THE HALDON RANGE LTD

IRRIGATION DAM

DAM AND RESERVOIR WORKS

CONSTRUCTION CONTRACT SPECIFICATION

Contents

1. Bulk Earthworks

1.1. Scope

This section covers the work necessary to excavate and fill the specified works to the required levels, grades and standards. It covers clearing the Site, stripping topsoil, controlled filling, cut to waste, topsoiling and grassing, excavation of open drains and other related incidental work including drainage zones, armour zones, geotextile fabric and the like.

1.2. Standard Specifications

Construction work performed under this Section shall comply with the general requirements of the following documents and the specific requirements of this Section:

NZS 4402	Methods of Testing Soils for Civil Engineering Purposes
BS 1377	Methods of Test for Soils for Civil Engineering Purposes

1.3. General Requirements

1.3.1. Surface Drainage and Erosion Control

All earthworks shall be carried out in fully drained conditions with no free water on the working surfaces. Where it is impracticable to maintain excavations of unsuitable material deposits in a fully drained condition, the Designer will have discretion to relax this requirement to the degree that is necessary. Cut areas shall be sloped and graded adequately so that they do not pond water or allow water to infiltrate, and drains shall be installed or pumping carried out as necessary on a regular basis to remove water from the areas of operations, or to drain water as soon as it is seen to develop. Any filling which has been allowed to become too wet or soft shall be removed and dried, or replaced. All fill surfaces shall be rolled off at the end of each day's work to prevent erosion. Prior to commencement of the filling operations the following day, the smooth surface shall be scarified by approved plant to prevent layering of the fill.

The Contractor shall divert watercourses as necessary to enable construction of the works, and shall be responsible for determining the size of the temporary diversion arrangements so that any floods are carried safely past the Works during the construction period. Any specific consent conditions related to diversion shall be complied with.

1.3.2. Dust and Silt Control

Earthmoving shall be carried out and maintained so that dust is not raised near or blown over the working area vines to the extent that a nuisance is caused or any local regulations or consent conditions are breached. The Site shall be kept watered as necessary to meet this requirement until covered by dust-free materials.

Silt control shall comply with consent requirements and employ appropriate methods within industry practices. Proposed methods and details shall be submitted in advance to the Principal for review and be amended as necessary to take account of any review comments made by the Principal. Retained silt shall be placed at a location on site as approved by the Principal.

1.3.3. Over Excavation

The Contractor shall direct operations to avoid excavating beyond designated profiles. Any excavation beyond these profiles carried out without express instruction by the Designer or Principal shall be made good to the direction of the Designer with compacted fill of equal quality to that designated to cover the excavated profile. This reinstatement work shall be at no cost to the Principal.

Where excavation is carried out beyond the footprint of designated works for the purposes of obtaining and processing filters, drainage, armour and the like, the residue from processing shall be replaced tidily in the excavation with compaction.

1.3.4. Preservation and Maintenance

The Contractor shall preserve and maintain all earthworks, including partly completed earthworks, and make good at no cost to the Principal any earthworks which have deteriorated below the specified standards for whatever reason.

1.3.5. Tolerances

All earthworks shall be carried out to the lines, levels and grades shown on the Drawings. The accuracy of surfaces to be overlain by specified pavement layers or concrete structures shall be such as to preserve the minimum thicknesses of the overlying layers. Tolerances shall otherwise be as follows:

Foundations	-	0 mm to - 25 mm
Batters	-	0 mm to +150 mm perpendicular to the batter
Topsoiling	-	0mm to + 50 mm
Other surfaces	-	0 mm to + 75 mm

Additionally, finished earthworks surfaces shall be of neat and regular shape, free of abrupt irregularities.

1.4. Clearing

1.4.1. Removal of Vegetation and Obstructions

The Contractor shall remove all vegetation from the site of earthworks and below normal top reservoir level, and shall clear all obstructions from the Site of the Works. Clearing

shall mean the removal of all growth (other than grass and weeds), extraction of stumps, and other items remaining above the surface of the ground, and the complete disposal of all items. Extraction of stumps (if any) shall remove all roots greater than 25 mm diameter. The removal of grass and weeds shall be provided for under topsoil stripping. Fencing materials unable to be burnt shall be disposed of off site. Any burning shall be to local bylaws and approvals with all residue buried at an approved location on site with at least 1 m cover.

Any existing culverts or access tracks under the embankment footprint shall be treated as an obstruction as discussed above.

1.4.2. Removal of Topsoil

Turf and organic topsoil shall be stripped from the areas subject to earthworks whether cut or fill, before other operations commence in these areas. All topsoil shall be stockpiled for future reuse in the locations shown on the Drawings or areas approved on Site by the Principal.

The depth of topsoil stripping shall be sufficient to remove all turf and significant plant roots and expose the underlying materials, but not necessarily remove all soil with organic content which may be distributed into the underlying materials. The principal objective is to remove all turf. Except where limited by boundaries, existing works or other limiting features; stripping shall extend 2 metres beyond the limits of areas subject to earthworks or construction. The Contractor shall cooperate with the Designer ahead of and during stripping operations to determine the stripping depth and shall avoid unnecessary overexcavation.

Topsoil shall be organic material suitable for reuse as a growth medium. Topsoil stockpiles shall be separate from stockpiles of other materials.

1.4.3. Foundation Preparation

The Contractor shall remove all foreign matter, loose material or other kinds of debris from the surface of the foundation prior to inspection by the Designer. If the Designer is satisfied by the condition of the prepared surface, the Contractor shall then immediately scarify the exposed surfaces to a depth of 100 mm, and recompact the scarified soil using no less than 4 passes of a static compactor (roller) weighing no less than 15 tonnes, or its vibrating equivalent.

Preparation of the foundation at the abutments (in places where the surface of the ground is inclined at a slope steeper than 1 vertical to 5 horizontal) shall include for benching steps into the ground. The steps shall be no more than 200 mm high and no less than the depth of one layer of fill after compaction. The sides of the steps shall be as close to vertical as may be practicable. Steps shall be cut and prepared no more than one step ahead of the current layer of fill.

1.5. Cut to Waste

Overburden removal from below the topsoil layer (if any) shall be deemed to be surplus material. Material shall not be cut to waste/stockpile without prior agreement by the

Designer. All surplus material or material unsuitable for use in permanent works shall be retained on the Site and be disposed of in the location and to profiles as confirmed on site by the Principal.

1.6. Fill Work

1.6.1. General

Fill material shall be obtained from areas designated on the Drawings or described in this Specification and to the profiles shown on the Drawings.

Prior to compaction, all fill material shall be spread uniformly in layers of less than 200 mm thickness or such greater thickness as may be confirmed by field test and approved by the Designer, and conditioned to an appropriate average and consistent water content. Fills in confined spaces or where it is impractical to do otherwise, all fill shall be spread and compacted parallel to the crest.

The fill shall always have a positive gradient from the chimney drain to the outside batters so that no runoff reaches the drain area.

New fill shall not be spread over surfaces which have deteriorated from their specified condition. Where necessary, the old surface shall be scarified and conditioned and recompacted before placing new fill.

Particular care shall be taken to ensure tight bonding between layers of Type 1A fill. Where the fill process is interrupted and the fill surface becomes desiccated by sun or softened by rain, it shall be trimmed back and scarified before recommencing fill operations.

Handling and spreading methods shall ensure that the typical bulk fill gravel materials do not segregate, particularly at abutment contacts. Experience elsewhere indicates that it may be necessary to spread by digger bucket rather than by blade at the abutment contacts to avoid segregation and a permeable path which cause excessive seepage through the dam.

Drainage zones shall be placed and compacted without segregation and at all times shall be protected against contamination.

Outside batter profiles shall be overfilled as necessary then trimmed to final profile to ensure full compaction. Abutment contacts shall be benched so that the bench width is in all instances at least twice the fill layer thickness.

1.6.2. Chimney Drain Construction

The chimney drain shall be constructed in lifts expected to be less than 1.5 m high for worker safety reasons by excavating through previously placed bulk fill and then placing the chimney drain material. Excavated material shall be reused, as bulk fill. Special measures shall be taken to protect each completed lift against contamination by the next fill lift (e.g. geotextile and boards), with the protective layers thoroughly cleaned off before removing them. If separate filter and drainage zones are used they shall be

separated by temporary vertical boards as each loose layer is placed with the boards removed before compaction.

1.6.3. Cutoff Trench Construction

The cutoff trench shall extend to a depth of not less than 0.5m below the stripping depth for the dam foundation as determined by inspection of the Designer or a suitably qualified geotechnical engineer approved by the Designer. Preparation of the base of the cutoff trench shall be as per Section 1.4.3.

IMPORTANT NOTICE - The lateral extent of the cutoff trench, particularly in the vicinity of the spillway, shall be determined by the Designer once subsoil conditions have been exposed on site.

1.6.4. Fill Materials

a) Bulk Fill (Type 1 Fill)

The specified grading for Type 1 fills matches samples taken from trial pits in the site (refer geotechnical information). Type 1 fill shall be the silty gravels and gravely silts encountered in designated borrows or other approved borrows outside the main works designated for material processing as needed.

For the embankment Type 1 fill shall have the following grading conditions but not be gap graded:

- Minimum of 7% silt size or finer than 0.075mm sieve

b) Core (Type 1A Fill)

The specified grading for Type 1A fill matches samples taken from within trial pits onsite. Type 1A fill locations shown on the Drawings shall be the clayey silt encountered in the designated borrow area or other borrow areas approved by the Designer. Type 1A fill shall be selectively borrowed to include material with higher clay fractions. Alternatively, materials may be mixed to achieve the grading. Any mixing must be to a methodology approved by the Designer following field trials and laboratory grading tests on the mixed fill.

For the embankment dam Type 1A fill shall have the following grading conditions but not be gap graded:

- Minimum of 20% clay size or finer than 0.002mm
- Maximum of 5% of particles greater than 0.6 mm sieve

Type 1A fill shall achieve a permeability of no greater than 1×10^{-8} m/s (see Section 1.7.2).

c) Topsoil

Growth medium (shown as Topsoil) shall be placed at the locations and thickness shown on the Drawings.

This shall be generally sourced from materials stripped from the dam footprint and elsewhere. See also the requirements of Section 1.8.

d) Armour (Type A)

Type A armour material as designated on the Drawings shall be clean, durable, unweathered rock obtained by on-site processing or imported from an approved external source, graded between the following limits, but not gap graded.

