SOUTH AUSTRALIAN WATER CORPORATION

TG 10m

TECHNICAL GUIDELINE

GENERAL TECHNICAL INFORMATION FOR GEOTECHNICAL DESIGN

~ Part M ~
Survey Pillars

Issued by: Manager Engineering

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No Changes Required In The January 2007 Edition

The following lists the major changes to the December 2004 edition of TG 10m:

1. Nil

Contents

Tables & Figures

Section 1: Scope

Section 2: Survey Pillars – Site Selection Criteria

The criteria for the selection of survey pillar sites (eg for the monitoring of a dam) are:

- Lines of sight and angles to other survey pillars
- Lines of sight and angles to targets (eg on a dam)
- Ease and safety of access for construction
- Ease and safety of access for ongoing observations
- Likely cost of construction
- Geotechnical stability

The best compromise between the various criteria is probably arrived at most quickly and efficiently by having the person responsible for setting up the monitoring of the structure, the surveyor, and the geotechnical specialist on site simultaneously.

2.1 GEOTECHNICAL STABILITY

A high degree of stability is required for survey pillars and so, from the geotechnical point of view, it is almost essential to found them on stable "bedrock" – not in soil or on a rock floater.

However, even so-called "stable" bedrock is, at some scale or another, broken up into blocks by "defects" (joints or faults). Movement would have occurred on these defects in the past and is likely to occur on them again in the future.

Joints can be spaced as close as a few tens or hundreds of millimetres apart (the typical "jointed rock" with which most people will be familiar), and most such joints may have historically only had displacements of a few micrometres on them. Nevertheless even such small displacements can still add up to significant total displacements on the scale of, say, a valley side.

On the other hand, *faults* can be spaced many tens or hundreds of metres apart (typical "regional" scale faulting, generally less obvious to the lay person), but may have had displacements on them of up to several kilometres. (It is movements like these that build mountain ranges such as the Mount Lofty Ranges.)

What this means for survey pillars is that there is no such thing as a truly stable site:

- Valley sides will creep (out and/or down) in response to a whole range of subtle drivers (lunar tides, thermal strains, chemical forces, internal stress relief, erosion, etc), and will take the survey pillars with them.

- Larger and more sudden movements of bedrock may occur anywhere during earthquakes – even to the extent that a survey pillar might become part of a rockslide. The movement of a survey pillar during an earthquake is a particularly unfortunate occurrence, because it is usually after an earthquake that we would most like to know whether and by how much a structure (such as a dam) has moved.

Despite these reservations, survey pillars are often essential (eg for dam surveillance) and so geotechnically "acceptable" though inevitably "imperfect" sites will need to be found.

This "Technical Note" was prepared by Ed Collingham, 08/07/2003
(Ex Principal Engineer Geotechnical)

Section 3: Dam Target Installation Specification

3.1 INSTALLATION OF BRACKETS

Material & Work by Principal

The Principal will

1. Supply the brackets and mark the position of each bracket on the Dam wall.
2. Supply the survey pillar tube assemblies ready for encasing in the pillar base.

Type 1 Bracket

Fix to dam wall in position indicated using 4 – 10 mm dia 316 stainless steel masonry anchors (Ramset Dynabolt or an equivalent approved by the Superintendent's Representative), with an embedment length not less than 55 mm. Apply sufficient Epirez 8242 adhesive to the back of the bracket to fully bed the bracket in adhesive immediately prior to installation, and remove surplus material immediately after tightening the anchors.

Design, supply and install a hot dip galvanised mild steel canopy over the bracket to protect it from stones and other objects dropped or thrown from the top of the dam. Fix the canopy to the dam wall with hot dip galvanised masonry anchors, and provide a minimum clear distance of TBA mm from the bracket to the underside of the canopy.

Type 2 Brackets

Fix to the top downstream edge of the downstream kerb at positions indicated. Fix using 2 – M10 316 stainless steel chemical anchors (Ramset Chemset Maxima capsules or equivalent approved by the Superintendent's Representative) vertically into the top horizontal surface with a minimum embedment length of 90 mm, and 2 – 10 mm 316 stainless steel masonry anchors (Ramset Dynabolt or an equivalent approved by the Superintendent's Representative), with an embedment length not less than 55 mm, horizontally into the vertical face.

Apply sufficient Epirez 8242 adhesive to the back of the bracket to fully bed the bracket in adhesive immediately prior to installation, and remove surplus material immediately after tightening the anchors.

