents prepared by the Engineer or Principal have been checked,

   ii. The shop drawings have been coordinated with all requirements of the Drawings and Specifications, and

   iii. The shop drawings have been coordinated with the requirements and shop details of all other trades.

c) The Contractor shall advise the Engineer of any errors, omissions or ambiguities in the Drawings or Specifications found in the course of preparing the shop drawings and shall comply with the Engineer's notice of the manner in which the error, omission or ambiguity is to be resolved.

d) Shop drawings shall contain sufficient detail to enable competent tradespersons to fabricate the items to the dimensions and standards stated in the Drawings and Specifications.

e) The Contractor shall allow at least 10 Working Days for first review by the Engineer of shop drawings and layouts and at least 5 Working Days for re-review.

1.5.3 Contractor Designed Items

a) Contractor designed items in this section refers to detailed Drawings, designs and calculations relating to Temporary Works or the Contract Works or portion thereof that are specified to be prepared by the Contractor on the basis of outline designs, descriptions and performance specifications contained in the Contract Documents or otherwise provided by the Principal or Engineer.

b) For review of drawings or other data relating to Contractor designed items prior to their issue for construction, the Contractor shall allow at least 15 Working Days for review by the Engineer and 5 Working Days for re-review.

c) The Contractor shall avoid submitting large quantities of Drawings and other design submittals at any one time, particularly if these are complex. Failure to observe this requirement may result in the period specified for review by the Engineer being extended, which shall not, of itself, entitle the Contractor to an extension of the Due Date for Completion.

d) Unless otherwise specified, Contractor designed items shall be submitted with a designer's producer statement in the form included in the Contract Documents.

2 Materials

2.1 Approval of Materials

2.1.1 Quality Assurance

a) It shall be the Contractor's responsibility to ensure that the construction of all precast and insitu concrete work complies in all respects with the Drawings and Specifications.

b) The Contractor's quality assurance procedures shall encompass all aspects of the concrete construction, including, but not necessarily limited to:

i. concrete mix design;

ii. evidence of compliance with requirements to prevent alkali-aggregate reaction;

iii. proposed concrete testing procedures;

iv. shop drawing submission and review;

v. pre-pour inspection procedures;

vi. reinforcing compliance records;

vii. certificates for pre-stressing and post tensioning strand;

viii. extension calculations for pre-stress strand;

ix. post tension calculations of extensions, friction losses and force profiles along the cable length;

x. concrete batch/delivery docket records;

xi. curing methodologies for the various parts of the structures; and

xii. off site precast inspection.

c) The Contractor shall nominate and advise the Engineer of a suitably experienced and qualified representative to be responsible for the quality control of all precast and in-situ concrete.

d) The Contractor shall supply evidence of production quality standards to the Engineer in advance of construction in accordance with NZS 3109.

2.1.2 Concrete Technical Information

Should it be requested by the Engineer, the Contractor shall provide the following information for review:

i. the ready mixed concrete supplier's mix design (see clause 2.2.4.2), including evidence from the Contractor that he has provided full information to the supplier to enable him to understand the concrete design requirements and to enable him to design the concrete mix to satisfy the requirements of the Contract;

ii. curing methodology;

iii. concrete compression test results analysed in accordance with the requirements of NZS 3109;

iv. slump tests analysed in accordance with the requirements of NZS 3109;

v. shop drawings of precast concrete items;

vi. delivery dockets and pre-pour check sheets which shall be available for the Engineer's inspection on site;

vii. extension calculations for prestressed concrete items; and

viii. extension, friction, and force calculations for post tensioning cables.

2.2 Material Standards

2.2.1 Cement

a) Cement shall comply with NZS 3122, and be certified as made in New Zealand unless otherwise approved in writing by the Engineer, or specified in section 4 of this Specification or on the drawings. Alternative cement may only be used if specifically approved in writing by the Engineer.

b) Alternative cements shall comply with NZS 3123 or NZS 3125.

2.2.2 Aggregate and Water

Aggregate and water shall comply with the requirements of NZS 3122. The maximum nominal aggregate size used in the concrete mixes shall be 20mm, with the exception of mass concrete or unless otherwise specified in section 4 of this Specification or on the drawings.