Grading Limits for Type A Armour	
Minimum Size (mm)	80
Average Size (D_{50}) mm	140
Maximum Size (mm)	200

Prior to the placement of this material in the works, the Contractor shall provide a grading curve to the Designer for approval

e) Armour (Type B)

Type B armour material as designated on the Drawings shall be clean, durable, unweathered rock obtained by on-site processing or imported from an approved external source, graded between the following limits, but not gap graded.

Grading Limits for Type B Armour	
Minimum Size (mm)	120
Average Size (D_{50}) mm	200
Maximum Size (mm)	300

Type B armour material shall consist of rounded river gravels only. Prior to the placement of this material in the works, the Contractor shall provide a grading curve to the Designer for approval

f) Filter (Type C)

Filter material as designated on the Drawings shall be clean, durable, unweathered gravel and sand obtained by on-site processing or imported from an approved external source, graded between the following limits, but not gap graded.

Grading Limits for Type C Drainage	
Particle Size (mm)	**Percent Finer Than**
6.7	100
4.75	86 - 100
2.36	66 - 100
1.18	47 - 92
0.6	28 - 73
0.3	9 - 54
0.15	0 - 34
0.075	0 - 3

The permeability of Drainage Material Type C after placement and compaction in the Works shall be not less than 1×10^{-4} m/s (see Section 1.7.2).

Prior to the placement of this material in the works, the Contractor shall provide a grading curve to the Designer for approval

g) **Drainage (Type D)**

Drainage material as designated on the Drawings shall be clean unweathered river gravel and sand obtained from on-site processing or imported from an approved external source, graded between the following limits, but not gap graded.

Grading Limits for Type D Drainage	
Particle Size (mm)	**Percent Finer Than**
75	100
53	89 - 100
37.5	80 - 100
26.5	70 - 100
19	61 - 100
13.2	50 - 100
9.5	41 - 86
6.7	31 - 76
4.75	22 - 67
2.36	0 - 47
1.18	0 - 28
0.6	0 - 9
0.3	0 - 3

The permeability of Drainage Material Type D (after placement and compaction in the Works) shall be not less than 5×10^{-3} m/s (see Section 1.7.2).

Prior to the placement of this material in the works, the Contractor shall provide a grading curve to the Designer for approval

1.6.5. Control of Water Content

When fill needs to be dried, the Contractor shall scarify the fill and allow it to dry uniformly to its full depth.

When the fill requires wetting, this shall be done with sprinkling equipment ensuring uniform and controlled distribution of water in conjunction with blading or harrowing.

1.6.6. Compaction Trials

Compaction trials shall be carried out at the start of construction, commencing within 2 weeks of the Contractor taking possession of the site. Trials shall be carried out on the following fill materials.

a) Type 1A Fill (Core)

A Compaction trial shall be carried out on material excavated from the designated Borrow area and within the specified grading range for Type 1A fill. The pad be compacted using the equipment proposed by the Contractor for the core. The pads shall be tested for density, water content and air voids, using a Nuclear Densometer (NDM) in direct transmission configurations, by the methods detailed in Section 1.7. A permeability test shall be carried out in the trial pad, using the methodology specified in Section 1.7.

b) Type 1 Fill (Bulk Fill)

A Compaction trial shall be carried out on material excavated from the designated borrows and within the specified grading range for Type 1 fill. A pad with 3 layers shall be compacted using the equipment proposed by the Contractor for the bulk fill construction. The pad shall be tested for strength (Scala penetrometer), density, water content and air voids by the methods detailed in Section 1.7.

Failure to achieve the specified compaction or permeability criteria may, subject to the decision of the Designer, require the Contractor to carry out additional compaction trials at the Contractor's expense.

1.6.7. Compaction

1.6.7.1. General

The Designer may carry out check tests of compaction at any time. The Contractor shall stop or divert his machines as required by the Designer to allow the tests to be carried out safely.

Where field tests indicate that the specified standard of compaction has not been achieved, the Designer may order cessation of work and/or removal of the fill and/or further testing, subject to the nature of the fill concerned. All costs associated with the further or re-testing of any fill areas which fail to meet the specified standards will be a charge to the Contractor and will be deducted from Progress Payments. Such costs will include all related supervision and administration time incurred by the Designer in determining the extent of compacted fill failing to meet the specified standards, its subsequent re-testing and the effecting of the appropriate advice to all parties concerned.

1.6.7.2. Compaction Requirements

The compaction requirements for fill material shall be as follows:

(i) General:

The water content of bulk fill shall be controlled so that there is no significant visible deformation, recoverable or non-recoverable, during equipment trafficking and compaction, and no rutting after the passage of plant. The design restricts the pore pressures which can be tolerated due to overly wet material and over compaction leading to weave.

(ii) Bulk Fill (Type 1):

Unless otherwise modified by the Designer after compaction trials, the compaction requirements shall be as follows:

The dry density after compaction shall not be less than:

(a) 1.95 t/m^3 for any single test

(b) 2.0 t/m^3 on a rolling 10 test average basis

Air voids after compaction shall not be greater than:

(a) 10 % for any single test

(b) 8 % on a rolling 10 test average basis

Scala penetrometer test results shall not be less than 6 blows per 100 mm penetration, as recorded between 100 mm and 300 mm depth below the ground surface.

(iii) Core (Type 1A)

Unless otherwise modified by the Designer after compaction trials, the compaction requirements shall be as follows:

The dry density after compaction shall not be less than:

(a) 1.75 t/m^3 for any single test

(b) 1.79 t/m3 on a rolling 10 test average basis

Air voids after compaction shall not be greater than:

(a) 7 % for any single test

(b) 5 % on a rolling 10 test average basis

Undrained shear strength after compaction shall be not less than:

(a) 100 kPa for any single test

(b) 120 kPa on a rolling 10 test average basis

(iv) Filter/Drainage (Types C/D)

Filter/drainage under external armour shall be spread uniformly avoiding segregation, but otherwise does not require compaction.

Filter/drainage within embankments or under concrete structures shall be spread in layers not exceeding 150 mm loose thickness without segregation and be compacted as follows:

- in restricted areas, a minimum of four passes of a vibrating plate compactor or three passes of a vibrating "footpath" roller
- elsewhere not less than two passes of the same roller as used for bulk fill

(iv) Armour

Armour does not require compaction but shall be placed by digger bucket so as to obtain uniform profiles with the various stone sizes well distributed through the armour layer and the underlying filter remaining intact.

1.6.8. Fill Adjacent to Structures

All filling in the vicinity of and against structures, including concrete pipes, shall be undertaken with care to avoid damage to the concrete surface or causing excessive stresses in the structures.

When fill is placed around such structures, the difference in fill elevation on either side of the structures shall not exceed 300 mm at any stage of backfilling.

Fill within 2 metres horizontal distance of walls of concrete structures shall be compacted using light machine to the Designer's approval and/or hand operated equipment. Where drainage material is placed adjacent to structures, compaction shall be by means of a hand operated vibrating plate compactor.

Compaction equipment and methods proposed for use in the fill immediately above an embedded structure shall be subject to the approval of the designer as to matters such as timing, weight of equipment, vibration and depth of fill between the top of the structure and the layer to be compacted. Special consideration is needed for the conduit under the embankment, as shown on the Drawings.

A minimum depth at 1m of fill shall be placed over the conduit using light compact equipment prior to any heavy machinery trafficking over the conduit.

1.7. Testing

1.7.1. General

The Contractor shall be responsible for ensuring that the specified compaction and permeability parameters are achieved and shall carry out such testing as is needed to ensure the consistent quality of the fill.

The Designer may also carry out independent tests described and defined in Clause 2.7.2 to determine the classification and compaction standards of fill materials.

Approximate test methods may be employed to obtain rapid indicative results, but approximate methods shall not be used for acceptance purposes where the adequacy of materials, processing or workmanship is in doubt or the amount by which the test result fails, falls within the confidence limits of the approximate test result.

The Contractor shall be responsible for carrying out all testing and supply and maintenance of all test equipment (e.g. Nuclear Densometer, etc).

1.7.2. Tests and Test Methods

Test No.	Test	Test Method
1	Permeability	Standpipe Field Permeability Test (Appendix A) for Type D drainage NZS:4402 Test 5.1.3 for Type 1A fill and Type C filter
2	In-situ Density	NZS 4402:1986 Test 5.1.1 (Sand Replacement) ASTM D2922 (& D3017) (Nuclear Densometer) may be used as an approximate method
3	Water Content	*NZS 4402:1986 Test 2.1
4	Particle Size Analysis	NZS 4402:1986 Test 2.8.1 & 2.8.2
5	Air Voids	NZS 4402:1986 involving intermediate tests, 4A, 4B, 4C
6	Specific Gravity	NZS 4402:1986 Test 2.7.1
7	Scala Penetrometer	NZS 4402:1986 Test 6.5.2
8	Vane Shear	*NZGS 8.2001 : Guidelines for handheld shear vane tests

* Test method qualified by following notes.

Note 1: **In-Situ Density**

The in-situ density of the compacted soil at any test location shall be taken as the mean of results from a set of density tests. A set of density tests shall comprise two or more individual tests made within an area of 0.5 m^2.

Note 2: **In the water content test** the oven performance and forced ventilation requirements shall be waived provided that operating temperature range is verified and checked daily. Before the mass of a dried sample is accepted it shall be dried for at least 14 hours, and be weighed at least twice at periods not less than two hours apart until the loss in mass between successive weighings is less than 0.1 grams per 100 grams.

Note 3: **Vane Shear Tests:**

The vane shear strength of the soil at any test position shall be taken as the mean of the results of a set of tests. A set of shear tests shall comprise four or more individual tests made within an area of 0.5 m^2.

1.7.3. Test Frequency

The frequency of testing will depend on the consistency of fill operations and materials used, but the testing rate shall initially be as follows (using compacted volumes)

Test	Purpose	Initial Frequency
In-situ Density and associated water content	Density compliance	1 per 500m^3 Type 1 fill and 1 per 250 m^3 Type 1A fill, with a minimum of 1 test per compacted layer
Particle Size Analysis	Grading compliance	1 per 2,500 m^3 of Type 1 fill and 1 per 1,000 m^3 Type 1A. 1 per 250 m^3 C, D over and above supply/ manufacture tests with a minimum of 3 tests.
Permeability	Permeability Compliance	1 per 2500 m^3 Type 1A fill 1 per 100 m^3 Type D drainage 1 per 500 m^3 Type C filter
Shear Vane	Shear Strength	1 per 100 m^3 Type 1A fill
Scala penetrometer	Strength	1 per 500 m^3 Type 1 fill
Solid Density		2 per material type

As soon as the Designer is satisfied that the materials are consistent and work is being carried out in a systematic and consistent manner, he may allow a reduction of the frequency of testing as he judges to be appropriate.