Note that it may be necessary to temporarily remove the bottom fence rail to facilitate the drilling of the vertical holes for the anchors.

Provide an opening 200 mm (to be confirmed) square in the fence chain wire mesh immediately above the bottom rail centred on each bracket, for the installation and removal of targets on the brackets. Twist together and turn back the cut ends of the chain wire mesh to provide a knuckled selvedge around the opening to prevent scratches and unravelling of the mesh. Lace with galvanised wire if necessary as added precaution against unravelling.

3.2 GENERAL REQUIREMENTS

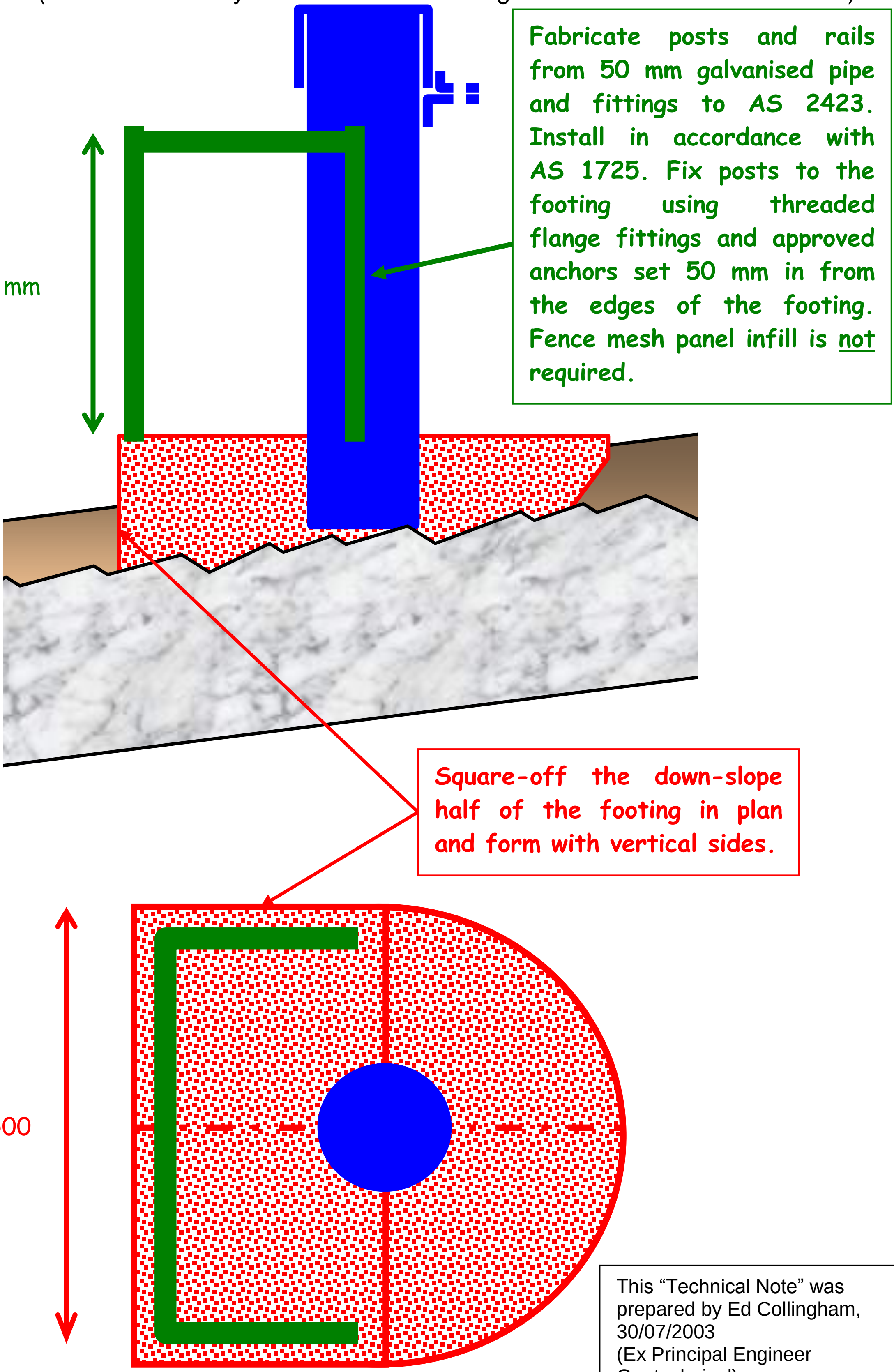
Install all chemical and masonry anchors in accordance with the manufacturer's written instructions. Supply full details of proposed anchors (including manufacturer's literature) with tender.

