SOUTH AUSTRALIAN WATER CORPORATION

TG 127

TECHNICAL GUIDELINE

TRENCHING
& GROUND
SUPPORT SYSTEMS

Issued by: Manager Asset Management

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Government of South Australia

CHANGES INCORPORATED INTO V1 EDITION

The following lists the major changes to the V1 edition of TG 127, which have been incorporated in this edition:

1. NEW DOCUMENT

NOTE:

Wording shown as normal text is an SA Water requirement.

Wording shown as italic text is for information only.

Contents

APPENDICES

Section 1: Scope

This Technical Guideline supersedes the "Trenching and Ground Support Systems" training manual (1995) produced by the SA Water Operations Training Unit. It includes the relevant requirements of the South Australian OHS&W Act (1986) and associated Regulations (2010) and covers the general trenching and shoring requirements for laying water supply and sewerage infrastructure

The document has been produced by Asset Management section in conjunction with engineering and geo-technical specialists. The document will be revised on a two yearly basis and be signed off by the Manager Asset Management. Minor technical amendments may be added in the intervening period and these will be signed off by the Infrastructure Standards Manager

Unless otherwise specified, all enquiries regarding this Technical Guideline shall be referred to the Infrastructure Standards Group.

1.1 GENERAL REQUIREMENTS

Any excavation below the natural surface level inevitably disturbs the forces acting to keep the ground stable. It therefore follows that to restore an acceptable measure of stability and to prevent the walls of an excavation collapsing it is necessary to install a ground support system.

This should be carried out as soon as possible, preferably as the excavation proceeds, and **MUST** remain in position until such time as the excavation is backfilled.

The South Australian Occupational Health, Safety and Welfare Regulations (2010) dictate that ground support systems **MUST** be used in **EVERY** excavation or opening in the ground 1.5 m or more in depth, in which personnel are required to work, unless the sides of the excavation are self-supporting by virtue of the angle of the slope of the sides e.g. Battering.

Experience has shown that in general, 1.5 m is a reasonable maximum depth to reach before ground support becomes necessary, but in some soil conditions it may be necessary to install shoring or to batter before a depth of 1.5 m is reached.

The height of a person **MUST NOT** be used as criteria since people spend much time in a stooped or crouched position in excavations and in most cases they do not need to be buried to be injured or killed.

An extract showing the relevant South Australian Occupational Health, Safety and Welfare Regulations (2010) is included as Appendix A.

1.2 DEFINITIONS

ANGLE OF REPOSE	The steepest angle of incline of a slope relative to the horizontal plane when the material on the slope face is on the verge of sliding. This angle is in the range 0°–90°.
BATTERING:	To form the face or side or wall of an excavation to an angle, usually less than the natural angle of repose, to prevent earth slippage.
BENCHING:	Where the trench walls are stepped down at the trench edges.
CLEAT:	Wood block nailed to a timber soldier to locate and support a strut or a waling.
CLOSED SHEETING:	Vertical timbers or metal sheeting used to fully cover and support a trench wall.
COMPETENT PERSON	Someone delegated by the employer who has relevant site experience and training.
HYDRAULIC STRUTS:	Two (2) aluminium solders held apart by a pair of hydraulic jacks.
SHEET PILING:	Vertical interlocking planks of steel, reinforced concrete or other structural material driven to form a continuous wall ahead of the excavation and supported either by tie-backs into solid ground or structural members from within the excavation as the work proceeds.
SOLDIER:(Sheet)	Vertical upright (wood or steel) used for the purpose of supporting the trench wall.
SPOIL:	Excavated material.
STRUT/TOM: (Spreader)	Horizontal spacer (timber or metal) used to hold soldiers against the trench wall or press walings apart in close sheeting.
PACKING PIECES:	Softwood blocks used between the struts and the soldiers. (Maximum thickness 50mm).
TRENCH:	An excavation where the length is greater than the width or depth.
TRENCHING:	Excavating to form a trench for the purpose of laying pipes, conduits or cables.
TRENCH JACK:	Steel jack (screw or hydraulic) used to press soldiers against the trench wall.
TOM/STRUT: (Spreader)	Horizontal spacer (timber or metal) used to hold soldiers against the trench wall or press walings apart in close sheeting.
SHIELD (Cage):	specially designed frame placed into a trench to prevent trench wall collapse or debris from falling on personnel working in trench.
SHORING:	Method of physically restraining trench walls using special equipment (timber or metal) to prevent trench wall collapse or debris from falling on personnel working in trench.
WALER: (Waling)	Horizontal beam (timber or metal) used to hold closed sheeting in position.
ZONE OF INFLUENCE:	The volume of soil around the excavation affected by any external load (for example, vehicles, plant, excavated material).

