SOUTH AUSTRALIAN WATER CORPORATION

TG 10c

TECHNICAL GUIDELINE

GENERAL TECHNICAL INFORMATION FOR GEOTECHNICAL DESIGN

~ Part C ~
Earthworks

Issued by: Manager Engineering

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Government of South Australia

No Changes Required In the November 2007 Edition

The following lists the major changes to the November 2004 edition of TG 10c:

1. Nil

Contents

Figures

Referenced Documents

Geotechnical job file: “Heathfield – Damage Claim – 3 Scott Creek Road”

AS 1289 Methods of Testing Soils for Engineering Purposes

Section 1: Scope

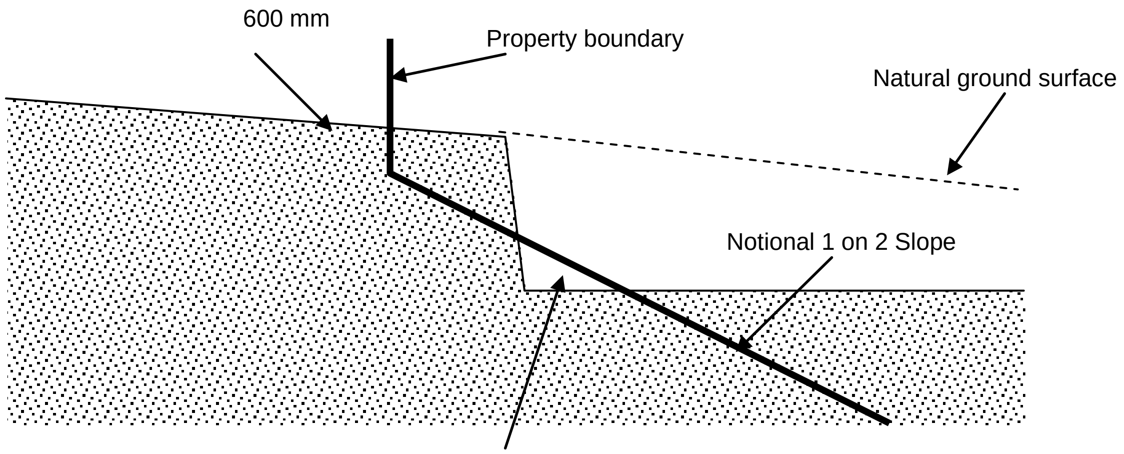
Section 2: Cuts at Boundaries – SA Development Act

Note: For full report refer to geotechnical job file (electronic or in cabinet): "Heathfield – Damage Claim – 3 Scott Creek Road"

2.1 Regulation and Inferences Regarding the Design of the Excavation

The South Australian Development Act (15 January 1994), Regulation 75(2), requires a professional engineer who has "appropriate experience and competence in the field of civil and geotechnical engineering" to specify appropriate requirements "to shore up any excavation … that affects the stability of other land .." where that excavation "intersects a notional plane extending downwards at a slope of 1 vertical to 2 horizontal from a point 600 mm below natural ground level at a boundary with an adjoining site .."

This verbally complicated sounding geometry is illustrated in the following diagram:



Professional engineering design is required if a proposed excavation extends below this heavy line, as it does in this illustration.

<u>Figure 2.1 - Illustration of Sounding Geometry</u>

The exact location of the property boundary has not yet been established on the site, but it is understood that it is at the tree line, and that all of the trees are within the SA Water reserve.

If this is correct, then it would appear that the excavation falls within the above criteria and therefore that a professional engineer with "appropriate experience and competence in the field of civil and geotechnical engineering" <u>should</u> have been engaged to specify the excavation works.

However, I would have expected it to have been obvious to such an engineer (if not from a trial hole investigation then certainly from the exposure provided by the cut face) that the face would not be stable in the long term at the angle it was cut to. I therefore infer that an engineer was not involved in the design of this excavation.