2.2.3 Reinforcement

a) Reinforcing steel bars shall be hot rolled steel bars complying with AS/NZS 4671 as supplied by Pacific Steel unless otherwise approved in writing by the Engineer.

b) Reinforcing steel shall be Class E in accordance with AS/NZS 4671. Class L and N shall not be used unless expressly noted on the drawings.

c) Grade 500 reinforcing steel shall be manufactured by micro alloy techniques. Reinforcing manufactured by quenching and tempering processes will not be permitted.

d) Reinforcing steel shall be identified along its length with:
   i. The strength grade
   ii. The ductility class
   iii. The steel producer
   iv. The method of manufacture

e) Plain round mild steel bars (Grade 300E) are denoted by the symbol **R** in the drawings.

f) Deformed mild steel bars (Grade 300E) are denoted by the symbol **D** in the drawings.

g) Deformed high tensile steel bars (Grade 500E) are denoted by the symbol **HD** in the drawings.

h) Reid bars are denoted by the symbol **RB** in the drawings.

i) Laps shall be located where shown on the drawings and these positions shall not be varied without the approval of the Engineer. Where no laps are shown for long length bars, then random lapping shall be used provided laps in adjacent bars are staggered. Unless shown otherwise the length of laps shall be in accordance with NZS 3101.

j) Hooks and bends shall be in accordance with NZS 3101 and NZS 3109.

k) Reid reinforcing bars, and fittings (couplers, footplates etc) shall comply with the requirements of the manufacturer, Reid Engineering Systems Ltd, and shall be used strictly in accordance with their recommendations.

l) Except where shown on the drawings, mechanical connection of reinforcement shall not be permitted without prior written approval from the Engineer. All mechanical connections where permitted shall be installed in accordance with the manufacturer's recommendation, and shall comply with the provisions of NZS 3101.

2.2.4 Concrete

2.2.4.1 Concrete Strengths

Concrete strengths shall be as shown on the Drawings or as specified in section 4 of this Specification.

2.2.4.2 Concrete Mix Design Submission

a) Concrete mix design details shall be submitted to the Engineer at least two weeks before concrete supply commences. Submission of these details in no way reduces the Contractor's obligation to meet the requirements of this Contract. Neither does the submission of details infer in any way that the Engineer has approved them.

b) The following mix details shall be supplied in writing:

i. specified strength of concrete and grade;

ii. minimum target mean strength;

iii. nominated slump;

iv. grading curve for the aggregates;

v. source and type (crushed etc) of aggregate;

vi. batch weights of cement and aggregate;

vii. total free water content;

viii. water/cement ratio by weight;

ix. fineness modulus of the sands;

x. any admixtures, name and quantity;

xi. yield;

xii. source and type of cement and aggregates including sands; and

xiii. proposals for extending the workability for time periods longer than the 90 minutes in NZS 3109 cl 7.4.1, if required.

c) Concrete mixes shall be capable of being readily placed and compacted in normal placing situations without segregation. They shall result in homogeneous, dense concrete with low shrinkage characteristics, and capable of achieving the specified surface finish. The Contractor shall show by previous records or trial mixes that these requirements can be met with concrete achieving the specified strength.

d) No change shall be made to the submitted mix details without reference to the Engineer.

e) All concrete mixes shall be produced strictly in accordance with submissions accepted in writing by the Engineer.

1.1.1.1 2.2.4.3 Concrete Supply

a) Concrete used in the construction shall be either made on the site, supplied ready mixed, or supplied in the form of precast products. Site mixed concrete shall comply with NZS 3104 or NZS 3124 as appropriate.

b) The concrete plant must have a current Certificate of Audit in terms of NZS 3104. The concrete supplier shall submit to the Engineer the current Certificate of Audit and the name and contact details of the assigned plant engineer.

c) Delivery dockets shall be supplied by the producer for each load. Dockets shall contain the following minimum information for each load:-

i. name of concrete supplier;

ii. specified grade of concrete (strength);

iii. cement content;

iv. maximum aggregate size;

v. slump;

vi. date and time of mixing;

vii. quantity delivered;

viii. identifying number of truck; and

ix. additives used.