Section 2: Pre-Construction Activities

Prior to commencing any trenching projects a number of activities and technical considerations must be undertaken. These include conducting a pre-construction survey and a review of the soil types and their failure modes by a “competent person” (or persons). Various environmental and on-site activities can result in trench collapse and these need to be considered as part of the pre-construction survey.

Typical causes of trench collapse include:

- Failure to install shoring / ground support.
- Mechanical failure of soil (inability to support its own weight).
- Breakdown of soil strength due to moisture.
- Vibration from vehicle and/or plant movement
- Surcharge of spoil or heavy weights close to trench edge.
- Change in soil composition (sand pockets etc).
- Previously disturbed ground (landfill, old trenches).
- Trench walls being struck by heavy loads.
- Undercutting.
- Premature removal of shoring.

2.1 PRE-CONSTRUCTION SURVEY

The intention of the pre-construction survey is to enable hazards at the WORKSITE to be identified and specific control measures planned before any work commences. The development of an **EMERGENCY PLAN** to deal with unexpected incidents is recommended**.**

If no knowledge of the ground conditions can be obtained, test holes using an excavator should be dug in doubtful areas to observe ground conditions and determine suitable ground support systems.

For work on arterial roads, major intersections or carriageways the transport authority or local council involved must be advised.

Refer to AS 1742.3 for Traffic Control Devices to be used when working on roads.

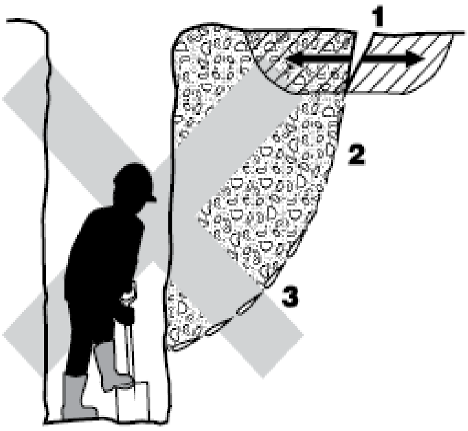
The survey should identify suitable locations for the positioning of vehicles, plant and equipment.

Ensure prior permission is given by the owner for storage of plant and materials on private property.

2.1.1 *Nature of the Ground*

The pre-construction check must determine the following:

- Soil or rock
- Moisture content of soil - is it wet or dry? If dry will it lose its cohesive characteristics when it becomes wet?
- Local water table, is level above trench floor level?
- Faults or bedding planes.



(a) This is a very dangerous situation, requiring ground support. No worker should be in the trench unless support has been installed.

1. Area of tension, as wall starts to collapse.
2. Slipping plane.
3. Seepage along the slippage plane further reduces the stability of the wall. Water seeping into the excavation, tension cracks on the surface and bulging sidewalls are all signs of imminent collapse.

Seepage in trench bottom may not be obvious until the actual collapse.

(b) Shear Plane failure along the seepage (slippage) pane

(c) Worker trapped and crushed against the trench wall by a quick collapse

(d) Worker badly injured and probably smothered after being crushed against the opposite wall by the collapsing ground. The weight of a wedge of sand over one metre length of trench 2 metres deep is about three tonnes, more than enough to crush a worker's chest.

2.1.2 *Power and Communication Lines*

If present and it is intended to use machinery that could come in contact with, or near these lines, the relevant Authority must be contacted. Isolation or sheathing of the lines at the time of construction may be necessary.

If the power or communication poles are located in close proximity to the proposed excavation, the relevant authority must be notified. That authority can arrange to stabilise the pole during the excavation process if required.

Further information/documentation relating to this aspect is available in Section 8 - Reference Documents.

2.1.3 *Existing Water Table*

The pre-construction check must identify if the following conditions exist:

- The wet weather water table will be above or affect the trench floor.
- The soil is sandy which can become unstable when continuously wet.
- There is an underground stream near or crossing the proposed trench

Where any of these conditions apply a specialist de-watering company should be consulted to determine the most cost-effective method of dewatering the trench.

2.1.4 *Possibility of Flooding*

The pre-construction check must determine the following:

- Surface run off after heavy rain.
- Swamp, dam, reservoir, lake or river.

Flooding can be sudden and tragic, so precautions should be taken, which could include drainage run-off control and pre-placement of pumps on site.

2.1.5 *Underground Services*

Proximity of underground services such as gas, electricity, sewer, water mains or telecommunication lines **MUST** be confirmed.

The Dial Before you Dig service (www.1100.com.au or call phone number 1100) provides free and easy access to the records of a large number of services including water, sewer, telecommunications, electricity and gas.

Enquiries can also be made to the appropriate authority in regard to location of their services prior to excavating. It is good practice to provide details of planned work to the relevant authority(s) so that they can advise if they believe their services are likely to be affected. On many occasions, minor re-design of proposed works can reduce the risk of contact with underground services.