1.8. Topsoiling and Grassing

1.8.1. General

For the replacement of topsoil ex stockpiles from stripping, the Contractor shall use equipment such as tracked vehicles, in preference to wheeled vehicles.

Topsoil shall be spread over all areas to be revegetated to the thickness shown on the Drawings. The objective shall be to distribute available stockpiled material uniformly over surfaces designated to be topsoiled and grassed. Spreading shall not be done when the ground or the topsoil is excessively wet or otherwise in a condition detrimental to the work.

A seed mix suitable for the local conditions and climate shall be used. The grass seed mix shall be agreed with the Principal prior to sowing.

The seed and fertiliser shall be uniformly distributed and harrowed into the topsoil to a depth of 15 - 20 mm, leaving a smooth, evenly graded, open textured surface which will not hold water. The topsoiled surface shall not be compacted.

Maintenance shall include cutting at regular intervals to produce a uniform sward.

1.9. Geotextile (Filter cloth or Fabric)

Geotextile fabric shall be located as shown on the Drawings and be laid out on accurately profiled surfaces without wrinkles and with 500 mm minimum length laps. Fabric shall be stored, erected and covered with fill so as to avoid deterioration by ultra violet light and be held in place against uplift by wind until covered, by means of temporary weights, local mounds of fill or similar, but shall not be pinned or otherwise punctured.

1.9.1. Type A Geotextile

Type A geotextile fabric shall be Bidim A19 as supplied by Maccaferri or other similar product approved by the Designer.

1.9.2. Type B Geotextile

Type B geotextile fabric shall be Bidim A44 as supplied by Maccaferri or other similar product approved by the Designer.

2. Concrete Work

2.1. Scope

The work covered by this section includes the supply of all labour, materials and plant for the mixing and placing of all concrete, together with all other associated trade work, complete as shown, all as described in the Drawings and/or Specification, or as necessary.

This section of the specification shall be read in conjunction with the Drawings and the Standards listed in this specification.

2.2. Standard Specifications

Construction work performed under this Section shall comply with the general requirements of the following documents and the specific requirements of this Section:

NZS 3101	The Design of Concrete Structures
NZS 3103	Specification for sands for mortars and internal and external renderings
NZS 3104	Specification for concrete production
NZS 3105	Concrete Mixers (batch type and truck type)
NZS 3109	Concrete Construction
NZS 3111	Methods of test for water and aggregate for concrete
NZS 3112	Methods of test for concrete
Part 1	Tests relating to fresh concrete.
Part 2	Tests relating to determination of strength of concrete
Part 4	Tests relating to grout
NZS 3113	Specification for chemical admixtures for concrete
NZS 3114	Specification for concrete surface finishes
NZS 3121	Specification for Water and aggregate for concrete
NZS 3122	Specification for Portland and blended Cements
AS/NZS 4671	Steel reinforcing materials

NZS 4203 General structural design and design loadings for buildings (part 4 only)

AS/NZS 1170 Structural Design Actions

AS/NZS1554 Part 3 Welding of reinforcing steel

BS 1881 Method for determination of the compressive strength of concrete (Part 120) cores

BS 5212 Specification for joint sealants.

2.3. Materials

2.3.1. Special Concrete Requirements

Materials for concrete and grout shall comply with the relevant requirements of NZS3104 and material limitations of NZS3109 clause 6.1 for chloride and sulphate content.

The following concrete mixes as specified below shall be used in different parts of the Works as shown on the Drawings and schedule of quantities:

Strength Designation	Maximum Aggregate Size (mm)	Specified Compressive Strength (MPa)	Specified Slump (mm)	General Location
30 (normal concrete mix) N	19	30	100	Intake and other reinforced concrete structures
20 (normal concrete mix) N	19	20	100	Conduit surround
15 (normal concrete mix) N	19	15	100	Armour interlocking concrete

The designated concrete strengths shall be manufactured and supplied from an off site plant approved by the N.Z. Ready Mixed Concrete Association to produce special concrete mixes, and satisfying the requirements of Section 2.3 of this specification and Section 2.16 of NZS 3104. Plant including transit trucks shall have sufficient capacity to meet comfortably the requirements of the largest daily pour required to be undertaken continuously between authorised concrete joints.

Concrete shall be delivered to where it will be placed and be discharged either directly into formwork or concrete buckets. It is an objective of this specification that dense, water thigh, low shrinkage concrete be achieved. Mix designs should aim to provide concrete with the minimum cement contents which are consistent with a cohesive concrete of adequate workability, density, surface finish and required strength. The target air content shall be 5%. Pumped concrete is not permitted.

The concrete shall be composed of the following materials: ordinary Portland cement, coarse and fine aggregates and water. An air entraining admixture, a retarder and a waterproofing admixture may be used. No other ingredients shall be added to the concrete unless requested and permitted in writing by the Designer.

Concrete for blinding concrete shall have a minimum compressive strength at 28 days of 17.5 MPa and shall be placed over all areas so designated in the Drawings and as advised by the Designer during construction.

2.3.2. Aggregates

Fine and coarse aggregates shall comply with the requirements of NZS 3121 and NZS 3111. The maximum size of coarse aggregate shall be 19 mm. The Contractor shall provide the Designer with details of the mix design, a minimum of two weeks before work is to commence. Once a review of the mix design has been completed by the Designer, the mix design shall not vary without the prior approval of the Designer.

Aggregates in off-site supply shall be those for which the high grade designation of the off-site concrete plant has been obtained. The aggregate shall not have a temperature in excess of 30° C prior to mixing.

2.3.3. Additives and Admixtures

No admixtures shall be used without prior agreement with the Designer.

A water reducer, retarder or air entraining agent may be used in the concrete mix to give added waterproofing and plasticising properties. The amount to be added shall be as per the manufacturer's specifications. This shall be shown in the mix design (refer Section 2.4). The Contractor shall not use other additives in the concrete without the prior written permission of the Designer. Details of admixtures shall be provided to the Designer for evaluation. These must include the manufacturer's specification, the brand and type, the recommended and proposed dosage rate and the corresponding test certificates to verify that the admixture meets the compliance test requirements of NZS 3113 together with the manufacturer's recommended maximum acceptable variations in the uniformity test criteria, of pH, solids content, relative density and total ash content.

Calcium chloride as an admixture is not permitted.

All admixtures must comply with NZS 3113 and meet the compliance and uniformity test requirements of NZS 3113.

If admixtures are approved then an automatic dosing device must be employed at the mixing plant.

For any admixture approved, the following applies:

(i) it shall contain not more than 100 ppm of any chlorides

(ii) it shall be tested for compliance and uniformity in accordance with NZS 3113.

(iii) it shall have a pH value of not less than 4.5.

2.3.4. Reinforcing Steel

Reinforcing bars shall be hot rolled steel Grade 300 or 500 as shown on the Drawings. They shall comply with AS/NZS 4671.

2.3.5. Mortar

The mortar mix proportions shall be such as to meet the following requirements:

Compressive strength at 28 days – f'_c (50 mm dia x 100 mm cylinders tested in a similar manner to the concrete compression test) shall be 20 MPa.

Volumetric proportions of cement to moist sand with 3 to 5% moisture content (or equivalent proportions if weigh-batched) shall be not less than one part of cement to three parts of sand.

Admixtures containing chlorides, nitrates or any other compounds likely to adversely affect the strength or durability of the mortar shall not be used.

The mortar shall be mixed to a uniform consistency before application.

2.3.6. Cement

Cement shall be type GP – general purpose Portland cement complying with NZS 3122 and the following requirements governing supply, quality and storage. The temperature of the cement shall not exceed 30 degrees Celsius prior to mixing.

2.3.7. Water

The water shall not exceed 30°C temperature prior to mixing. The Contractor shall note the requirements of clause 4.4.5.

2.3.8. Proprietary Grout

Proprietary grout shall be provided in a pre-mixed form. 10 mm aggregate may be added where permitted by the manufacturer and where the thickness of voids to be grouted permits.

2.4. Off Site Concrete Supply

2.4.1. Production

Mixing and supply shall be from a NZ Ready Mixed Concrete Association audited plant meeting all respects the requirements of this specification.

Note the specific requirement for an appropriate retarder to cover travel waiting and discharge time. The Plant Engineer is responsible for the design of the mixes and monitoring of the manufacturing, quality control and testing procedures. The Engineer

to the Plant defined under Clause 102.1 of NZS 3104 shall be available for consultation and direction when required. The Plant Engineer defined in Clause 102.1 of NZS 3104 shall be stationed at the plant at all times during production.

Facilities shall be provided for the separate simultaneous addition of at least two admixtures. The method of measuring and dispensing the admixtures shall be accurate to within +/- 3%. All admixtures shall be added to the concrete in accordance with the manufacturer's recommendations.

Liquid admixtures shall be dispensed into the mixing water supply line between the water weighing device and the mixer at a constant rate throughout the supply of water to the mixer. No admixtures shall be added to any of the mixes without the prior agreement of the Designer, as to type quality and dosage.

Each weighting unit shall include a visible springless dial or equally suitable device which shall indicate the scale load at the stages of the weighting operation from zero to full capacity. All proportioning shall be by weight.

The batching equipment shall be capable of ready adjustment for compensating for the varying weight of any moisture contained in the aggregate and for change of mix proportions.

The mechanism for delivering water to the mixer shall be such that leakage will not occur when the valves are closed, and that small increments of water may be discharged when required for final slump adjustment of the concrete in the mixer. The filling and discharge valves for the water tank shall be so interlocked that the discharge valves cannot be opened before the fill valve is fully closed. The water weighing device shall be constructed so that the water will be discharges freely and quickly in to the mixer without significant dribble from the end of the discharge pipe.

Weighing hoppers shall be so constructed so as to permit the convenient removal of material in excess of the prescribed tolerances, and suitable facilities shall be provided for readily obtaining samples of aggregate from each of the streams between the storage hoppers and weigh hoppers.

All weighing devices shall be inspected and certified by qualified scale technicians using calibrated masses immediately prior to commencement of operations on this contract and thereafter at least at the frequency specified in NZS 3103. The weighing system shall be capable of clearly showing the empty cement bin weight. Routine tests by the plant Engineer shall be made at the frequency specified in NZS 3104 and records of such checks kept available for the Designer.

Every weighing indicator shall be in full view of the operator and the weighing equipment shall be so arranged that the operator may conveniently observe the operation of the bin gates and also the materials charged into the truck hopper.