After installation of the brackets, including tightening to the torque recommended by the manufacturer, burr all exposed threads to prevent removal of nuts from the anchors.

This "Technical Note" was prepared by Ed Collingham, 29/07/2003
(Ex Principal Engineer Geotechnical)

Section 4: Standard Design for Safety Railing

(Refer also "Survey Pillars – Standard Design for Shallow Rock Foundation")



This "Technical Note" was prepared by Ed Collingham, 30/07/2003 (Ex Principal Engineer Geotechnical)

Figure 4.1 - Standard Design for Safety Railing.

Section 5: Standard Design for Shallow Rock Foundation

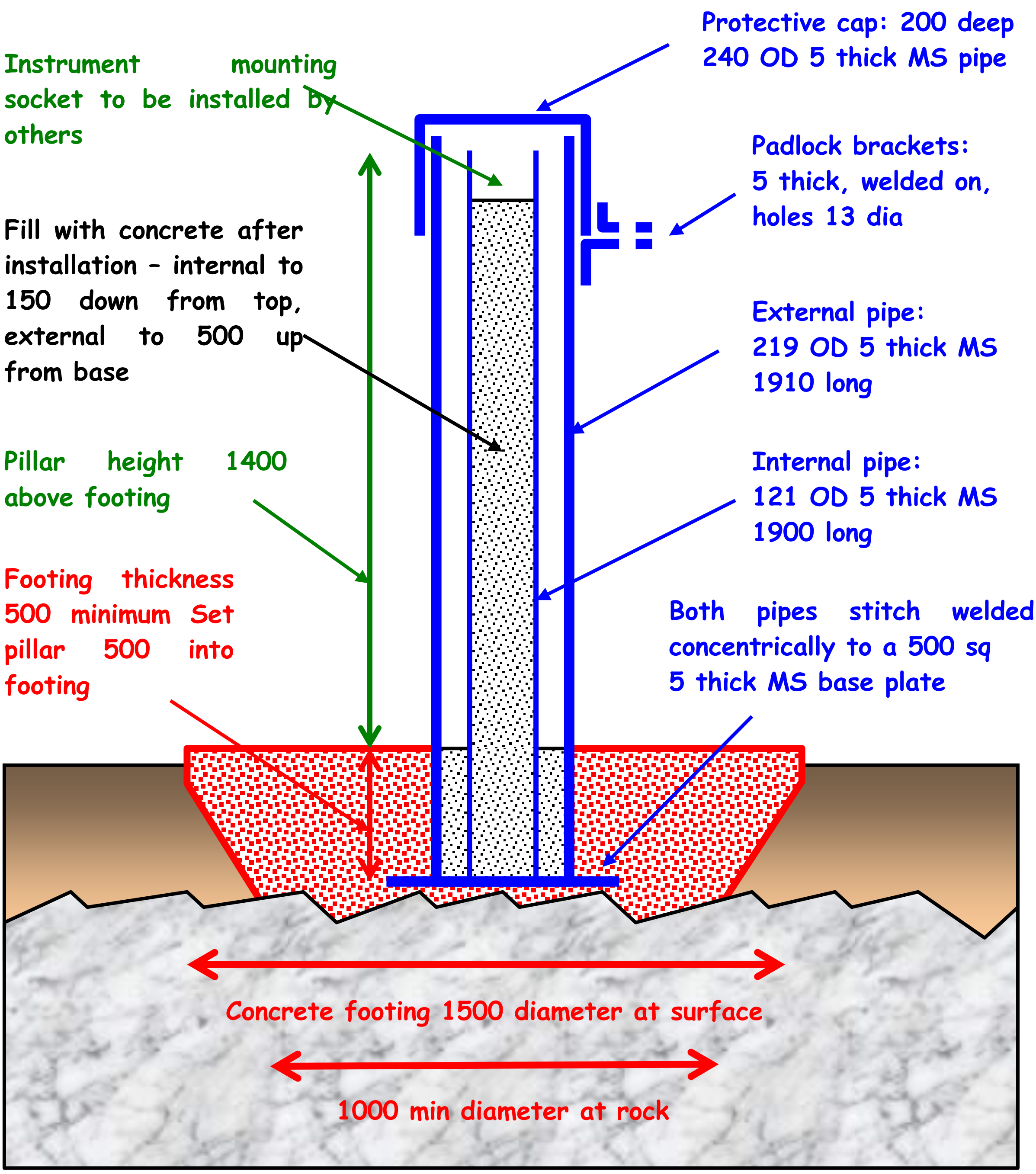


Figure 5.1 - Standard Design for Shallow Rock Foundation.