Previously dug excavations have a weakening effect on a trench wall if they are in close proximity, close sheeting or shields may be necessary. This shoring should also be used in unstable ground, reverting to soldier sets when stable ground is encountered.

2.1.6 *Hazards - natural or artificial*

The pre-construction check must determine the following hazards:

- Intersecting old trenches.
- Maintenance Holes and other shafts.
- Bends in an excavation line.
- Leaking services.
- Trees
- Threat to health and safety from the past dumping of toxic waste.

2.1.7 *Static Loads*

The spoil placed in a pile near the trench. (An excavation in wet clay 3m deep by 1 m wide will create a spoil pile having a mass of approx. 6 tonnes/metre of excavation). Typical static loads are:

- Buildings, including garages and outbuildings.
- Water tanks or towers.
- Brick or stone walls or earth embankment

In instances where static loads are located adjacent to the excavation, additional shoring should be installed. The survey should identify suitable locations for the positioning of stockpiles of pipes and other ancillary equipment

2.1.8 *Dynamic Loads*

Dynamic loads consist of heavy mobile vehicles/equipment such as:

- Trucks, semi-trailers and railway trains and carriages)
- Excavation equipment and other items of plant (particularly on-site equipment)

2.2 GEO-TECHNICAL ASSESSMENT

Where any doubt exists regarding the bearing capacity of the trench walls a Geo-technical specialist must be engaged to assess the conditions and provide a written report which should include the following:

- Details of the bearing condition of the soil,
- Shoring, benching or battering requirements (this may include no requirement for shoring if the ground conditions are extremely stable),
- Any dewatering requirements
- Time period for which the recommended trench support exist.

Where any excavation is greater than 5 m a Geo-technical specialist assessment **MUST** be undertaken.

2.3 SOIL GROUPINGS

The type of material to be excavated has a large bearing on the design of shoring. Generally, hard compact ground requires 'open' sheeting, and saturated loose or other unstable ground requires 'close' sheeting.

In between these types, exists a wide variety of ground conditions where a decision on shoring method is difficult and requires a careful and continuous assessment of ground and site conditions.

Soils may be grouped under three (3) physical types:

- Coarse grained
- Fine grained
- Organic

The course grained soils, sands and gravels may be described as soils composed largely of particles visible to the naked eye.

The fine grained soils which are mostly made up of particles NOT visible to the naked eye, these may include silts and clays.

Organic soils have either a large proportion of organic content such as peat, or they are sands, silts or clays with a certain amount of organic matter which usually has the effect of reducing their value for engineering purposes.

The granular sands and gravels derive their strength from friction between the grains which can give a certain safe slope or angle of repose for the particular material. Sands, gravels and silts may be stable on a vertical face due to natural soil cementing materials. This cementing material may lose its value when affected by water or by exposure to air.

Clays have cohesion which is a force derived from the interaction of absorbed layers of water on the microscopic particles. Clays may give way suddenly in large blocks due to unbalanced pressures or due to the action of water seeping into cracks or due to cracks formed by the drying out of soil.

Details of the various Soil Groupings have been included at Appendix B and General Trenching and Pipe Laying Issues have been included as Appendix C.

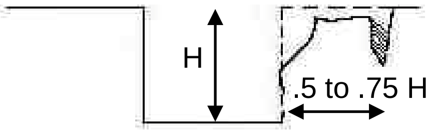
Where any doubt exists a geotechnical specialist should be consulted:

- for SA Water funded schemes the SA Water Geotechnical staff in the Infrastructure Engineering Group should be used, or
- for developer funded schemes a specialist geotechnical consultant must be used.

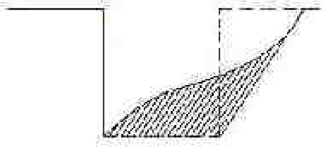
2.4 SOIL MECHANICS

A number of stresses and deformations can occur in an open cut excavation or trench. For example, increases or decreases in moisture content can adversely affect the stability of a trench or excavation. The following illustrations show some of the more frequently identified causes of trench failure.

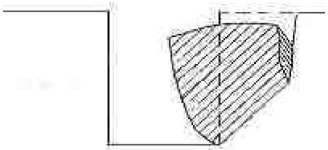
a) **Tension Cracks**. Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench. See the sketch below.



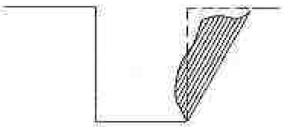
b) **Sliding** may occur as a result of tension cracks, see below.



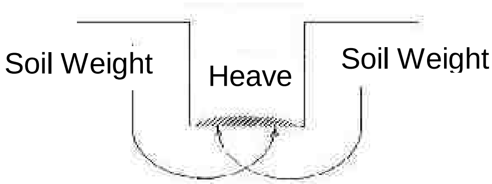
c) **Toppling**. In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.