2.2 Conclusions

- The cut face is unstable, has failed in the recent past, and will continue to fail in the future.
- The reason that the cut face is unstable is that it was cut too steep.
- The SA Development Act, that commenced about one-year before the cut is understood to have been excavated, requires that a professional engineer with appropriate experience and competence in the field of civil and geotechnical engineering should have been engaged to specify the excavation works.
- There would have been ample clear evidence on the site at the time the earthworks were done to indicate to a “professional engineer with appropriate experience and competence in the field of civil and geotechnical engineering” that the slope as cut would not be stable in the long term.
- It is estimated that the long term stable angle for this cut face might be of the order of 1 vertical on 2 horizontal. Ie, either it should have been cut to this angle, or in the long term it will naturally fail back to about this angle.
- Well before the cut face reaches its natural long-term stable angle, the top of the cut face will have encroached into the SA Water reserve.
- In encroaching into the SA Water reserve, the failing cut face will cause many of the trees in the SA Water reserve to fall. Some may topple in the direction of Mr Kierns’ property, and some of these might reach the house.
- To stabilise the cut face it would be necessary to (for example):

  (a) Support it by placing extensive fill in front of it.

  (b) Support it by an engineered retaining wall built in front of it.

  (c) Support it by soil-nailing and meshing on the existing face alignment.

  (d) Batter it back into SA Water property.

This “Technical Note” was prepared by Ed Collingham, 25/07/2003
(Ex Principal Engineer Geotechnical)

Section 3: Principles of Good Earth Embankment Design

Finish the top of embankments with a definite crown (or at the very least a one-way crossfall) so that runoff makes its way off the top by the shortest possible route. This will prevent rainwater ponding and seeping into the embankment (risking tunnelling erosion), or running off in concentrated rivulets (causing rill erosion).

To be effective, the crossfall on the top of the embankment must be significantly steeper than the longitudinal gradient - this usually means at least 1V on 20H crossfall even for a "horizontal" length of embankment. Embankments with a longitudinal slope need special consideration.

If a one-way crossfall is used it is better to direct it to the (usually) well grassed and/or flatter outer slope of the embankment.

Very wide embankments or elevated plant areas would probably benefit from having "internal" drainage to sumps or paved spoon drains.

Tops of embankments should be topsoiled and grassed as a minimum, or "sealed" with a quarry rubble topping.

Ensure that no "windrows" of topping material are left along the edges of the crest - a definite "chamfer" is preferable.

Avoid using open graded toppings such as screenings. These will not seal the top of the embankment, but will simply disguise any poor shaping in the embankment beneath and make it difficult to see whether tunnelling erosion is occurring (crabholes).

Specify low angle side slopes where possible to ease maintenance and minimise risk of erosion. 1V on 2H can barely be stood on. 1V on 3H can just be walked up. 1V on 5H can be topsoiled, grassed and mown with ease and is visually pleasing.

Compact the whole embankment well in order to:

a. Ensure that the design shape of the top is not lost by differential settlement or rutting,
b. Ensure that the design elevation of the top is not lost by settlement
c. Reduce permeability and therefore the risk of tunnelling erosion.

Compaction Specification: The surface of the embankment foundation (to a depth of not less than 150 mm) and all of the embankment fill, shall be compacted to a relative density of not less than 96% (clay fill) or 98% (sandy fill) of standard maximum dry density (AS 1289.5.1.1). Where the material does not exhibit a defined moisture-density curve or is cohesionless as defined in Note 1 of AS 1289.5.5.1, then it shall be compacted to a density index (AS 1289.5.6.1) of not less than 70%. The embankment shall be constructed in horizontal layers not exceeding 150 mm thick following compaction.

This "Technical Note" was prepared by Ed Collingham, 09/06/2000
(Ex Principal Engineer Geotechnical)

Section 4: Example EL 423 – 2.4 ML Tank Earthworks Specification

4.1 Stripping and Storage of Topsoil

The topsoil shall be stripped from all areas to be excavated (including tracks and pipe trenches) and stockpiled for use in the reinstatement of areas which have been filled or disturbed.

For the purposes of this contract, topsoil is defined as all friable organic soil (ie soil rich in humus and usually dark in colour), including the surface vegetation (grass etc), but excluding noxious weeds (blackberries etc).

The topsoil shall be stockpiled in a manner which prevents contamination by any other excavated material.

4.2 Excavation for the Tank Foundation

The excavation for the tank foundation shall be taken down to a minimum level of 150 mm below the underside of the floor/footing as shown on the drawing, and additionally until “rock” is encountered.