2.4.2. Delivery Records

Records shall be kept at the batching plant for each batch including the following:

- batch number and docket number which can be referenced back to the batch plant
- print out of quantities for the batch
- specified slump
- mix designation (minimum strength, aggregate size and admixtures)
- specified strength
- date and time of mixing
- quantity delivered
- actual weight and type of cement, fine and coarse aggregate, weight of free water and hence the free water / cement ratio.

If concrete is delivered by truck from an off-site batching plant, delivery dockets containing this information shall accompany each truck.

These dockets shall be made out in triplicate by the batch plant operator. The original shall be retained by the batch plant. The remaining two copies shall be given to the truck driver who shall retain one copy and give the other copy to the Principal.

No water shall be added to the mix after it has left the mixing plant. If delivery records do not agree with the approved mix design, the Designer may not accept the concrete for placement in the Works.

2.4.3. Discharge Time

Discharge of concrete into the structure or formwork shall be completed within the following period of time after the first introduction of the cement to the aggregates or of mixing water to the cement and aggregates.

For concretes without an approved retarder: 45 minutes

For concretes containing an approved retarder: 100 minutes

2.4.4. Mixing and Transport Equipment

All materials and concrete shall be fully discharged from any mixing and transporting equipment used before it is charged with a new mix. The drum of the mixer and the trucks shall be thoroughly cleaned of all adhering concrete at frequent intervals during continuous operation; the mixers which have been out of use for more than 30 minutes shall be cleaned before any fresh concrete is mixed or introduced. Any water in mixing or transporting equipment shall be removed before concrete or materials are discharged into.

Transit mixer trucks shall not carry additional water at any time. Water from within the confines of the construction site shall be used as necessary for the washing of transit mixers only after discharge of all concrete.

2.4.5. Additional Water

After discharge from the central plant, water may only be added to the concrete mixes in the transit mixer trucks, in accordance with clause 9.4.2.1 of NZS 3109. See clause 4.4.2 for the limited addition of water to normal concrete mixes where the slump of the concrete is less than that specified.

2.5. Testing of Concrete

2.5.1. General

All equipment for the tests as required in NZS 3112 shall be provided by the Contractor and all testing will be carried out by him. The Contractor shall supply all necessary labour to assist with sampling of the concrete and supply all necessary concrete for the testing.

All laboratory tests shall be performed by a registered testing laboratory approved by the Designer and the Contractor shall pay all costs and incidental expenses incurred for testing services.

Where stripping times are required to be reduced because of the construction time-tabling or for other reasons deemed valid by the Designer, the number of specimens shall be increased. This number will be determined by the Designer but will not normally be fewer than six compressive strength test specimens.

2.5.2. Slump Tests

The results of slump tests taken on samples of concrete at the point of delivery shall be the only basis for defining the slump of the mixes supplied.

The slump for cast-in-situ concrete shall be as specified in Section 2.3.1 unless authorised by the Designer as a variation. Tolerances for slump shall be in accordance with NZS 3109, Table 9.1. Where a test sample at the time of placing fails to come within these tolerances the concrete is liable for rejection by the Designer. Slump tests shall be carried out in accordance with NZS 3112: Part 1. At least one slump test shall be performed on each batch of concrete. Where the slump of the concrete as delivered is less than specified and the concrete is less than one hour old, a limited addition of water by the supplier shall be permitted subject to conditions set out in clause 9.4.2.1 of NZS 3109.

2.5.3. Compressive Strength Test Samples

A total of three compressive strength test specimens shall be moulded for each pour between construction joints unless the Designer directs otherwise. The specimens shall be prepared, stored and cured in accordance with NZS 3112: Part 2. If a specimen is required for testing for early strength indication at 7 days, a fourth sample shall be made.

Three specimens shall be tested at 28 days and the other specimen (if required) shall be tested for early age strength at 7 days. The strength of the concrete will be determined from the cylinder test strengths with tolerances as set out in NZS 3109.

2.5.4. Core Sampling

If after 28 days the compressive test specimens do not reach the required strength, the Designer may at his discretion order the concrete represented by the failed tests to be removed from the work. The Contractor may elect, at his expense, to take core samples of the concrete to confirm the in-situ strength of the concrete. The Contractor shall notify the Designer before such samples are taken.

If after 28 days the compressive strength test specimens do not reach the required strength, the Designer may at his discretion (and taking into consideration the provisions of C9.5 of NZS 3910) order cores to be taken in accordance with BS 1881 Part 120 (Method for determination of the compressive strength of concrete cores) Section 4 and tested and/or the concrete represented by the failed tests to be removed from the work. Testing concrete cores shall be undertaken in accordance with NZS 3112 Part 2, Section 9. Sample testing is to be performed by an independent agency.

2.5.5. Concrete Liable for Rejection

When concrete is liable for rejection from slump testing, the extent of the affected concrete shall be identified and assessed. No further concrete shall be placed where it would prejudice the removal of the concrete in question. The Contractor or concrete supplier shall, if disputing the test results, arrange to have confirming tests made from hardened cores taken from the concrete in question. Such cores shall comply with the requirements of clause 9.5.3 of NZS 3109.

2.6. Execution of Work

2.6.1. Excavation, Filling and Compaction

All excavation and filling, including sub-base, basecourse and compaction, including compaction testing requirements necessary for the concrete works shall comply with Section 1 of this specification detailing bulk earthworks requirements.

Filling behind retaining structures shall not commence until 1 week after the concrete pour. Specified compaction behind retaining structures shall be achieved using hand held compaction equipment and the Contractor shall not allow heavy compaction equipment within 1.5 m of retaining structures.

2.6.2. Formwork

2.6.2.1. General

Formwork shall comply in all respects with NZS 3109 Chapter 5. The Contractor shall ensure thorough checking of the formwork design as part of quality assurance. Where the Contractor uses proprietary materials, these shall be used in accordance with the manufacturer's recommendations and designed in accordance with the relevant New Zealand Standard.

Off the form surface finish shall comply with NZS 3114 and Section 2.10 of this Specification.

2.6.2.2. Tolerances

The Contractor shall provide final concrete tolerances as set out on the Drawings and in accordance with NZS 3109.

2.6.2.3. Striking of Formwork

The striking of formwork shall be carried out in accordance with NZS 3109. Where formwork is required to be removed early, the Contractor shall obtain the written approval of the Designer.

The Designer will only give this approval if results of compressive tests show that the concrete is up to the strength of that would normally be obtained at the minimum stripping time as given in Table 5.3 of NZS 3109.

2.6.2.4. Re-use of Formwork

Where formwork is to be re-used, the forms shall be clean and free of any laitance that may exist on the surface. Oil or other approved formwork release agents shall be applied to the surface of the form before it is re-used.

2.6.2.5. Support of Formwork

Supports shall be designed and constructed to provide the necessary rigidity and strength to support the loads to be carried. Bracing shall be provided both transversely and longitudinally and provision shall be made by means of wedges or jacks for adjusting the formwork.

2.6.3. Concrete Handling, Placing and Curing

Preparation, handling, placing, compaction and curing of concrete shall be carried out in accordance with the relevant clauses of Chapter 7 of NZS 3109 as modified or qualified by this specification. The Contractor shall not wash down formwork until vibration is complete.

Prior to any concreting, the Contractor shall provide to the Designer his proposed handling, placing and curing methods together with the proposed sequence and timing of pours. Concreting shall not commence until the Designer has undertaken a review, provided comments and any inadequacies are made good. All preparation for concreting is subject to the Designer's inspection and approval.

Skipped concrete or concrete placed by truck chute or hand placed shall not be allowed to drop through a free fall greater than 1.5 metres in height. When concrete pour heights exceed 1.5 m the Contractor shall use a tremie pipe or place concrete through letterbox openings in the formwork so pour heights do not exceed 1.5 m.

Concrete shall be compacted with vibrators. A spare vibrator shall be available on site during all concrete pours. The Contractor shall protect the surface of the wet concrete immediately in the event of rain occurring during or shortly after placing.

Concrete shall be cured for at least seven days starting immediately after placement. Generally, where wall pours follow up on floor or foundation pours, the curing period for the floor or foundation shall not be terminated before the completion of the wall curing.

Concrete in any one pour shall be placed in even layers.

The maximum differential at any one time on the wet concrete surface shall be 500 mm. During concreting around conduits, particular care shall be taken to avoid any flotation and restraints shall be conservatively designed.

The integrity of joints is particularly important in this project and special care shall be taken to achieve dense concrete filling all voids within the forms at all joints, especially where a water stop is included in the joint.

2.6.4. Construction Loads and Deflections

In providing support to construction from a previously constructed portion of the works the Contractor shall plan the removal of propping such that stresses and deflections are not excessive.

The construction loads imposed on a structure of age 28 days or more shall be such that the strength requirements do not exceed those induced by the design loading, unless it is demonstrated by calculation that the strength requirements are within the capacity of the supporting structure.

Where the structure is less than 28 days old, the allowable loads shall be appropriately reduced. The Contractor shall seek approval from the Designer for all loads imposed during construction.

Where construction loads on a structure are such that strength requirements are greater than those due to the design loading, or where a structure is to be loaded at an age less than 28 days. The Contractor shall demonstrate that calculated final deflections (following removal of construction loads and application of design loads) are either less than the calculated deflections which would be caused by the application of the design loading or within acceptable limits as defined by the Designer. Such calculations shall take into account, where appropriate, non-recoverable deflections due to creep of young concrete.

2.7. Cast-In Items and Anchors

Items embedded in concrete include items fixed integrally with fresh primary concrete or fresh secondary concrete in blockouts or by fixing into holes drilled in hardened concrete and subsequently grouted into place.

If shown on the Drawings or if directed by the Designer, recesses or blockouts shall be made in the concrete and the holding down bolts shall be grouted in place, or embedded in the second-stage concrete. The surfaces of all holding down bolts to be in contact with concrete shall be thoroughly cleaned immediately before the grout or concrete is placed. Holding down bolts shall be positioned and aligned in accordance with the tolerances

specified in Section 2.10 of this specification or as shown on the Drawings to achieve the correct grade and alignment before the concrete is placed. Cast in items shall be held securely in the correct position during placing and setting of the concrete.

Items shall be embedded with care to achieve the correct grade and alignment. All surfaces in contact with concrete shall be thoroughly clean at the time of concreting or being surrounded by any other fixing medium. The embedded items shall be held securely in correct position during embedment within the tolerances permitted and together with the zone of embedment be protected against damage.

Cast in bolts shall be in accordance with AS 1111 and be hot dip galvanised to AS/NZS 4680 unless otherwise detailed on the drawings or supplied by others.

Holes for anchors shall be thoroughly clean, dry and free from all loose material when the anchors are installed.