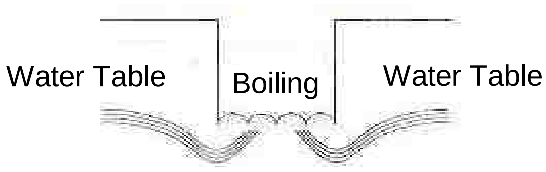
d) **Subsidence and Bulging**. An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.



e) **Heaving or Squeezing**. Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut, as illustrated in the drawing below. Heaving and squeezing can occur even when shoring or shielding has been properly installed.



f) **Boiling** is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.



g) **Unit Weight of Soils** refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic metre of soil can weigh more than 1300 kg (1.3 tonnes).

POTENTIAL HAZARDS and CONTROL MEASURES	
Underground / Overhead Utilities Gas, Communication, Power, Water etc.	Locate, mark and expose any underground services by HAND prior to the machine excavating. Visually inspect the site, especially for overhead wires. Contact **Dial Before you Dig (a free service)** at http://1100.com.au/default.aspx or **phone 1100**. You may also wish to check other authorities' site plans.
Waterlogged Ground	Install dewatering system. Use CLOSED sheeting, metal shoring or shields to prevent collapse.
Pockets of Unstable Ground	Shore trenches using CLOSED sheeting or trench shields wherever unstable ground is located.
Other Trenches Close By	Check plans and leave an adequate distance between the existing trench and the new trench. Shore the new trench using the appropriate method e.g. Closed, Open, Shields or Struts etc.
Uneven / Sloping Ground	Level a track for the excavating equipment. Place the SPOIL from the trench on the DOWNHILL side of the excavation.
Watercourses / Creeks etc.	Install extra shoring where necessary, check for seepage, Check all shoring and monitor regularly.
Buildings and Structures	Install EXTRA strength shoring to avoid property damage. Under some circumstances it may be necessary to leave the shoring in place and backfill the lot.
Traffic	Barricade and protect the work area. Install extra shoring if required. Keep the traffic well clear of the trench line and be aware of the problems with traffic vibration, inspect the trench for danger signs.
Machinery and Plant	Keep all plant and machinery well back from edges of the trench. Strengthen shoring if vibration is likely to cause the trench to collapse.
Intersecting Trenches (or Groups of Trenches)	Start with deepest trenches. Install extra shoring where trenches intersect. Close shore if necessary.
Lack of / Inadequate Shoring	Install adequate shoring and ensure it is installed correctly.
Hazardous Atmospheres	Ensure exhaust fumes of plant and machinery DO NOT enter the trench. Check the atmosphere with a Gas Detector. If doubtful of air quality, ventilate mechanically as required.
Spoil and material near trench edges	Keep spoil and materials a minimum of 1 m (1 5 m preferred) from edge of trench. Install spill boards. Chock pipes with wedges
Vermin	Clear all underbrush. Visually inspect all trenches before entering. Plug all pipe openings when work is completed each day.

Section 3: Trench Stability

Where the trench is over 1.5 m in depth and space is limited, shoring must be used to prevent trench wall collapse. If there is sufficient land available, a simpler method of ensuring trench safety is to batter or bench the trench to prevent trench wall collapse (see Fig 3.1).

- **Shoring/Shielding** — Shoring and shielding requires the placement of metal sheeting or timber along the walls of the trench to prevent collapse. The type of sheeting that is used, and the method of fixing it in place, will depend on the soil conditions.
- **Battering** — Battering is the widening of the trench above the embedment zone to reduce the possibility of trench collapse by using a sloping batter (usually 45°) to widen and stabilise the trench.
- **Benching** — Benching is the use of horizontal excavated steps to stabilise the excavation.

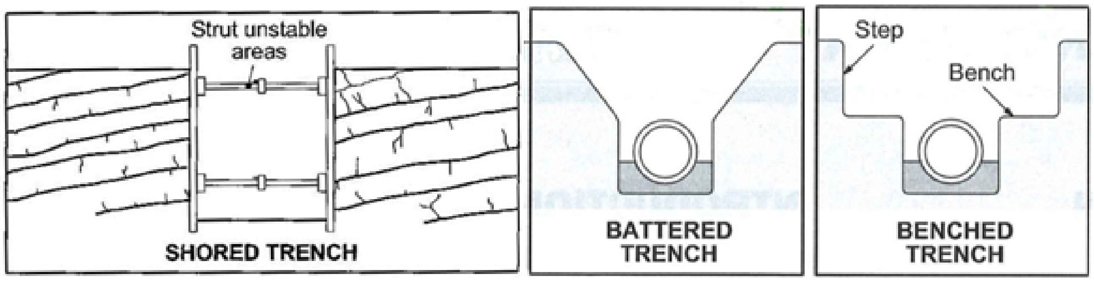


Fig 3.1 Difference between Shoring, Battering and Benching

The traditional method of shoring was using timber struts and stays, but this has now progressed to metal shields and shoring systems. In this guideline we will cover both systems.