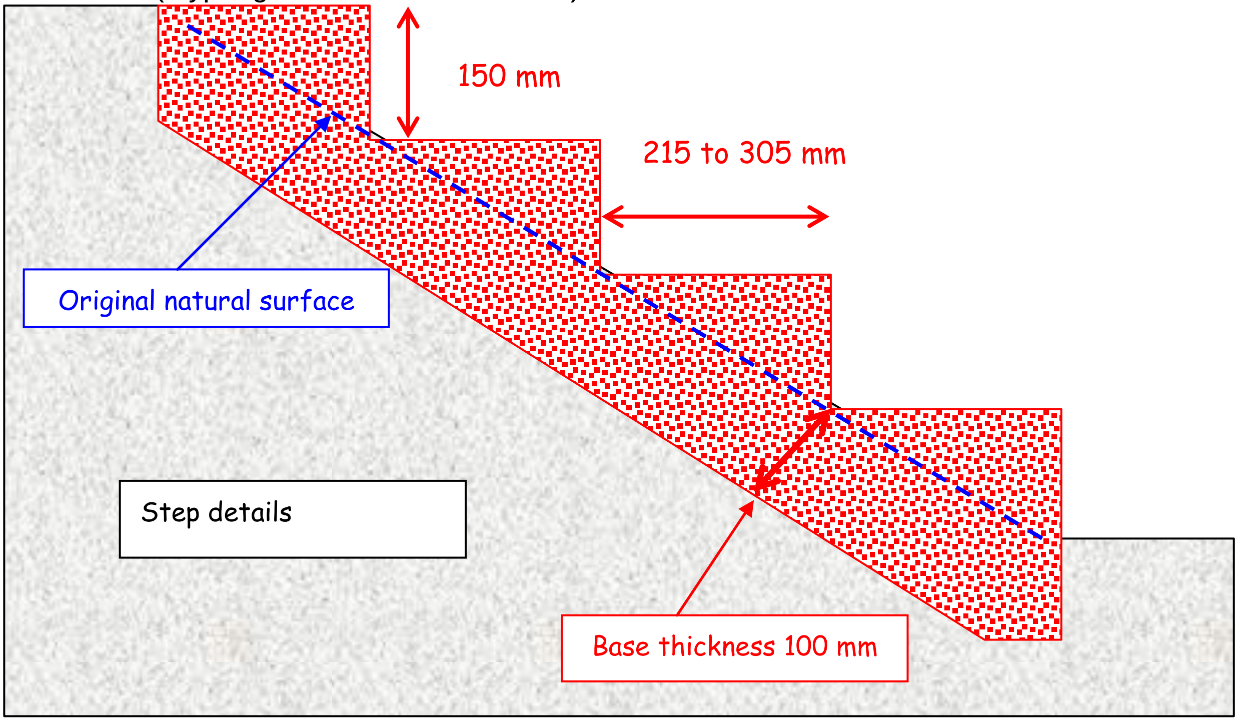
1. The pillar is designed to be bushfire proof and vandal resistant.
2. The pillar is designed to be thermally stable. Extension = 0.75 mm for 43 °C rise.
3. The pillar unit (blue) is designed to be pre-fabricated. Total mass is about 80 kg.
4. The instrument-mounting socket will be installed separately by a surveyor.
5. If rock is shallower than 500 mm, extend the concrete footing above the surface.

6. If rock is deeper than 1000 mm and concrete volumes are a problem, consult a geotechnical specialist for a special design.
7. Pour a pad of concrete to the correct height for the base plate. Set the base plate on the pad and prop/guy the pillar dead vertical. Pour the remainder of the footing concrete against the excavation. Use formwork above ground level if necessary.
8. Use a concrete mix of 1 : 12 : 3 (cement : sand : aggregate) by volume.
9. Coat with “cold galvanising” paint to paint manufacturer’s specifications after installation.
10. Over-paint with cosmetic finish as and only if directed.