Installation And Grouting shall be carried out by personnel experienced in this type of work and familiar with the Materials to be used. Materials including proprietary anchor bolt systems, shall be stored, mixed and placed in strict accordance with the manufacturers written instructions and recommendations.

Epoxy Resin Grout shall be chemically resistant and suitable to give an ultimate anchor pull out resistance of at least twice the specified test load. This shall be demonstrated by documented test results.

2.8. Concrete for Armour Interlocking

Concrete for interlocking of spillway and stilling basin armour shall mix properties as specified in Section 2.3.1. The volume of concrete required will be that necessary to provide filling of interstitial voids to the depths shown in the Drawings.

Armour shall be wet immediately prior to commencing the grouting operation.

Spading, rodding and vibration shall be used where necessary to fill all interstices to the depths shown on the Drawings.

Weep holes shall be provided through the concrete interlocking to relieve hydrostatic pressure build-up behind the concrete. Weeps should extend through the concrete surface to the interface with non interlocked armour below. Weep pipes shall not contact the geotextile below the armour. Weeps should consist of 50 mm diameter UPVC pipes having a maximum horizontal spacing of 2.0 m and a maximum vertical spacing of 3.0 m. Exposed weep pipes shall be temporarily capped prior to concreting. Capping shall be removed and pipes trimmed back to the surface of the concrete following curing.

The finished concrete shall leave face stones exposed for one-fourth to one-third their depth.

2.9. Construction and Contraction Joints

2.9.1. Construction

Construction and contraction joints shall be in the positions shown on the Drawings unless otherwise approved by the Designer. Construction joints shall be made in accordance with Section 5.6 of NZS 3109. Movement control joints shall have a concrete finish similar to that of the adjacent concrete.

Proprietary products included in or at the joints shall be installed in strict accordance with the suppliers' specifications and recommendations.

Unless shown otherwise on the drawings all joints between precast and insitu concrete shall be prepared and constructed to meet the requirements for 'Type B' construction joints in accordance with NZS 3109.

The Contractor's proposals for the pattern of joints for surfaces that will be visible on completion of the work must be agreed by the Designer before any concrete is poured, including precast concrete.

20 x 20 mm fillets and chamfers shall be used on all corners, unless expressly noted otherwise on the Drawings. All external angles in exposed members shall be protected against damage after stripping of formwork. The Contractor shall give a slight bevel to all insertions to ensure easy removal without damage to the concrete.

The Contractor shall nominate a limited number of responsible personnel who shall be involved in the mixing and placement of the insitu joints. The Contractor shall demonstrate his familiarity with the procedures required to ensure that the quality requirements shown on the Drawings and contained in this specification are achieved.

Should edges at construction joints be damaged the Designer reserves the right to nominate the method of repair.

2.9.2. Preparation of Horizontal Joints

The preparation of the construction joint surface shall be carried out by scabbling. The Contractor shall apply a thin coat of cement grout to the joint, no more than ten minutes before placement of the fresh concrete on top of the prepared surface of the joint, so as to cover the exposed surface of the joint completely.

2.10. Tolerances and Surface Finishes

All concrete work shall be set out and constructed to achieve the structural tolerances specified in NZS 3109. The Contractor as part of quality assurance shall check setting out for all concrete work for accuracy. Surface finishes shall comply with the requirements of NZS 3114 Specification for Concrete Surface Finishes and additional special requirements as designated below.

Location	Type of Finish
Conduit	F1, U1
Exposed surfaces	F5, U4

All penetrations, nibs, chases, embedments etc shall be positioned as required. The Contractor shall check the requirements of other trades and shall be wholly responsible for the accuracy of locating all such items. The Contractor shall confirm any penetration not detailed in the Drawings before work starts in that area.

Where an error has to be corrected between one bay and the next or between one level and the next, such correction shall have the express approval of the Designer before being carried out.

2.11. Repair of Concrete

2.11.1. General

The following requirements supersede Section 10 of the NZS 3109:1987. No repairs shall be undertaken without instruction from the Designer. The Contractor shall alert the Designer to the presence of any defective concrete.

Unless otherwise approved by the Designer, repair of imperfections in the concrete shall be completed within seven days of removal of the forms. Where epoxy resin repairs are required, the repair shall not be made until 28 days after the concrete has been placed. Repair of the concrete shall be performed by skilled workmen, and the repairs shall be of a quality comparable to the adjacent area of the structure.

The Designer shall determine the extent and depth of the repair work prior to commencing removal of the faulty concrete.

Repairs to surfaces with F4 finish shall be colour-matched with the parent concrete and where necessary, limestone or marble dust shall be mixed with the sand, and white cement mixed with Portland cement to ensure a satisfactory colour match. The Contractor shall ensure that the texture of the repairs shall match the texture of adjacent surfaces. The Designer may require defective areas to be over-excavated to ensure that the finished surface of the repair shall be a rectangular or other regular shape.

2.11.2. Mortar or Repair with New Concrete

Existing concrete surfaces to which the new concrete or dry pack mortar is to be bonded shall be clean and surface roughened. The surface shall, if necessary be roughened, and all damaged, loosened or un-bonded portions of existing concrete must be removed by a chipping hammer or other suitable method.

The methods of repair shall follow the procedures set out in NZS 3109 Chapter 10 (1987) for dry pack mortar, concrete or plaster. Where steel remains exposed after all areas of loose or otherwise unacceptable concrete have been removed, the material for repair shall

be concrete. Existing concrete shall be removed from behind the steel for a distance of at least twice the normal aggregate size, and fresh concrete placed in accordance with Section 10.3.3 of NZS 3109:1987. The repair shall be free of shrinkage cracks and drummy areas.

Dry pack mortar filling shall not be used for holes extending entirely through concrete sections, for holes which are greater in area than 300 mm square and deeper than 100 mm and for holes in reinforced concrete which extend beyond the reinforcement nearest the surface.

Holes remaining after dismantling form ties shall be neatly plugged with mortar filling. The mortar shall be colour matched with surrounding concrete and the finished surface of the repair shall be recessed 3 mm below the surface.

2.11.3. Epoxy Mortar Repair

Where epoxy mortar or epoxy concrete is proposed to be used for the repair, such work shall be carried out in accordance with the manufacturer's requirements. Before any repair of this nature is carried out, the approval of the Designer shall be obtained.

Immediately prior to carrying out a repair, using on epoxy mortar the surface of the concrete in the hole shall be cleaned of all contaminants by sandblasting, etching with a 5% solution of hydrochloric acid or other approved method. If acid-etch is used, immediately the foaming ceases the hold shall be thoroughly flushed with clean, fresh water to remove the acid and clean the area. The surface of the hole shall be mopped dry, and where necessary, effective means taken to exclude all surface water. The surface of the hole and the concrete immediately surrounding it shall be dried using lamps, an oxy-acetylene flame fitted with a de-scaling tip, heaters, dry oil-free compressed air or other suitable means approved by the Designer. Prevent damage to the concrete during drying. When the hole is free from surface moisture, a temperature of approximately 25° C shall be maintained over the whole affected area for a period of 30 minutes.

After the filling has been cured and dried, it shall be bonded tightly to be surface and shall be free of shrinkage cracks and drummy areas.

3. Pipework and Fittings

3.1. Scope

This Section covers the pipework and fittings within the Contract Works including drawoff facilities from the dam and subsoil drains. Appropriate parts of the Earthworks Specification apply to the work.

3.2. Compliance

Construction work performed under this Section shall comply with the general requirements of the following documents and the specific requirements of this Section:

NZS/AS 2033	Installation of polyethylene pipe systems
NZS/AS 2566	Buried flexible pipelines
NZS/AS 1462	Methods of test for plastic pipes and fittings
NZS/AS 4129	Fittings for polyethylene (PE) pipes for pressure applications
NZS/AS 4130	Polyethylene pipes for pressure applications
NZS/AS 1554.1	Structural steel welding
NZS 4442	Welded steel pipes and fittings for water, sewage and medium pressure gas
NZS/AS 4087	Metallic flanges for waterworks purposes
NZS/AS 4331	Metallic flanges
NZS/AS 2280	Ductile iron pipes and fittings
NZS 3107	Specification for precast concrete drainage and pressure pipes
AS 4795	Double flanged butterfly valves for waterworks purposes
NZS/AS 2638.2	Gate valves for waterworks purposes - Resilient seated
NZS/BS 5163	Specification for predominantly key-operated cast iron gate valves for waterworks purposes
AS 1646	Elastomeric Seals for Waterworks Purposes

NZS/AS 4680	Hot dipped galvanised (zinc) coatings on fabricated ferrous articles
NZS/AS 4791	Hot dipped galvanised (zinc) coatings on ferrous open sections
NZS/AS 4792	Hot dipped galvanised (zinc) coatings on ferrous hollow sections

3.3. Materials

3.3.1. General

Materials shall be stored, handled, and distributed on Site with care to avoid damage and in accordance with the manufacturer's recommendations. All materials to be used in the Works shall be in new condition.

3.3.2. Concrete Pipes and Manholes

Concrete drainage pipes and manholes shall be manufactured in accordance with the requirements of NZS 3107.

3.3.3. Small diameter HDPE Pipes and Fittings

HDPE pipes and fittings shall be heavy wall to the requirements of NZS/AS 4130 and to thicknesses shown on the Drawings with all connections other than to fittings and structures being welded.

All ND 160 HDPE pipes shall be SDR 17 P80. Other equivalent corrugated perforated subsoil drain pipes such as "Novaflo" are not acceptable in lieu of ND 160 Hi-way Drain unless approved by the Designer.

HDPE pipes shall be butt fusion welded in accordance with the manufacturer's procedure guidelines for the butt welding process.

3.3.4. Rubber Rings

Rubber rings for pipes shall be manufactured in accordance with requirements of AS 1646. Rubber rings shall be stored away from direct sunlight and shall be kept free of grease, oil, paint and other substances deleterious to rubber. Rings showing any signs of damage or fault shall be removed from the Site and replaced at no additional cost to the Principal.

3.3.5. Fittings

Cast iron fittings and specials shall be manufactured from high quality grey iron and factory coated with a proven bituminous protective compound and adequate for the pressure Class shown on the Drawings.

Other fittings such as gibault joints, tapping straps and saddles, are not covered by standard specifications but must be approved types. Bolts used in these fittings shall be hot dip galvanised after threading. Nuts shall be tapped after galvanising up to 0.4 mm oversize to enable them to mate with the bolts and the threads shall be oiled. The bolts shall be liberally coated with "copper-cote" or similar approved prior to assembly. Following assembly of the unit the nut and exposed thread on the end of the bolt shall be securely wrapped with at least two layers of Denso tape to form an impermeable cover.