Benching and battering can be used in conjunction with shoring to provide additional depth of safe shoring or shielding.

3.1 TRENCH WIDTH

Care must be taken to ensure that the trench is dug to the correct width, as well as the correct depth. Where the width of the trench is not specified it should be as narrow as practicable, but adequate enough to allow space for working and for compaction. The minimum trench width applies only for the embedment zone, once above that level the trench can be benched or battered as required. The requirements for the relevant shoring must be added to this width.

Common sized backhoe or excavator buckets widths are 300, 450, 600, 750, 900, 1100 and 1200 mm. The bucket used should be the next size larger than the specified minimum width.

The width of the trench will normally be specified on the design drawings and specifications. If not provided, the AS 2566.2 (Installation of flexible buried pipes) minimum trench width requirements are shown below.

Pipe Diameter (DN)	Minimum Trench Width
≤DN150	Pipe OD + 200 mm
>DN150 - ≤DN300	Pipe OD + 300 mm
>DN300 - ≤DN450	Pipe OD + 400 mm
>DN450 - ≤DN900	Pipe OD + 600 mm
>DN900 - ≤DN1500	Pipe OD + 700 mm

AS2566.2 Minimum Trench Width requirements

Where worker access is required the minimum width should be 600 mm.

There is also a maximum trench width which should not be exceeded as it can result in insufficient side support for the pipe. If you need to use an excessively oversize bucket, it's suitability should be confirmed with a geo-technical specialist.

The minimum trench width shown above does not include any allowance for shielding or shoring which will need to be allowed for when selecting the appropriate bucket width.

3.2 BATTERING AND BENCHING OF TRENCHES

Battering and Benching (see Figs 3.3 and 3.4) is based on the principle of removing enough soil such that the soil will not fail (battering) or in the event of a failure the soil will not fall into the actual trench (benching).

The size and shape of the excavation is based on the "Angle of Repose" (see Fig 3.2) which is normally taken as 1:1 (45°), but in some instances, depending on the stability of the soil/rock it can be a maximum of 1 horizontal: 4 vertical (76°)

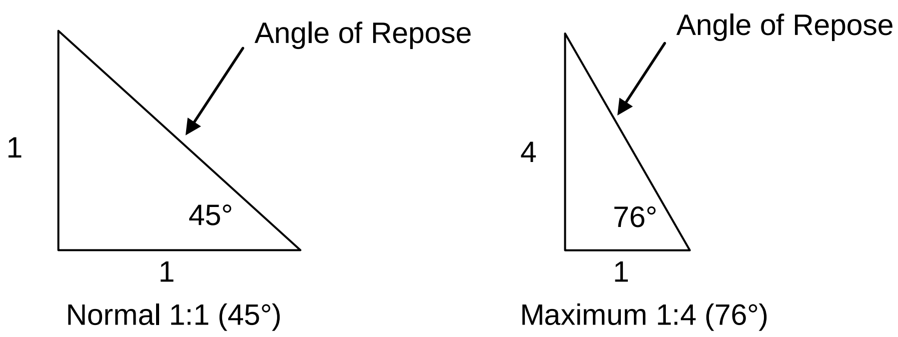


Fig 3.2 Angle of Repose

Comment
A simple method of determining the Angle of Repose is to check the trench spoil heap and determine the maximum slope which can be maintained without slippage.