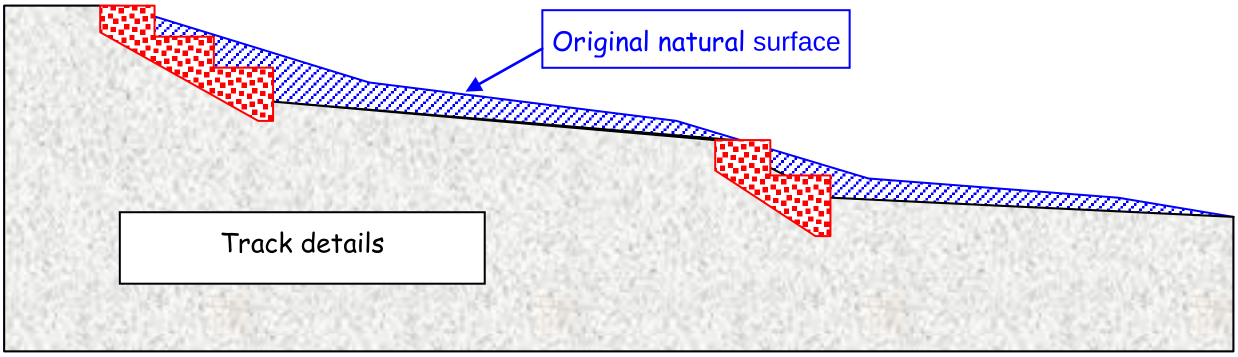
This “Technical Note” was prepared by Ed Collingham, 30/07/2003
(Ex Principal Engineer Geotechnical)

Section 6: Access Track and Step Construction Guidelines

(Myponga and Sturt Dams 2003)



The "slope" of all flights of steps to be between 1:1.4 and 1:2 (35° and 26°).
All risers to be 150 mm high. Goings to be between 215 mm min and 305 mm max – but constant on each flight. Treads to be 800 mm wide and horizontal. The number of risers in any flight of steps shall not exceed 18. Concrete to be N20 (normal grade 20 MPa) unreinforced.
Strip topsoil and loose materials and found steps on firm natural soil foundation or compacted granular fill. Backfill all excavations around completed steps with well-compacted select fill. Regrade surrounding natural surface to neat fit using matching material (topsoil/rock/etc).



Tracks to be 800 mm wide. Fit tracks to the natural lie of the ground as much as possible using the minimum of clearing, grading, or cut-and-fill necessary to give cross and longitudinal slopes of 1 on 6 or flatter. Avoid disturbing natural drainage patterns where this might lead to erosion, otherwise manage runoff as per the SA EPA code of practise for stormwater pollution prevention for the building and construction industry. Match the track surfacing the to the surroundings (eg grass, rock rubble, etc). Install flights of steps between stretches of "ramp" as necessary. Make use of natural rock outcrops as steps where possible.

Figure 6.1 - Illustration of Access Track and Step Guidelines.

Section 7: Hope Valley Dam Survey Pillar Construction

MEMO TO **Angus Paton – Principal Dams Engineer – Infrastructure**

SUBJECT **Hope Valley Dam – Recommended Design for Combined Survey Pillars and Permanent Benchmarks**

DATE **17 May 2002**

The following design for combined survey pillars / permanent benchmarks at Hope Valley Dam is based on discussions held on site on 6/5/02 between Angus Paton (Principal Dams Engineer), Ed Collingham (PE Geotechnical) and Nigel Hudson (Survey Coordinator).