“Rock” will be defined as well-interlocked jointed weathered rock or better.

Rock of appropriate quality will be indicated on site by the Superintendent’s Representative in trial pits dug at the commencement of excavation work.

The Contractor shall allow for the excavation to be inspected and approved by the Superintendent’s Representative before compacting the surface as detailed in Section 4 below.

4.3 Excavation for the Access Road

The access road alignment shown on the drawing shall be boxed-out to a nominal minimum depth of 150 mm below the natural surface to give a smooth grade to the formation.

Any pockets or zones of soft clay, silt or other unsuitable soils exposed at formation level shall be removed until suitable soils are encountered or for a nominal maximum depth of 300 mm below formation level as approved by the Superintendent’s Representative.

All excavation below road formation level shall be backfilled with readily compacted, low-reactivity fill material, won from the site or imported, and approved by the Superintendent’s Representative.

The backfill material shall be placed in layers not exceeding 150 mm compacted thickness, and each layer shall be compacted to not less than 98% of the standard maximum dry density of the material (AS 1289.5.1.1).

4.4 Compaction for Tank Excavation and Road Formation

The surface of both the tank excavation and the access road formation shall be compacted by not less than six passes of a 10 tonne vibrating smooth drum roller, and additional passes as required until (i) no observable settlement occurs on additional passes, (ii) the onset of “bouncing” occurs, and (iii) the rolled surface achieves a relatively smooth finish.

Any areas on which any of these criteria cannot be met shall be referred to the Superintendent’s Representative for evaluation.

4.5 Tank Excavation Backfill

The tank excavation shall be backfilled with 3% cement treated 20 mm quarry rubble (CTQR) in accordance with Department of Transport Standard Specification PM 21, C3.

The quarry rubble shall be compacted to not less than 98% of its modified maximum dry density (AS 1289.5.2.1).

The finished level of the top of the CTQR shall be the proposed underside of tank floor level to within a tolerance of + 0 mm and - 20 mm.

The Contractor shall be responsible for arranging for insitu density testing to be carried out to demonstrate that CTQR backfill has been compacted to the required minimum density, and for presenting the results to the Superintendent’s Representative.

The insitu density testing of the CTQR backfill shall consist of not less than five sand replacement or nuclear densometer tests per 300 mm thickness.

4.6 Access Road Pavement Construction

The access road pavement shall consist of a 150 mm compacted thickness of 3% cement treated 20 mm quarry rubble in accordance with Department of Transport Standard Specification PM 21, C3.

The quarry rubble shall be compacted to not less than 98% of its modified maximum dry density (AS 1289.5.2.1).

4.8 Testing Of the CTQR Access Road Pavement

The Contractor shall be responsible for arranging for insitu density testing to be carried out to demonstrate that CTQR access road pavement has been compacted to the required minimum density, and for presenting the results to the Superintendent’s Representative.

The in-situ density testing of the access road pavement shall consist of sand replacement or nuclear densometer tests, extending from the finished surface to a depth of 150 mm, at not less than five randomly selected locations evenly spaced over the area of the access road pavement.

4.9 General Fill

Any general fill or landscape fill required on the site shall consist of readily compacted, low-reactivity fill material, won from the site or imported, and approved by the Superintendent’s Representative.

The general fill material shall be placed in layers not exceeding 150 mm compacted thickness, and each layer shall be compacted to not less than 95% of the standard maximum dry density of the material (AS 1289.5.1.1).

4.10 Topsoiling

All cut faces and disturbed areas shall be reinstated with a layer of topsoil not less than 150 mm thick to the satisfaction of the Superintendent’s Representative.

All topsoiled areas shall be revegetated by applying, in accordance with the suppliers recommendations, a balanced trace-element fertiliser and a “hills pasture seed” mix.

4.11 Disposal of Surplus Material

Surplus excavated material shall be removed and disposed of off-site. It shall be the Contractor's responsibility to arrange for disposal and pay all associated fees.

4.12 Excavation of Pipe Trenches

The Contractor shall inform all relevant authorities and install signs in accordance with AS 1742 prior to commencing excavation.