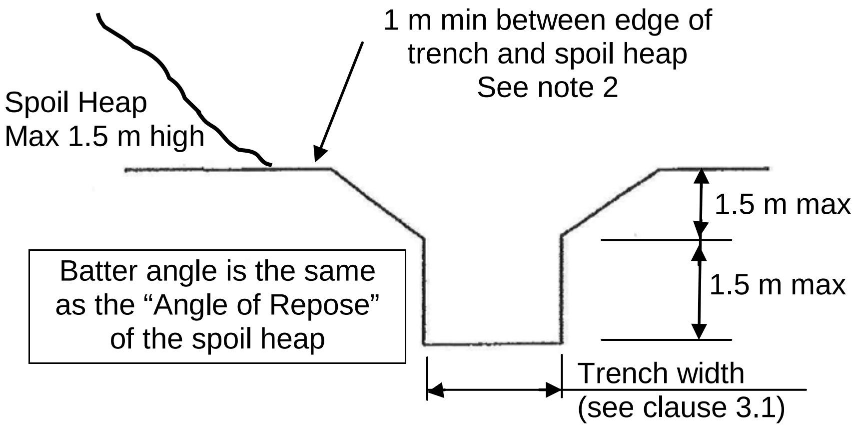


Fig. 3.3 Battering of Trench

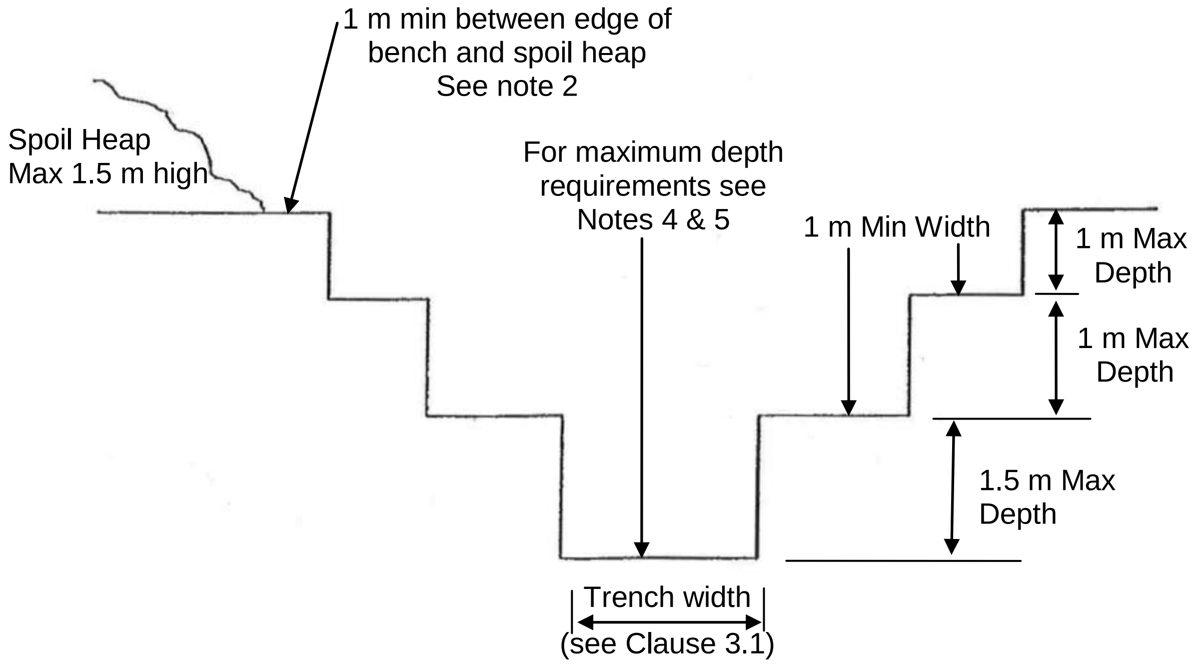


Fig. 3.4 Benching of Trench

Notes:

1. Providing sufficient open land is available, benching can be used to meet any depth requirement.
2. Where sufficient land is available 1.5 m should be allowed between bottom of the spoil heap and edge of trench, battering or benching.
3. Up to 3 m deep 1 m maximum width benches can be used
4. 3 to 5 m deep, special requirements exist (see appendix D)
5. Over 5 metres deep, geotechnical approval is required.

3.3 SHORING AND SHIELDING SYSTEMS

Shoring and Shielding both provide a safe working environment, but use different systems for providing worker safety as shown below. Shoring and shielding can be used in conjunction with battering and benching if required. For safety reasons shoring/shielding should extend 300 mm above ground level.

3.3.1 *Shoring*

Shoring has been the traditional method of providing worker safety. Shoring is a method of placing vertical “soldiers sets” (“planks” or “sheeting”) against the trench wall and holding them in place with timber struts or metal screw/hydraulic jacks. This effectively restrains the trench wall and prevents collapse.

In hard compact ground the shoring can be open sheeting or planks at appropriate spacing and held in place by a suitable jacking system. The vertical supports provide sufficient support to prevent wall collapse. See Fig 3.5