1.1.1.2 2.2.4.4 Concrete Additives

a) Unless otherwise specified, no concrete additive shall be included in the concrete mixes without the written approval of the Engineer. Chemical admixtures, where approved by the Engineer for use in concrete, shall comply with AS 1478, and shall be used in accordance with NZS 3109.

b) No calcium chloride or chloride containing admixture shall be added to any mix.

c) An approved air entraining agent shall be added to all concrete mixes sufficient to provide an air content of 4.5% ± 1½%.

d) An approved water reducing agent may be included in the mix designs.

2.2.5 Post tensioning and Pre-Stressing

1.1.1.3 2.2.5.1 System

The post-tensioning system, including anchorages, ducts, and tendons, shall be appropriate for the tendon layout and sizes shown on the drawings. The Contractor shall provide the Engineer with certified test results showing their minimum ultimate strength when used with the tendon proposed.

1.1.1.4 2.2.5.2 Stressing Strand

a) All stressing cables shall be 7 wire strand 12.9mm diameter Class 2 relaxation type complying with AS/NZS 4672.1. The minimum ultimate tensile strength of the 12.9mm diameter strand shall be 186kN and the 0.2 percent proof force shall be not less than 165kN.

b) A certified copy of the manufacturer's test certificates showing that each reel of strand used in the works complies with all tests in AS/NZS 4672.1 shall be incorporated in the Contractor's quality assurance documentation.

c) No stressing shall be carried out until the strand has been approved by the Engineer in writing. If test certificates are unavailable or in doubt, the Contractor shall deliver samples of the strand to an independent testing laboratory to carry out the relevant tests on the strand. A copy of this resulting test certificate shall be supplied to the Engineer.

1.1.1.5 2.2.5.3 Ducts

Ducts for post-tensioned grouted tendons shall be Drossbach corrugated metal sheathing.

2.3 Storage of Materials

2.3.1 Reinforcement

Upon delivery to the site, the reinforcement shall immediately be stacked in racks located in a clean dry area removed from construction traffic.

2.3.2 Acceptance of Precast Units on Site

The Contractor shall be responsible for accepting the precast units on site and erecting the units. Where units appear to be inferior to the requirements of this specification, the Contractor shall immediately report any defects or inaccuracies to the Engineer.

2.4 Defective Materials

2.4.1 General

Cracked or damaged precast units will not be accepted.

2.4.2 Acceptance Criteria for Concrete

a) Acceptance of concrete in the works will be primarily based on the results of slump and compression testing in accordance with the acceptance criteria in table 9.3 of NZS 3109 and tolerances for slump in table 9.1 of NZS 3109.

b) Where concrete is liable for rejection, the location and extent of the concrete so represented shall be assessed and identified. No further concrete shall be placed where it would prejudice the subsequent removal of the concrete in question. If the Contractor disputes the results and elects to have confirmatory testing of hardened cores undertaken, all coring and testing shall be at the Contractor's expense and shall be undertaken by a testing authority approved by the Engineer.

2.5 Precast Concrete

No additional requirement than given elsewhere in this Specification.

2.6 Quality Assurance

It shall be the Contractor's responsibility to ensure that the materials comply in all respects with the Drawings and Specification.

3 Execution

3.1 Inspection and Testing

3.1.1 Inspection

a) The Engineer may inspect construction in accordance with NZS 3109, clause 1.3. Before pouring commences, the Engineer or his representative shall be given 24 hours notice to enable inspection of formwork, reinforcement and construction joints. No concrete shall be placed until the Engineer is satisfied that all provisions of the specifications and drawings have been complied with.

b) Where necessary, the Engineer's instructions shall be carried out before concrete placing commences.

c) The Contractor shall submit in writing to the Engineer for approval a method statement for handling, placing, finishing, curing and protecting fresh concrete giving the precautions that will be taken to prevent the influences of the weather causing premature cracking of the concrete element. The sequence of placing of concrete and method shall not be varied without further approval.

3.1.2 Concrete Assessment

a) The concrete manufacturing process shall follow the sampling, testing and control requirements of NZS 3104.

b) Assessment of special concrete mixes and other concrete for this Contract shall be as specified in Section 4 of this Specification.

3.1.3 Assignment of responsibility of the role of the "construction reviewer"

i. Clause 3.3.5 of NZS 3109, "construction reviewer " is the Engineer.
ii. Clause 5.5 of NZS 3109, "construction reviewer " is the Engineer.
iii. Clause 5.6.1 of NZS 3109, "construction reviewer " is the Engineer.
iv. Clause 7.4.1 of NZS 3109, "construction reviewer " is the Engineer.
v. Clause 7.7.6 Of NZS 3109, "construction reviewer " is the Contractor.
vi. Clause 7.7.8 of NZS 3109, "construction reviewer " is the Engineer.
vii. Clauses 7.8.4 & 7.8.5 of NZS 3109, "construction reviewer " is the Engineer.