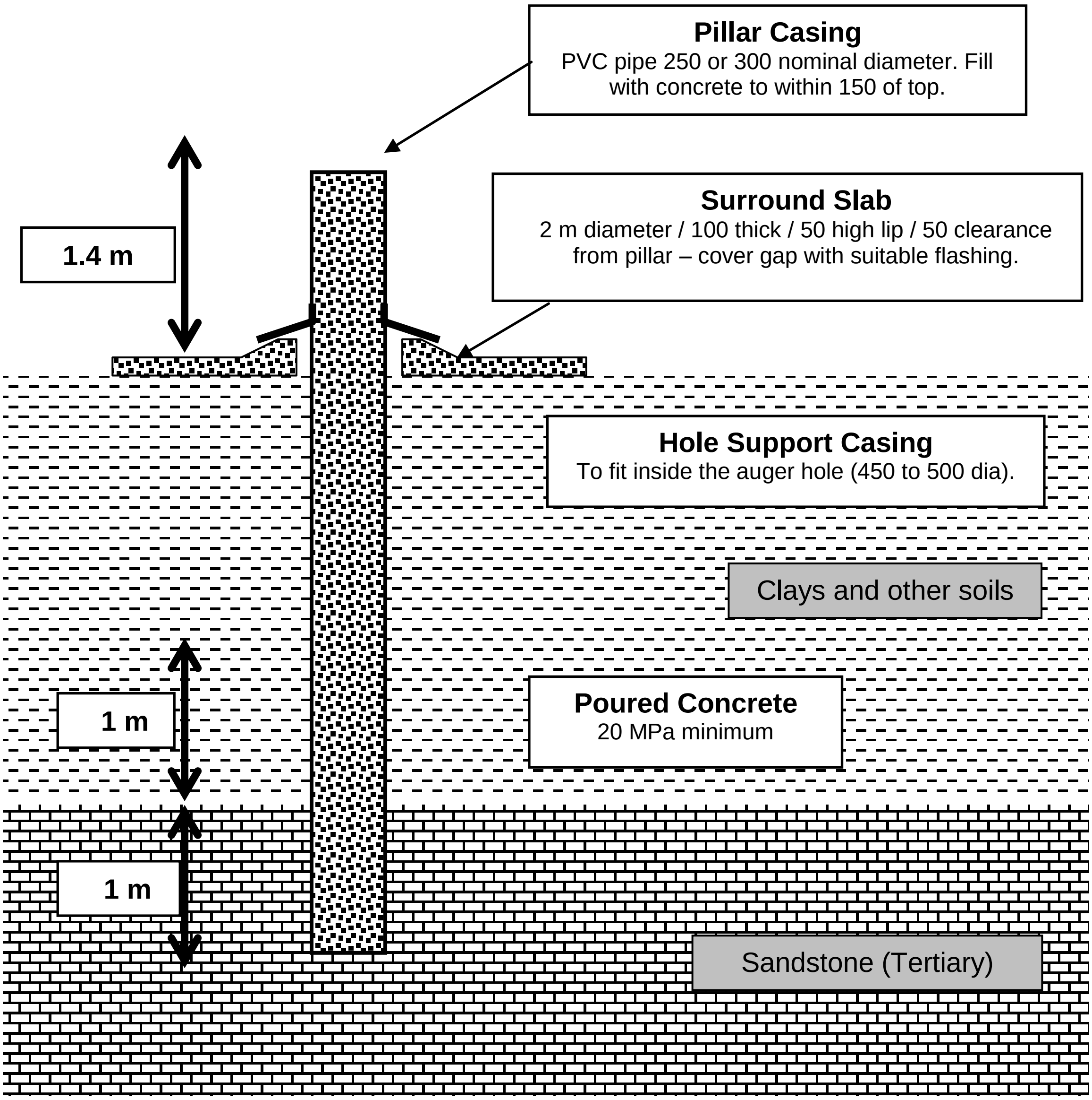


Figure 7.1 - Design example for Survey Pillars/ Permanent Benchmarks.

7.1 SURVEY PILLAR DESIGN LOGIC

a. **To ensure the required vertical stability** the pillar must be founded in the Tertiary "sandstone" below any reactive soils; isolated from reactive soils; resistant to changes in length with ambient temperature and/or direct exposure to the sun.

b. **To ensure the required lateral stability** the pillar must be of sufficient diameter; it must be socketed into the Tertiary sandstone; and it must be resistant to lateral deflection if exposed to sun from one side.

c. **The lower part of the soil profile** may be used to assist with the provision of lateral stability provided the pillar is socketed far enough into sandstone for it to be able to resist any tendency for the swelling reactive soils to pull it out of the socket.

d. **The most economical and effective way to achieve the requirements** in (A) and (B) and to take advantage of (C) appears to be to use a concrete-filled PVC pipe concreted into an auger hole.