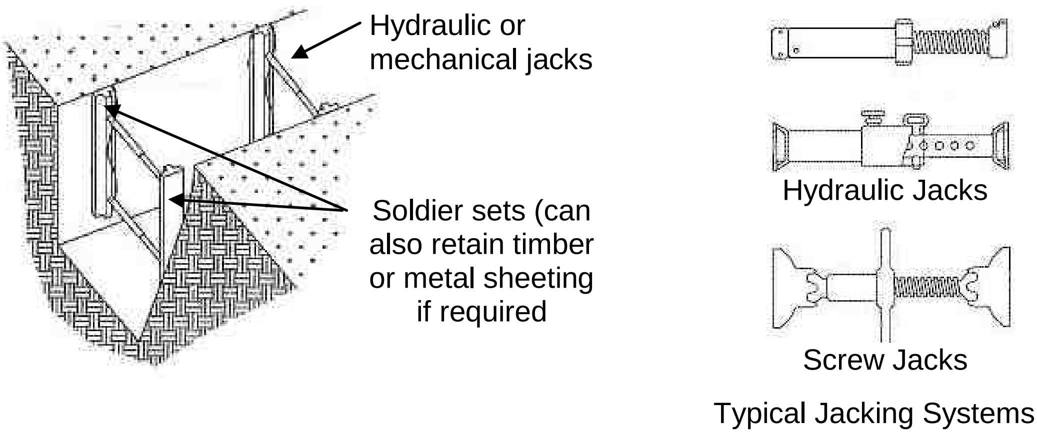


Fig.3.5 Open Sheeting in Hard Compact Ground

In saturated, loose or unstable ground closed sheeting is required. This involves the installation of a solid wall of planks or sheeting held firmly in place by horizontal beams (walings) and a suitable jacking system. The walls prevent any wall movement or soil entering the trench. See Fig 3.6

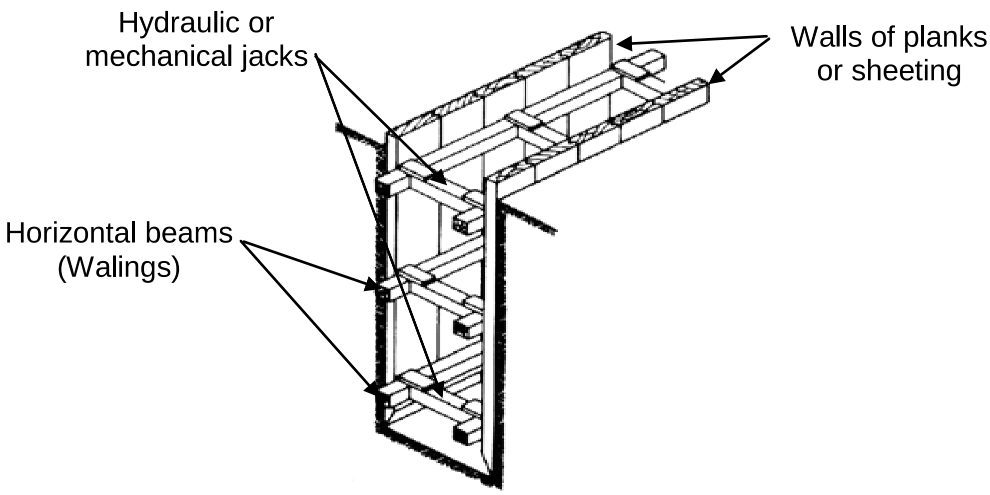


Fig.3.6 Close Sheeting in Unstable Ground

3.3.2 *Shielding*

Shielding involves the use of “Trench Boxes” which do not support the trench walls, but sit as a box inside the trench and protect the workers from cave-ins and similar incidents. See Fig 3.7. The gap between the outside of the trench box and the face of the trench should be as small as possible.