3.2 Durability

a) To provide durable concrete structures, the Contractor shall provide, in place, a dense low permeability concrete with low chloride ion content, sound aggregates free from alkali aggregate reaction, and a concrete which will provide adequate protection to the prestressing and reinforcing steel.

b) The Contractor shall ensure that the handling and placing of all concrete shall be in accordance with section 7 of NZS 3109.

c) The personnel placing concrete shall be experienced in the handling and placing of concrete.

d) Compliance with this specification shall be the minimum requirement necessary to meet the objectives in a) above.

3.3 Compaction

a) All concrete shall be vibrated in accordance with section 7.6 of NZS 3109. Complete compaction of the concrete will be required to ensure that the concrete in place has the durability necessary for its long term environment. Refer also to the Cement and Concrete Association guide "Placing and Compacting Concrete".

b) Control of compaction shall at all times be under the control of experienced operators and supervised by staff of at least foreman level.

3.4 Finishing

The surface finish of unformed concrete shall comply the requirements of NZS 3109 clause 7.7 and with the provisions of NZS 3114 applicable to the class of surface finish specified in Section 4 of this Specification.

3.5 Formwork

3.5.1 General

a) All formwork shall be designed by the Contractor to meet the requirements of Section 5 of NZS 3109 and AS 3610.

b) Formwork may be re-used provided forms are adequately cleaned to maintain the standard of finish and the tolerances specified.

c) Unless specified otherwise, forms shall be radiused or chamfered at all sharp edges with a dimension of 20mm across the diagonal face. The surface finish of the fillets shall match that of the forms. All fillets shall be well greased to avoid tearing of edges during form stripping.

3.5.2 Tolerances

Dimensional tolerances shall be in accordance with Table 4 of NZS 3109, except where modified in Section 4 of this Specification.

3.5.3 Ties

a) Where ties pass through joints, the ties shall be removed after concreting so that no part remaining in the concrete shall be nearer the surface than 40mm.

b) Ties left in the walls of hydraulic structures shall have a rubber ring waterbar attached. Ties which leave a penetration through the wall are not permitted.

c) Holes left after removal of the tie cones shall be filled with an epoxy mortar or hard pack cement grout such that leakage or damp patches are prevented in the completed hydraulic structure. The Contractor shall obtain the approval of the Engineer for the mortar or grout prior to filling the holes.

3.5.4 Surface Finishes

a) Surface finishes shall comply with NZS 3114. Specific surface finishes, if any, shall be as specified in Section 4 of this Specification.

b) Surfaces not specifically scheduled shall be finished to the most appropriate standard detailed in NZS 3114 Table 1 (formed finishes) and Table 2 (unformed finishes).

c) Defects such as honeycombing, voids around reinforcement etc shall not be repaired without the knowledge and approval of the Engineer. The Contractor shall provide a methodology of repair to the Engineer prior to execution of the work. Superficial defects shall be repaired by grinding and "bagging in" with mortar.

3.5.5 Stripping

Removal of formwork shall be removed without shock or vibration and in such a manner to permit the concrete to take the imposed stresses gradually. Stripping times shall be in accordance with Clause 5.4 of NZS 3109. Due regard shall be taken of the special characteristics of concrete containing Duracem cement, such as a longer cure time, for example.

3.6 Falsework

a) The Contractor shall be responsible for the engineering design, erection, maintenance, safety, and staged removal of all falsework, including staging, walkways, forms, ladders etc.

b) All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time.

c) Falsework shall be placed on solid footings, safe against undermining, and protected from softening.

d) Where falsework is supported on any portion of the structure which is already constructed, the load imposed by the falsework shall be spread, distributed and braced in such a way as to avoid any possibility of damage to the structure.