Gate valves shall be cast iron, anti-clockwise closing, heavy pattern, with a non-rising spindle. The valves shall conform with BS 5163 and NZS/AS 2638.2. Valves and flanges shall be of strength to match the designed working head. The use of so-called "light pattern valves" which do not conform with this Specification will not be permitted.

Butterfly valves shall comply with the following requirements:

- conform with AS4795
- nylon/epoxy coated, cast iron, wafer or lug bodies
- with flange locating holes that meet NZS/AS 4331
- be of resilient seat type

The Contractor shall provide detailed operation and maintenance information with any supplied valve.

3.3.6. Subsoil and Flexible Drain Pipes

Perforated subsoil drain pipes and flexible drain pipe shall be standard Nilex Hi-way drain or equivalent.

3.4. Construction

3.4.1. Setting Out

The Contractor shall provide all equipment necessary to set out pipelines accurately in both the horizontal and vertical planes. Upon request the methods that are proposed to be used shall be submitted to the Designer for approval prior to the commencement of the Works.

3.4.2. Tolerances

All pipework shall be constructed to the lines, levels and grades shown on the Drawings. Tolerances shall be +/- 20 mm unless manufacturer's requirements or the standard specifications in Section 2.10 specify more rigorous requirements, such as at joints.

3.4.3. Transport, Handling, Storage and Erection of Materials

The Contractor shall be responsible for the transport (unless noted otherwise), handling, storage and security of all pipe and fittings which shall be handled and stacked strictly in accordance with the supplier's recommendations.

Materials may be inspected by the Designer at his discretion. The Contractor shall provide every assistance, including lifting and rotating pipes, to enable these inspections to be undertaken efficiently.

Damaged or unsatisfactory materials noted at that time will be marked and the Contractor shall either replace the item or if the Designer permits, repair the defect in an approved manner. The costs of repair or replacement of damaged, unsatisfactory or repaired materials used or unused in the Works shall be borne by the Contractor, whether the Designer has inspected and approved the materials or not.

Any component damaged during erection or subsequent filling operations shall be replaced or repaired to the Designer's instructions at no cost to the Principal.

3.4.4. Pipe Laying and Jointing

3.4.4.1. General

Pipes and fittings shall be thoroughly cleaned before erection, and shall be kept clean throughout the jointing and testing procedures. Whenever work is discontinued or whenever there is any likelihood of entry of foreign matter, the open ends of the laid pipes shall be closed with suitable caps. If the excavations are likely to be flooded by stormwater, these end caps shall be watertight and effective precautions taken to prevent the pipeline from floating.

The jointing and laying of all pipes shall be carried out strictly in accordance with the manufacturer's written instructions.

Notwithstanding any tolerance given in this Section, the main pipe through the dam shall be laid on accurately positioned plinths or saddles to achieve as accurate a fit as possible. Any local offsets at joints arising from manufacture or erection shall be made flush, to the Designer's satisfaction.

3.4.4.2. Drawoff Pipework and Fittings

Concrete lined steel and HDPE pipework, flanges, gibault joints, valves and the like shall be matched to achieve proper fit and avoid any abrupt changes in diameter. Joints shall be leak proof and be confirmed as such by test under pressure before any backfilling. Bends shall be restrained during testing. The Designer will define the test pressure prior at the time of testing.

3.4.4.3. Flexible Pipe Drains and Subsoil Drains

Flexible pipe and subsoil drains shall be bedded and backfilled as shown on the Drawings. In some situations, subsoil drainage may be integral with special filter/drainage zones. At least 0.5 m of cover over the drain shall be provided before heavy plant is permitted to traffic above where the pipe has been laid.

IMPORTANT NOTICE - The upstream ends of all subsoil drains, where not provided with a detailed entry or connected to other pipes, shall be securely filtered, plugged or

capped to the satisfaction of the Designer, and the Contractor shall ensure that each procedure is witnessed and signed off.

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THE HALDON RANGE LTD

IRRIGATION DAM

DAM AND RESERVOIR WORKS

CONSTRUCTION CONTRACT SPECIFICATION

APPENDIX A

STANDPIPE FIELD PERMEABILITY TEST

T&T Construction Note
Standpipe Field Permeability Test

(Retyped from Power Design Office P.W. 92/19/32/1)

PREFACE

This technical instruction is based primarily on the results of an electrical analogue investigation carried out at Central Laboratory (see Central Laboratory Report No. 77). These results now serve as a rational basis for evaluating permeameter readings and therefore supersede any previous procedures. Other improvements and modification incorporated herein arise from past experience in the use of the standpipe test.

CONTENTS

1. Introduction

The measurement of the insitu permeability of soils can be accomplished by measuring the flow of water into the soil from boreholes, wells and pits. Probably the most common method is to test from a borehole, that can be either fully cased or partly or wholly uncased. In some materials perforated casing is used. The formulae for evaluating borehole tests are based on the approximation of the test to a point or line source and the limitation $H/R \geq 10$ is therefore usually imposed. Formulae applicable

to shallow pits and wells are also available but the disadvantages of these tests include the use of low heads and the instability of the hole.

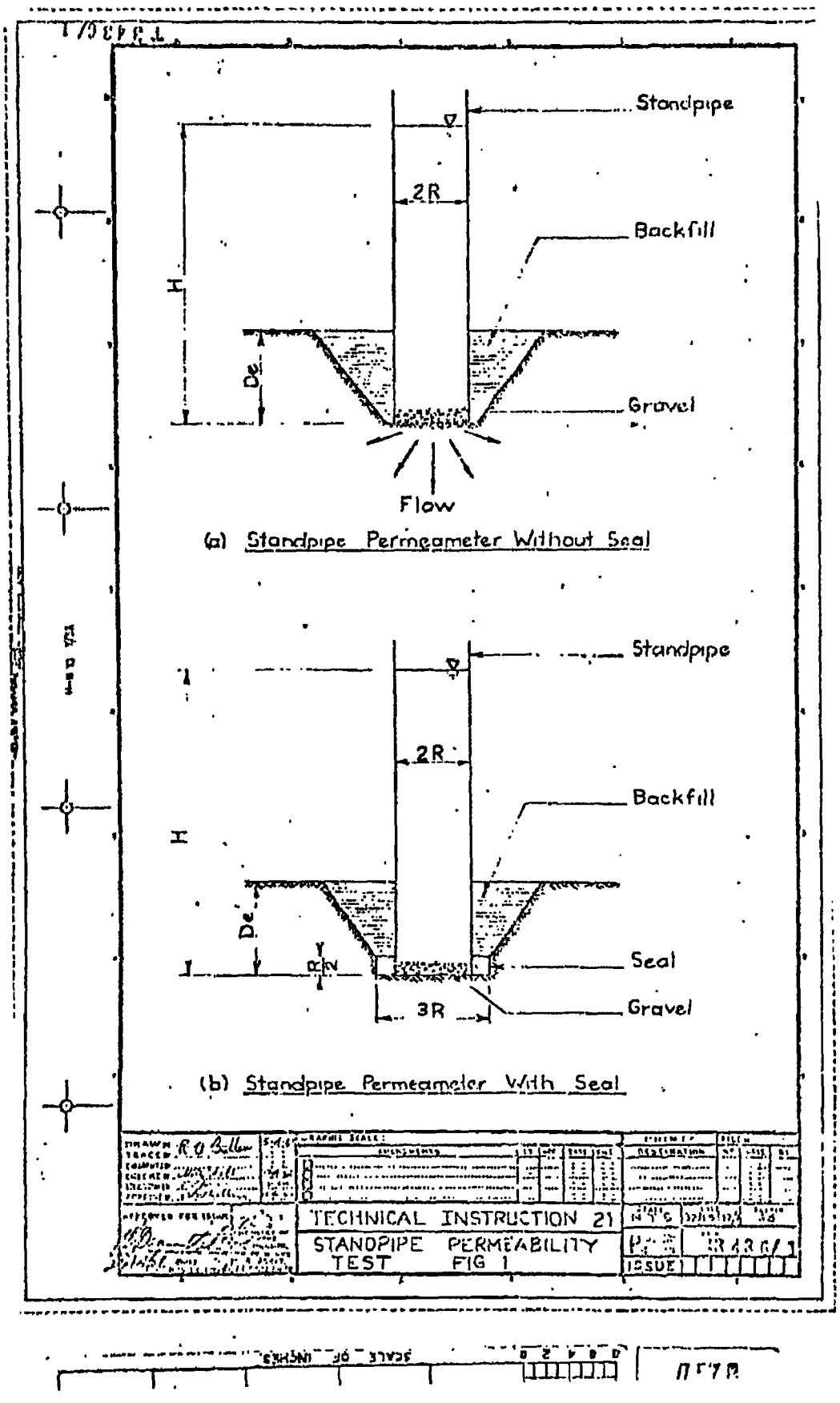
Where insitu permeability is required at or near ground surface, e.g. during earth dam construction, the standpipe permeability test has been found to be the best test available and it is to this test that this technical instruction applies. The standpipe permeameter consists of a short length of thin-walled, open-ended tubing partially embedded in the ground so that a prepared soil surface is exposed in the bottom of the cylinder. The cylinder is filled with water to a level which should be maintained constant. By measuring the outflow from the cylinder, the permeability of the soil can be computed.

2. Installation of Standpipe

There are two recommended methods for installing the standpipe and these arise from differences in the form of the backfill around the standpipe (see Fig. 1). First, a shallow hole is dug at the site to be tested and the bottom is struck off plane and level. Then the standpipe is placed centrally on the prepared surface and the hole outside the standpipe is backfilled. The two alternative backfilling procedures that can be used are:

a Backfill with the excavated material, compacting the soil in thin layers to approximately the same unit weight as the surrounding soil (see Fig. 1(a)).

b Place an impervious sealing material to a standard shape around the standpipe and follow this by backfilling with adjacent material as in (a) (see Fig. 1(b)).



Figures 1(a) and 1(b)

In future these two setups will be referred to as 'without seal' and 'with seal' respectively.

Once the standpipe is installed, the soil exposed inside the standpipe is covered with gravel about three inches deep and the standpipe is filled with water.

The following notes detail the various steps necessary for the installation of a standpipe permeameter both with and without a seal. However, it should be noted that the procedure described here for installing a seal may not be practical in all soils, in which case some experimentation would be necessary to find the best technique.

2.1. Technique for standpipe with a seal

Select the site for the permeability test and decide the depth of embedment. Referring to Fig. 4 the stages in the installation are as follows:

Stage 1: Dig the bulk of the material out of the hole using spade, pick, shovel, trowel, etc.