7.2 SURVEY PILLAR CONSTRUCTION SEQUENCE

a. **Auger the hole**. Use a 500 mm diameter auger. The auger hole should extend 1 m into the Tertiary sandstone (or equivalent strong non-reactive rock-like material) beneath the clay or other potentially reactive soil-like near-surface materials. Seek geotechnical confirmation that the soil profile is as assumed in this design.

b. **Install the "pillar casing".** Use 250 or 300 mm nominal diameter PVC pipe or approved alternative (ND 250 pipe has an outside diameter of 290 mm). Wedge the pipe in position vertical. Fill pipe and auger hole to 2 m above bottom of hole. Ie. To 1m above the sandstone.

c. **Install the "hole support casing".** Use Ribloc or approved alternative. The diameter of the casing should be selected to fit comfortably inside the auger hole (eg 450 to 500 mm).

d. **Fill the "pillar casing".** Fill the rest of the pipe with concrete to within 150 mm of the required level of the top. Allow the concrete to cure. Trim the top back to its final level if necessary ensuring that 150 mm of pipe extends above the concrete filling.

e. **Pour the surround slab.** Outside diameter about 2 m or about 2 m square. Minimum thickness 100 mm. Clearance around the pillar 50 mm. Lip around the pillar 50 mm high. No reinforcement. Minimum concrete strength 20 MPa. Formwork will be required – eg pre-fabricated annular "tray" left in place. Install approved flashing to cover the gap between the pillar and the surround slab.

f. **Install the instrument mount.** Allow three weeks between pouring and installing the instrument mount to allow the concrete to complete most of its curing shrinkage. The instrument mount will be installed by the surveyor.

g. **Paint the pillar white.** The top of the pillar will move vertically about 0.4 mm per 10 °C change in the overall temperature of the pillar, and laterally by a similar amount for a 10 °C differential in temperature between one side of the pillar and the other. Thermal stability was one of the reasons for recommending a large diameter for the pillar (the other was lateral stiffness) and for casting it inside thermally insulating PVC casing. Painting it white will help minimise all forms of temperature change.

h. **Protect the pillar from impact** – eg surround by four solid posts (timber or precast concrete).

This "Technical Note" was prepared by Ed Collingham, 17/05/2002
(Ex Principal Engineer Geotechnical)

Section 8: River Murray Survey Pillar Construction

MEMO TO: Peter Webber – River Murray Operations – Bulk Water
Nigel Hudson – Survey Coordinator – Design Services
Norm Shueard – Asset Inspections – Bulk Water
SUBJECT: SURVEY PILLAR CONSTRUCTION DETAILS (GEOTECH)
DATE: 26 September 2001 (Last Revision)

Table 8. 1 - Recommended Survey Pillar Construction according to Geotechnical Conditions.

Geotechnical Conditions at the Site of the Survey Pillar	Recommended Survey Pillar Construction Details
1 Shallow loose sandy soils over rock or strong sheet calcrete. 2 Shallow reactive clay over rock or strong sheet calcrete.	Excavate to the rock or strong sheet calcrete. Found a standard concrete pillar on the rock or sheet calcrete.
3 Shallow loose sandy soils over dense sandy soil or weathered rock. 4 Shallow reactive clay over dense sandy soil or weathered rock.	Excavate to dense sandy soil or weathered rock. Pour or place a footing slab (not less than 1 m diameter) on the dense sandy soil or weathered rock. Set a standard concrete pillar on the slab.
5 Deep loose sandy soils. 6 Deep loose sandy or carbonate soils with weak sheet calcrete or calcrete rubble. (The soil beneath calcrete is usually very loose, so calcrete should not be founded on unless it is strong.)	Drill a tight-fit pilot-hole to 1 m only. If weak sheet calcrete or calcrete rubble are present, drill through them also. Drive a suitable steel pile (not less than 100 mm diameter) to not less than 1.5 m AND to a set of not less than 10 kN (1 tonne). Leave 1.35 m standing above ground. Fill the pile with concrete to within 150 mm of the top. Set the instrument mount in mortar. Protect the pile from vehicle/cattle damage.
7 Deep reactive clays not on the floodplain. *(Eg Blanchetown Clay)* 8 River Murray floodplain. *(Typical profile: 1 to 6 m of reactive clay, over soft silts, over sand.)* *Note: The depth of seasonal shrink and swell on reactive clay sites in SA is generally taken as 4 m.*	Drill a tight-fit pilot-hole to 1.5 m. Drive a suitable steel pile (minimum 100 mm diameter) to a depth of not less than 4 m AND to a set of not less than 10 kN (1 tonne). Leave 1.35 m standing above ground. Fill the pile with concrete to within 150 mm of the top. Set the instrument mount in mortar. Surround the pile with a 2 m diameter concrete slab, with a PVC sleeve around the pile shaft through the slab. Protect the pile from vehicle/cattle damage.