3.7 Construction Joints

a) Concrete placed monolithically shall be of such size, geometry, and sequence that shrinkage cracking is minimised. Where any shrinkage crack exceeds 0.1mm in width and where required by the Engineer, remedial work shall be carried out. The Contractor shall obtain the approval of the Engineer for all materials and methods before undertaking the repairs.

b) Construction joints shall be either
   i. as shown on the drawings, or
   ii. “type B” in accordance with NZS 3109, located as shown on the drawings, or where the locations are not defined, at positions of low shear stresses as approved by the Engineer.

3.8 Curing

a) Curing shall be carried out in accordance with NZS 3109. This standard shall be the absolute minimum for any structure on this Contract.

b) From immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures and mechanical injuries. The concrete shall be maintained with minimum moisture loss for the period necessary for hydration of cement and hardening of the concrete as defined in clause 7.8 of NZS 3109.

c) For non-hydraulic structures, concrete shall be cured for a minimum of 7 days. Curing compounds may be used on these structures.

d) For hydraulic structures, membrane curing compounds shall not be used. Concrete shall be cured for a minimum of 14 days as follows:

first 7 days	all concrete and its formwork and other surfaces shall be kept continuously wet by ponding where possible, and protected from sun, frost and drying winds
8 – 14 days	all concrete surfaces shall be protected from sun, frost and drying winds, and shall be kept damp by occasional hosing

where approved in writing by the Engineer, a curing compound complying with ASTM C309 or AS 3799 may be used.

3.9 Reinforcement

3.9.1 Cover to Reinforcement

a) Where the cover to reinforcement is not stated on the drawings or specified in Section 4 of this Specification, the minimum cover shall not be less than 50mm on surfaces exposed to liquids or soil unless approved protective coatings are used, or 40mm elsewhere. Concrete cast against ground shall have a 75mm minimum cover.

b) Cover is measured from the concrete surface to the nearest layer of reinforcement.

c) If the concrete surface contains rebates or architectural features which in places reduce the cover, then the cover is measured from the deepest surface rebate to the nearest layer of reinforcement.

3.9.2 Workmanship and Care of Reinforcement

a) Prior to bending, bars shall be cleaned of all loose rust, mill scale, dirt, oil, paint etc. The use of flame for cleaning and straightening is not permitted.

b) Badly twisted bars shall be rejected and removed from the site. Bars shall not be bent or straightened after placing unless approved in writing by the Engineer, for each specific case.

c) At the time of concreting, the bars shall be free of any foreign coatings, form oil or dried accumulation of mortar, which reduce the effective bond between concrete and steel.

3.9.3 Additional Reinforcement Requirements to NZS 3109

a) In all hydraulic structures and in concrete cladding panels, all tie wire shall be galvanised. Ends of tie wire shall be bent back away from the cover concrete.

b) Spacer blocks shall be plastic or 40MPa concrete. Concrete masonry spacers, or spacers made on site shall not be used.

c) Reinforcing shall not be tack welded.

d) Welding of reinforcing is not permitted without the Engineer's approval. If approval is given, welding shall be in accordance with NZS 4702.

e) If approved, welding shall be carried out by qualified welders and shall be in accordance with NZS 4702, to achieve at least Class S welds. Welding shall not be carried out under damp conditions or at temperatures of below 10ºC. Welders shall be adequately supervised so as to ensure use of proper electrodes, suitable amperages and sufficient time for each weld to avoid sudden quenching. For 500E strength grade, welded using 'Manual Metal Arc Welding process', without preheating, low hydrogen electrodes are the only electrode that shall be used. Reduction in tie (bar cross section) area or faulty welding will be cause for rejection or repair of welds.

f) For concrete cast against ground, particular care shall be taken to ensure that
   i. no damage occurs to any waterproofing membrane or damp proof course; and
   ii. reinforcement is not displaced by foot traffic to reduce its cover.

3.10 Post Tensioning

Not used.

3.11 Precast Units

3.11.1 Erection

a) Precast units shall be adequately braced and supported during erection to ensure proper alignment and safety. Such bracing or support shall be maintained until adequate permanent connections have been made.

b) The Contractor shall not use any lifting or erection method which places excessive stress on the units.

c) Prior to erection of precast units, the foundation shall be levelled to within ±2mm using a pourable epoxy levelling grout (if required).

d) Post-tensioned curved units shall be seated on multiple layers of proprietary plastic shims which permit inwards movement of the panel during stressing.