Stage 2: Level off the hole at a height greater than $\left(\frac{R}{2}\right)$ above the proposed level of the bottom of the standpipe.

Stage 3: Take a short length of cylinder, 3R diameter, and place it centrally on the levelled ground.

Stage 4: Start excavating the material inside this cylinder, carefully pushing the cylinder down as excavation proceeds.

Stage 5: Continue stage 4 until the bottom of this cylinder is at the intended level for the bottom of the standpipe. Strike the soil off so that it is plane and level, removing loose fine material with brush and scoop. A carpenter's level placed on top of the cylinder will quickly check the level of the prepared surface.

Stage 6: Carefully lift out the short length of cylinder and place the upright standpipe centrally on the prepared surface. To assist in placing the standpipe central and to maintain it so while the seal is placed, 3 or 4 wooden spacers, cut to suitable radii, are placed around the standpipe and inside the trimmed hole (see Section X-X).

Stage 7: Compact suitable sealing material in the gaps between these spacer blocks; not greater than 25 mm layers should be used. Then remove the spacer blocks and fill the remaining spaces with sealing material. The top shape of the seal is probably not very critical; however, the correct level can be easily obtained by painting a line on the standpipe at a distance $\left(\frac{R}{2}\right)$ above the bottom edge. A convenient seal material can usually be made by mixing dry bentonite with some of the surrounding soil.

Stage 8: Backfill the remainder of the hole – with excavated soil, carefully tamping it down in layers 50 mm to 75 mm thick.

Stage 9: Cover the soil exposed inside the standpipe with e inch of gravel or other coarse, silt-free material. This protects the soil against scouring when the standpipe is filled. The scoured material could "silt up" the soil surface giving rise to a false result for the permeability.

Stage 10: Fill the standpipe with clean water to the desired level and thus the test is ready to start.

2.2. Technique for standpipe without a seal

The procedure for this arrangement is much simpler and should proceed as follows: (refer to Fig. 5)

Stage 1: At the selected site dig the bulk of the material out of the hole using spade, pick, trowel, etc. The hole should be proportioned so that at depth De the diameter will be approximately 2R + 100 mm, i.e. just sufficient to allow a tamper alongside the standpipe. The top of the hole can be somewhat larger.

Stage 2: Carefully trim the bottom of the hole, strike it off plane and level, and remove all loose particles using a brush and trowel.

Stage 3: Carefully place the standpipe upright and central on the levelled soil. Backfill the excavated soil, tamping it in place in 50 mm to 75 mm layers.

Stage 4: The rest of the procedure is the same as stages 9 and 10 for the setup including a seal.

3. Test Procedure

To measure the permeability, one of two recommended procedures can be used. They are as follows:

a) Maintain a constant water level in the standpipe by means of a domestic high-pressure ball valve connected to an independent water supply. The rate of flow is measured by some convenient external means e.g. the fall in level in a supply tank.

b) If the permeability of the soil is low, the outflow from the standpipe will be small for a reasonable interval of time (say 12 hours) and the test can be run as a falling-head test, i.e. no addition of water after the first filling. Normally a falling-head test is not recommended but if

$$H_1 - H_2 \leq \frac{1}{10} \left(\frac{H_1 + H_2}{2} \right) \quad \text{.....(1)}$$

where H_1 = initial head at time t_1

H_2 = head at time t_2

then it can be assumed that the constant-head condition is fulfilled with an effective head equal to $(H_1 + H_2)/2$, and with the quantity flowing represented by $(H_1 - H_2)$. As well as fulfilling equation (1), a continuously falling average head should be avoided by topping up the standpipe after each permeability determination, i.e. an approximately constant average head should be maintained.

4. Evaluation of Permeability

The following equation is used, in conjunction with Fig. 2, to evaluate test data

$$Q = C_1 K R^2 \quad \text{.... (2)}$$

or

$$K = \frac{Q}{C_1 R^2} \quad \text{.... (3)}$$

where K = coefficient of permeability (should be expressed in cms/sec.)

Q = rate of flow

R = radius of the standpipe

C_1 = a coefficient that can be obtained from Fig. 2.

In the case of 3(b) above, where the test is run as a falling-head test, equation (3) can be modified as follows:

From the fall in level in the standpipe we have:

$$Q = \pi R^2 (H_1 - H_2)/(t_1 - t_2)$$

$$\therefore \quad K = \frac{(H_1 - H_2)}{(t_1 - t_2)} \cdot \frac{1}{C_1/\pi} \quad \text{.... (4)}$$

C_1 is obtained from Fig. 2 for the value of H/R equal to $(H_1 + H_2)/2R$

Note that equation (4) only applies if the standpipe has constant area over its entire length.

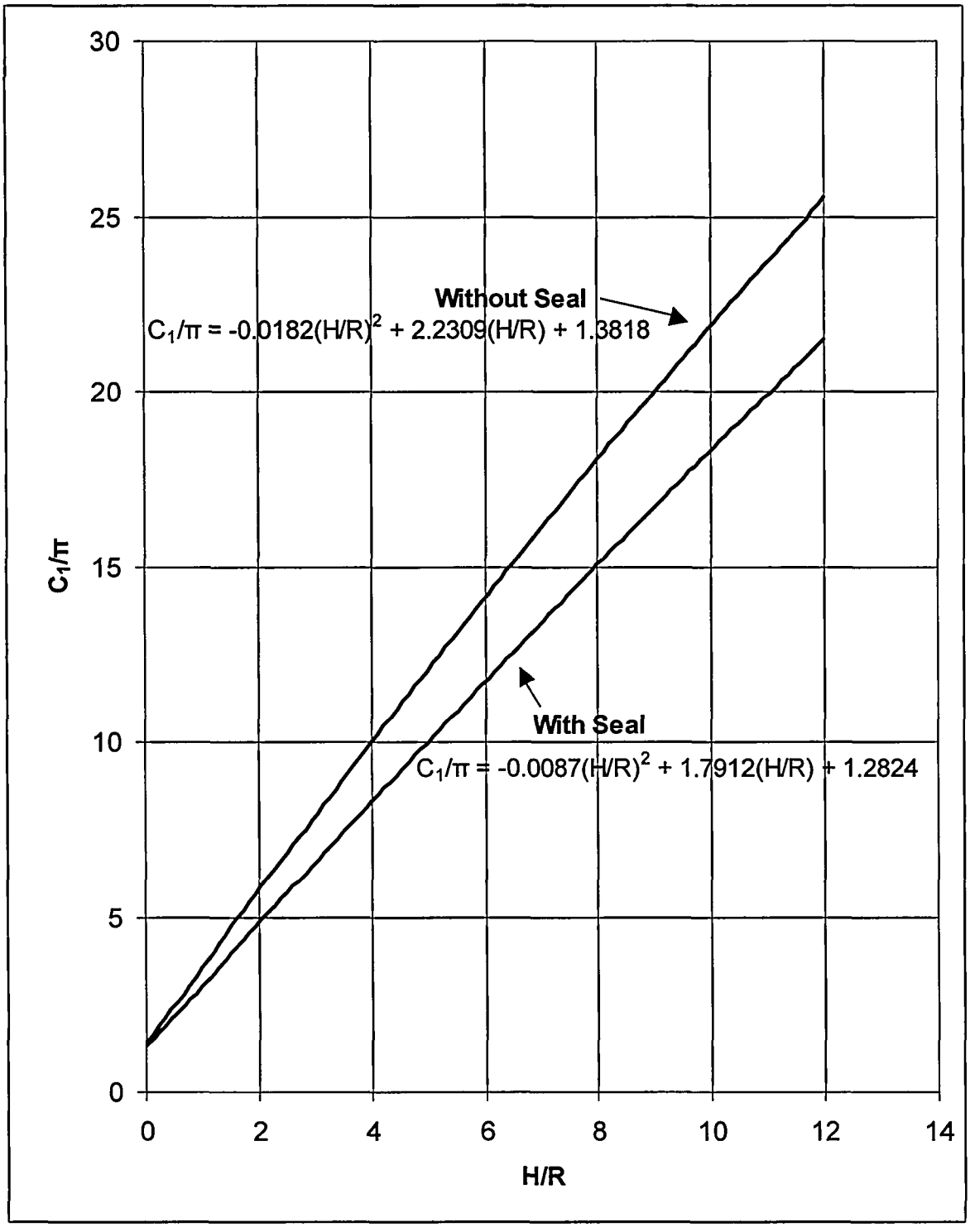

30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
C1/π
H/R
Without Seal
C1/π = -0.0182(H/R)2 + 2.2309(H/R) + 1.3818
With Seal
C1/π = -0.0087(H/R)2 + 1.7912(H/R) + 1.2824

Figure 2

5. Seal Dimensions

When the soil tested is such that there is a possibility of piping alongside the standpipe, it is advisable to incorporate a seal of plastic impervious soil. The size of this seal is quite arbitrary but in the electrical analogue investigation the effect of only one size of seal was investigated. The seal was assigned dimensions (R/2 x R/2), being a practical size for use with the standpipe diameters commonly in use. The geometry of the apparatus in the immediate vicinity of the standpipe is particularly important therefore the seal should be placed accurately with the lower and outside faces receiving the most attention. A suggested method for installation of a seal is detailed in Section D2.2.