The Contractor shall excavate the trench evenly to achieve the required grading.

The trench width shall be as narrow as practicable, consistent with the need to ensure proper laying of pipe and the proper placement and compaction of the pipe embedment and trench fill materials in accordance with this specification / Clause X.X / Drawing XX XXXX XX.

There will be no payment for any over excavation. If the trench floor is over excavated it shall be backfilled in accordance with this specification / Clause X.X / Drawing XX XXXX XX.

The Contractor shall be responsible for ensuring all the excavation work is carried out in accordance with the safety requirements specified herein / Clause 2.16.

It shall be the Contractor's responsibility to determine whether shoring or battering of the pipe trench is required.

Surplus excavated material shall be removed and disposed of off-site. Tenderers shall submit with their tenders details of the proposed disposal of surplus excavated material as it shall be the Contractor's responsibility to locate a suitable dump and arrange the payment of all associated fees.

No claims for extensions of time or cost will be considered by the Principal for the disposal of surplus excavated material as the tendered rates for the laying of the pipeline will be deemed to allow for the disposal of all surplus material from the excavation site.

4.13 Rock Excavation

Whenever the Contractor considers that the material to be excavated is rock he shall immediately notify the Superintendent's Representative for approval of the rock classification.

Rock shall be defined as material which cannot be effectively excavated with a 20 tonne hydraulic excavator in first class operating order equipped with the appropriate rock teeth, and hence requires the use of a single ripper or a hydraulic rock breaker.

All quantities of excavated rock material shall be measured and recorded by the Contractor. The quantities recorded, in a format as approved by the Superintendent's Representative, shall be submitted (at the completion of that section of rock excavation) to the Superintendent's Representative for verification and approval.

Measurement for payment of rock excavation shall be on the thickness of the layer of rock encountered in the trench and the minimum width and depth of trench required for efficient laying of the pipe.

Where sheet rock is encountered in the trench excavation, materials above and below the sheet rock shall be excluded from the measurement for payment of rock excavation.

No claims for extension of time for rock excavation will be considered by the Superintendent's Representative unless the volume allowed for in the Schedule of Rates is exceeded.

Note: The tendered rates submitted shall be for the complete contract and not each time rock is encountered.

4.14 Groundwater Control and Dewatering Of Excavation

The Contractor shall be responsible for obtaining, prior to commencing construction, geotechnical or groundwater information necessary for the design of any groundwater control or dewatering systems.

The watertable shall be lowered to below the level of the floor of the excavation or trench (eg: by wellpointing) BEFORE beginning to excavate:

a. Where there is a possibility that there may be heave of, or loss of density in, the material comprising the floor of the excavation or trench

b. Where there may be a threat to the stability of the walls of the excavation or trench

c. Where it may otherwise not be possible to maintain “dry” working conditions in the excavation or trench.

Observation wells shall be installed to verify and monitor the lowering of the watertable.

The watertable shall be maintained below the level of the floor of the excavation or trench until the excavation or trench has been backfilled, or until such time as there is no danger of flotation of the newly installed structure or pipes.

The Contractor shall remove any water which may enter or be found in excavations or trenches while the pipes are being laid and while any other works under the Contract are being constructed. The Contractor shall have available at all times sufficient pumping units for this purpose, ready for immediate use.

Provided that there is no possibility that there may be heave of, or loss of density in, the material comprising the floor of the excavation or trench, or a threat to the stability of the walls of the excavation or trench, the Contractor may use permeable screenings laid on the floor of the trench to convey water away from the immediate workplace to temporary pump sumps. Where permeable screenings are used they shall be covered by an approved geotextile prior to placing the pipe bedding.

Water from groundwater control systems, excavations or trenches shall be disposed of in such a manner that it shall not cause injury to persons or property, to the work completed or in progress, to the surface of the streets, or cause any interference with the use of the streets by the public or be a public nuisance.

The Contractor shall be responsible for and bear the costs and consequences of any damage to property or personal injury or death of any person, caused by the dewatering operations and/or water disposal, and also for dealing with and settling any claims arising there from.

This “Technical Note” was prepared by Ed Collingham, 07/11/1997
(Ex Principal Engineer Geotechnical)