3.11.2 Filling In

The Contractor shall fill in all lifting-eye holes, form tie holes and the like. Where visible in the finished works, all such filling shall be colour matched to the concrete of the main pre-cast concrete item.

3.12 Embedded Items

3.12.1 Minor Embedded Items, Holes, Chases, Rebates

a) The Contractor shall provide and adequately support prior to concreting, all sleeves, inserts, anchors, holding down bolts, conduits, pipes and other embedded items. Voids in sleeves, inserts and anchor slots shall be plugged, taped or filled temporarily with readily removable material to prevent entry of concrete into the voids.

b) The Contractor shall accurately form and position all chases, fillets, holes, upstands and nibs as shown on the drawings, prior to concreting.

3.12.2 Embedded Pipework

a) All pipes and fittings cast into concrete shall be provided with puddle flanges or other approved systems of ensuring water tightness.

b) Pipes passing through post-tensioned concrete shall be connected after completion of the post-tensioning in one of two ways. Either blockouts to accommodate such pipes shall be formed in the appropriate place, or spool pieces shall be cast into the concrete prior to tensioning.

3.13 Casting New Concrete Against Old

a) Where concrete is to be cast against old concrete (any concrete which is older than 60 days of age), the surface of the old concrete shall be thoroughly cleaned and roughened by water blasting or abrasive blasting (exposing aggregate).

b) The joint surface shall be coated with an epoxy based bonding agent unless indicated otherwise by the Engineer.

3.14 Concrete Placed Under Water

Not used.

3.15 Sealants and Waterstops

3.15.1 General

a) All joint sealants shall be mixed and applied strictly in accordance with the manufacturer's specification and applied by skilled applicators.

b) Concrete surfaces shall be prepared in accordance with the sealant manufacturer's specification. All surfaces in contact with sealant shall be clean and dry prior to the application of joint sealants. Sealing shall not be carried out while surfaces show any sign of dampness.

c) Joint cross section dimensions are shown on the drawings. The Contractor shall examine all joint details to confirm that the sealant may be formed in a satisfactory manner to provide a completely watertight joint. Where the Contractor considers modifications to the joint profiles are required, he shall advise the Engineer and propose an alternative for the Engineer's approval.

d) All joint surfaces shall be primed prior to the application of joint sealant material. Primers, bond-breaking tape and filler rods shall be as specified by the sealant manufacturer, and shall be applied and allowed to cure before sealant application in accordance with the manufacturer's specification.

e) Surfaces adjoining the joints shall be masked to prevent contamination by sealant or primer materials. Masking shall be removed on completion of sealant application.

f) The Contractor shall take care to prevent damage due to any action, including mechanical or chemical attack, after the application of sealant material.

g) A detailed record shall be kept of when sealants were placed so that curing times can be monitored. No sealant shall be relied upon to fulfil its purpose until fully cured.

3.15.2 PVC Waterbars and Waterstops

All waterbars and waterstops shall be joined, spliced and installed in accordance with the manufacturer's specifications. The Contractor shall allow for all necessary additional reinforcing, ties, supports, etc. to ensure that the waterstop is restrained in its correct position during concreting.

3.15.3 Hydrophilic Waterstops

a) Hydrophilic waterstops shall be butted and glued together in accordance with the manufacturer's instructions to give a water-tight junction.

b) Hydrophilic waterstops shall be installed with a minimum of 100mm cover.

3.15.4 Warranty and Guarantee

Where required by Section 4 of this Specification, a warranty and guarantee shall be provided for sealants.

3.16 Dry Pack Mortar

a) Dry pack mortar shall be a sand cement mortar in the proportions of one part cement to three parts sand by weight.

b) Additives to reduce water content or to enhance adhesion shall not be used without the written approval of the Engineer.

c) Water and additives shall be added to the sand cement to produce a mortar that has a dry consistency. When squeezed in the hand to a ball, the mortar shall retain its shape, but shall not be so dry that it shows cracking on its outer surface.

d) The water/cement ratio shall not exceed 0.40 by weight.

e) Mortar shall be placed in layers, packed hard with a wooden caulking tool and hammered tight. Adequate rigid formwork shall be used where required to confine the mortar during the packing operation.

3.17 Waterproofing Form-Tie Holes

3.17.1 Acceptable Products

Acceptable product to be used for waterproofing form-tie holes is Krystol Baricote (K-315). This product is manufactured by Kryton International Inc., Vancouver, B.C., and is supplied in New Zealand by Fraser Brown and Strathmore.