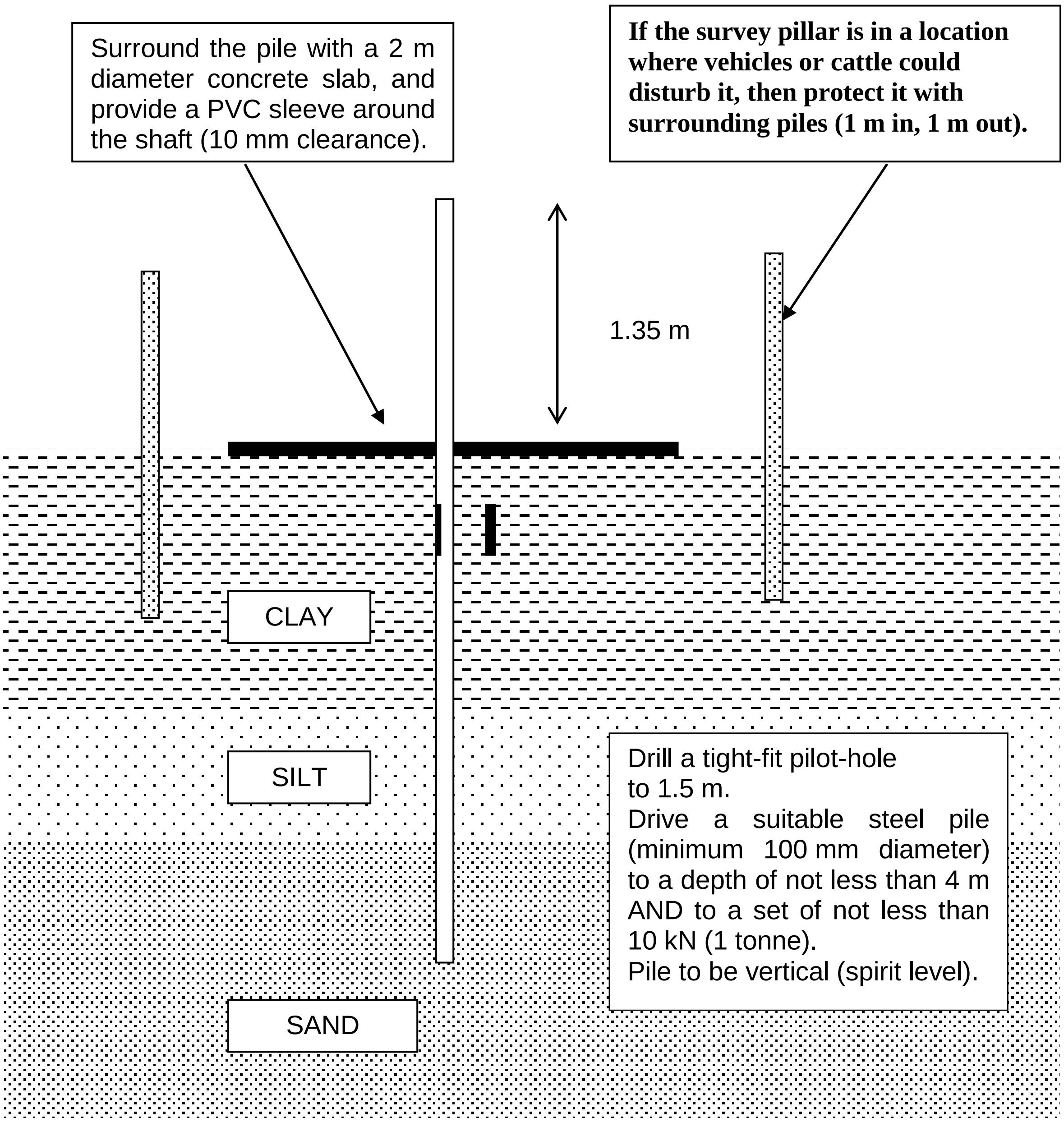


Figure 8. 1 Recommended Survey Pillar Construction according to Geotechnical Conditions.

(Geotechnical Condition “8” in the Table)

Note:
The geotechnical conditions at a site govern the construction details necessary to achieve a sufficiently stable survey pillar at minimum cost. Stable rock sites (1 to 4) are the easiest and cheapest to build on. Loose sand sites (5 and 6) need deeper foundations. Reactive clay sites (7 and 8) require quite sophisticated designs to ensure that the pillar is not disturbed by the shrink and swell movements of the clay, which can be up to several hundred millimetres.

This “Technical Note” was prepared by Ed Collingham, 26/09/2001
(Ex Principal Engineer Geotechnical)