6. Minimum Depth of Embedment

To ensure that the flow from the standpipe will not emerge at the surface of the soil, it is necessary to embed the bottom of the standpipe a minimum distance and this depth depends on the head in the standpipe. Fig. 3 gives curves of $\left(\frac{Dw}{R}\right)$, where D_w is the theoretical height of rise of the phreatic surface alongside the standpipe. Using these curves the following rule should be used to calculate the required depth of embedment:

Depth of Embedment (De) = Dw + 150 mm ..... (5)

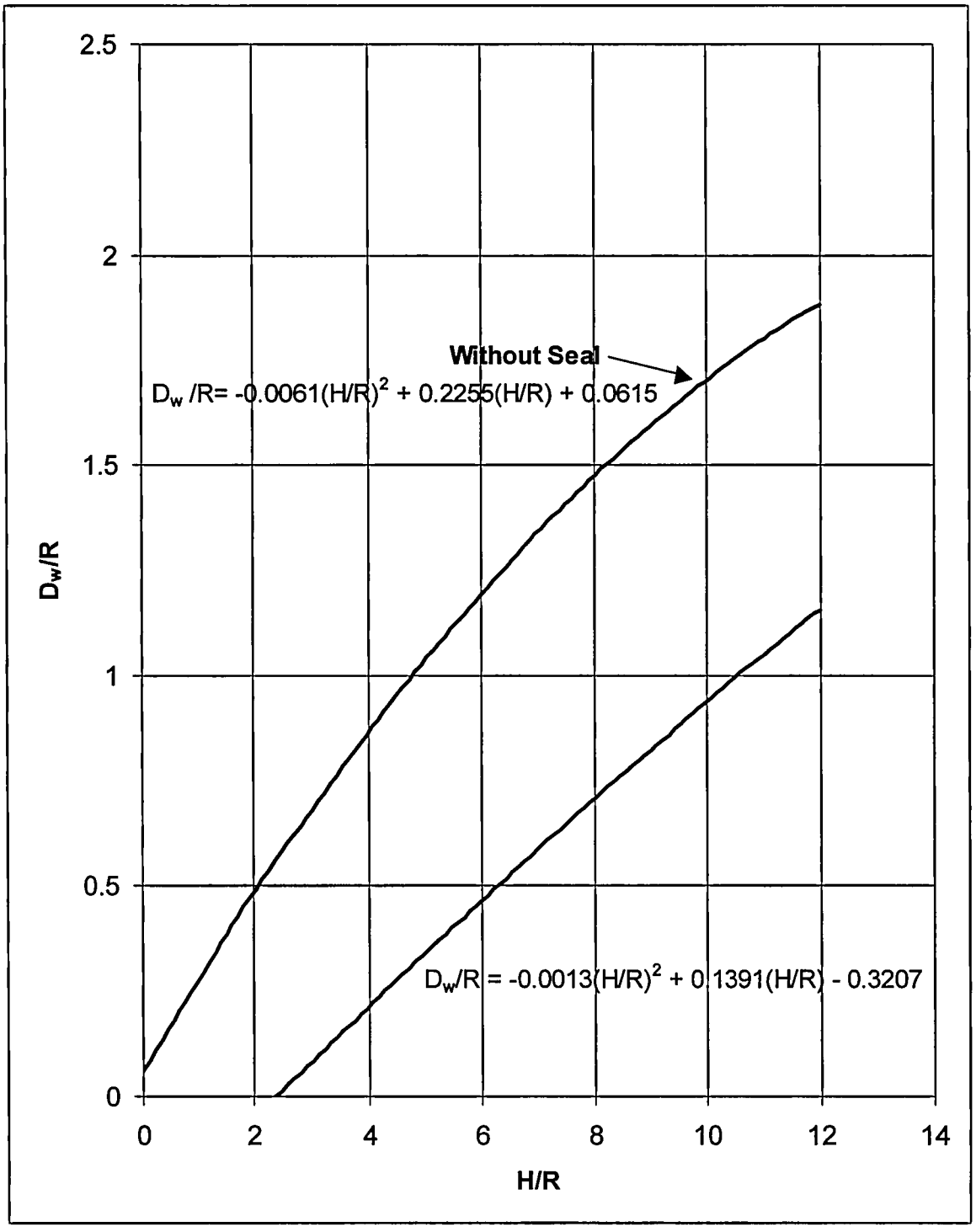

2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
D_w/R
H/R
Without Seal
D_w /R= -0.0061(H/R)^2 + 0.2255(H/R) + 0.0615
D_w/R = -0.0013(H/R)^2 + 0.1391(H/R) - 0.3207

Figure 3

7. Limitations on Boundary Conditions

Because the flow from the standpipe may be influenced by the proximity of a water-table, an impervious boundary or a highly pervious layer, it is necessary to impose limitations for the applicability of Fig. 2. These conditions are:

a) Minimum depth to water table or impervious boundary (assumed horizontal) = 2.5 H

b) Minimum depth to highly pervious layer (assumed horizontal) = 1.25 H

8. Time of Test

Equation (2) and Fig. 2 strictly apply only to steady flow conditions and the speed with which the latter will be developed depends on the permeability and capillarity of the soil, together with the amount of air displaced by the inflowing water. To ensure that ample time is allowed for steady flow to develop, it is necessary to compute and plot the apparent permeability at regular intervals as the test proceeds. When at least six computations covering a period of at least 1½ days of continuous running of the test, give results with comparatively steady values, then it may be accepted that steady flow is achieved and the average of the steady values may be taken as the insitu permeability. Experience in testing of a particular soil may indicate shortcut criteria that are suitable measures of steady flow conditions in that particular soil but this is only likely to be the case when there is extensive testing e.g. in construction control. It is estimated that in some soils the test may need to run for at least 72 hours whereas in other soils the time could be considerably shorter.

9. Relation of Standpipe Diameter to Largest Particle Size

When selecting the size of standpipe suitable for use in a particular soil, some consideration must be given to the maximum particle size. If the standpipe is too small, a single stone could become a major part of the soil exposed in the bottom of the standpipe, leading to a doubtful value for the computed permeability. Conversely, if the diameter of the standpipe is too large, the total quantity of flow may be so large that the supply of water becomes a problem. A 300 mm diameter standpipe is the most useful size and is quite suitable up to 37.5 mm maximum particle size. For larger material, it is advisable to use a proportionately larger standpipe. A convenient source for a large standpipe is a 44-gallon oil drum with both ends removed; the diameter is slightly less than 600 mm.

10. General Notes

10.1. Permissible Degree of Saturation of Soil

The applicability of the results from the analogue investigation depends greatly on the realisation of one important assumption. This assumption requires the soil to be sufficiently unsaturated for atmospheric pressure to be readily transmitted to a

substantial depth in the soil. If this condition is not realised, the boundary conditions are completely different and in effect we have a different test. It is considered that the required condition is obtained satisfactorily with soil compacted at a water content less than its optimum water content and showing no positive pore pressures in the top 1.5 m. For material compacted at a water content wetter than its optimum water content, the position is very doubtful.

10.2. Capillarity

In the past, the formula used to evaluate results attempted to correct for the effect of capillarity. The basis of this approach was somewhat doubtful and now it has been concluded that so long as steady flow conditions are obtained, no correction for capillarity is necessary.

10.3. Mesh Across Standpipe Bottom

In some soils, the relatively thin tubing used for the standpipe may penetrate into the soil, resulting in a plug of soil intruding into the standpipe. The effect of such a plug is not known but, because it is known that the geometry near the standpipe bottom is important, the intrusion should be prevented. To do this, it is suggested that a wire mesh be stretched across and fixed to the end of the standpipe, thus helping to spread the load during installation; a suitable size would be No. 4 mesh. With this mesh fixed to the standpipe, the gravel could be placed on top of the mesh before the standpipe is placed on the prepared soil, avoiding the need to drop stones directly onto the soil.

10.4. Standpipe Cover

A loose weighted cover should be placed on the standpipe at all times to reduce evaporation losses from the water and to prevent the entry of extraneous water and objects from outside.

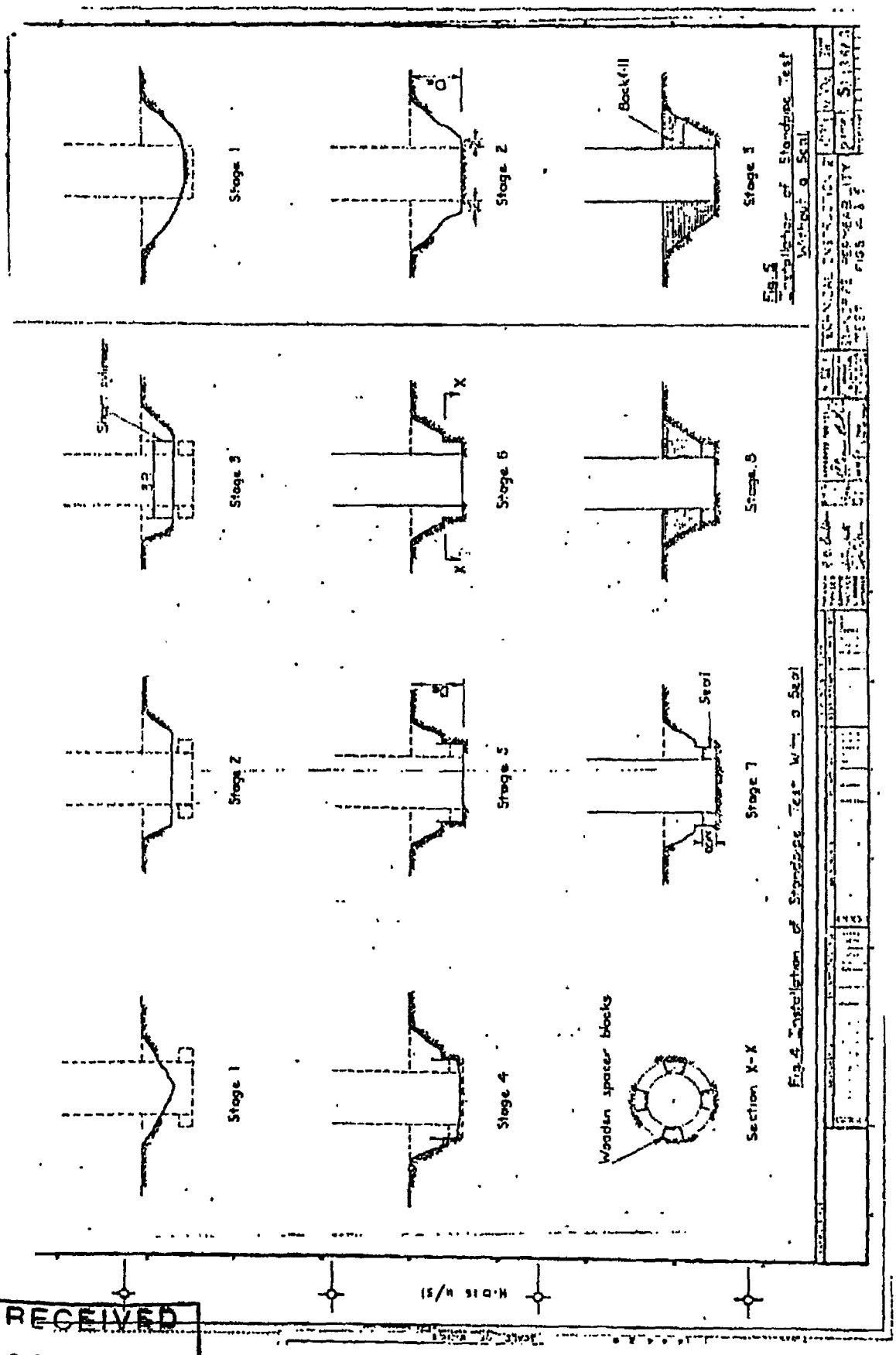


Fig.4 Installation of Standpipe Test with a Seal

Fig.5 Completion of Standpipe Test with a Seal