3.17.2 Preparation

Plastic cones, snap-ties and tapered rods shall be removed from the concrete to expose tie holes. Tie holes shall then be cleaned with a wire brush to remove loose debris and other contaminants. Tie holes shall then be flushed with clean water. If necessary, form oil is to be removed using Krystolklean 777.

3.17.3 Application

a) Tie holes and surrounding areas shall be pre-soaked with clean water to a saturated, surface-dry condition (SSD).

b) Krystol Baricote shall be mixed to a dry pack consistency (being 4 parts powder to 1 part clean water). This dry pack mixture shall then be installed into tie holes, filling entire void with material flush to the surface. Where necessary, a rod is to be used to force material into the depths of the tie hole void.

c) The application shall be protected for a minimum of 48 hours from:
   i. rapidly drying out due to heat;
   ii. damage from rain;
   iii. excessive wind;
   iv. freezing temperatures.

4 Project Specification

This section contains schedules and specifications that are specific to this Contract, and takes precedence over sections 1, 2 and 3 above.

4.1 General

Not used

4.2 Materials

4.2.1 Concrete Mixes and Grades

a) Concrete mixes shall be Normal Concrete mixes unless specified otherwise in the table below.

b) The 28 day concrete cylinder test strength and the concrete mix type of the various concrete components shall be as follows:

		Grade	Mix type
i.	Blinding concrete	10Mpa	Normal
ii.	Structural Concrete	As shown on drawings	Special

4.2.2 Specific Concrete Requirements of Special mixes

Special Mixes shall;

1. Include a minimum total cementitious binder content of 370kg/m^3.
2. Have a maximum water/binder ratio (by mass) of 0.45.
3. Be continuously water cured for a minimum 3 days by retention of formwork that has been sealed against moisture loss, or direct water application such as ponding, continuous sprinkling or continuous application of a mist spray. Where formwork is removed prior to completion of the curing period, curing by direct water application shall commence within half an hour of the formwork stripping. Curing beyond 3 days in accordance with Clause 7.8 of NZS3109.

4.2.3 Alternative Concrete Mix Designs

The Contractor is permitted to propose alternative corrosion inhibiting technologies, reinforcing materials, concrete mix designs and/or concrete covers to that defined above.

Alternatives shall achieve a minimum time to corrosion initiation of 100 years in the Fijian environment and have an equivalent time to initiation of corrosion similar to that defined above.

Alternative proposals must recognise the characteristics of the Fijian environment and its effect on accelerated corrosion of ferrous reinforcing compared to corrosion in more temperate climates.

4.3 Execution

4.3.1 Concrete Cover

Minimum cover shall be 55mm.

4.3.2 Concrete Assessment for this Contract

a) Assessment of the concrete for this Contract is required as follows
   i. Structural Concrete

b) Assessment of special and other concrete mixes defined in Section 4 shall be as follows:
   i. The Contractor, or his supplier, shall make control tests in accordance with NZS 3104 and shall pay the cost of such tests. Results from these tests shall be made available to the Engineer on request. Tests shall be made either at the supplier's plant or, if required by the Engineer, at the site.
   ii. In addition to the tests required by NZS 3104, the Contractor shall take test cylinders at random for each pour of concrete and test them in accordance with NZS 3112. These tests may be taken by the ready mixed concrete supplier at the plant or on site. Three standard cylinders shall be required for each 25 cubic metres of project concrete placed or part thereof, and tested in an approved laboratory. Test results from cylinders at 7 and 28 days shall be forwarded to the Engineer.
   iii. A slump test shall be made immediately concreting is commenced and at all times when compression test samples are taken.
   iv. Any additional concrete strength tests required sooner than 28 days after placing of concrete to justify earlier stripping of formwork or props or earlier loading of a portion of the structure shall be at the Contractor's own expense.
   v. Delivery dockets and other certified records of concrete quality and quantity shall be kept on site and shall be available for inspection by the Engineer on request.

4.3.3 Surface Finishes

a) Formed finishes shall be as follows:
   i) Buried surfaces F1
   ii) Exposed surfaces F4

b) Unformed finishes shall be as follows:
   i) Buried surfaces U1
   ii) Slab surfaces U4