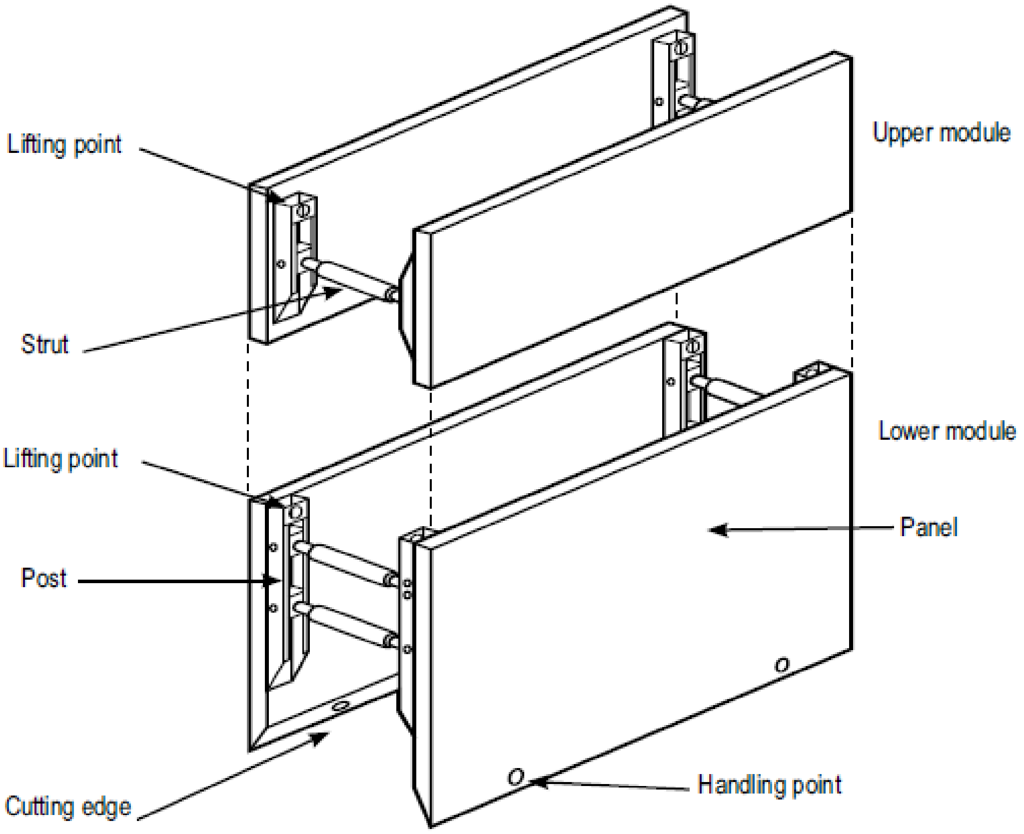


Fig.3.7 Shielding Systems

Trench Boxes have the advantage that they can be used in a stacked configuration and used as drag boxes to reduce time and cost. They can also include safety barriers

For sandy soils the trench should be excavated to approximately 1 metre deep, the trench box placed within the trench and the excavation completed from within the box.

For clay soils where the excavated sidewalls are stable, the trench can be excavated to the required depth and the trench box lowered into position.
Note: Some Authorities require that the space between the shield (trench box) and the excavated sides of the trench be backfilled.

Section 4: Shoring and Shielding Installation

There are a variety of Shoring and Shielding systems available and a number are available for hire. Installation procedures should be obtained from the manufacturer and be read and understood prior to use.

In this section we will cover Wood and Metal Shoring and Metal Shielding

4.1 TIMBER SHORING SYSTEMS

The two principal methods of timber shoring are open sheeting and closed sheeting. Their use is determined by the strength of the ground, expected weather conditions and depth of trench.

4.1.1 *Open Sheeting*

Open sheeting should be used in HARD COMPACT ground for trenches up to a depth of 4.8 m. It should consist of vertical sheeting spaced at a maximum horizontal distance of 2.4 m and with horizontal struts in accordance with the following: -

- Struts must be placed horizontal and to the sides of the excavation at distances not exceeding 1.5 m (unless walings are used, when the vertical distance should not exceed 2.4 m).
- Top struts should be positioned approximately 300 mm below natural surface.
- Extreme care must be exercised when transferring the load in shored structures to prevent release of stresses developed in the soil.
- Installation loads on struts must be equal.
- Blocks, cleats or props must be used to support walings against slipping or accidental displacement. A softwood packing piece should be used to give each strut a tight drive fit.
- **Packing pieces must be applied at one end only and not more than two pieces used per strut**.
- At the intersection or junction of two or more trenches care must be taken to ensure that the struts are placed to provide support for each other.

Note: Timber shoring MUST be carried out under the supervision of a trained and experienced timber shoring installer.

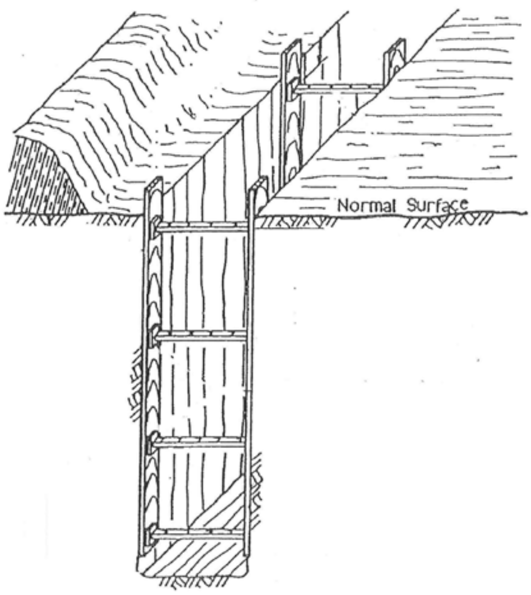


Fig. 4.1 Typical timber open sheeting shoring installation

4.1.2 *Closed Sheeting*

Close sheeting must be used in saturated, loose or unstable ground.

- Sheeting should be placed with edges abutting.

Where wet running material is encountered, shields or interlocking steel sheets should be used, or the spaces in between sheeting should be caulked with hessian or any other suitable material.

- Walings must be placed at a vertical spacing not exceeding 2.4m.

Never, should less than two (2) sets of walings be used in a trench.

The bottom set should be placed as low as practicable. Provision must be made by using blocks, cleats, hangers or props to support the walings against slipping.

Struts MUST be placed horizontally between walings and square to the sides of the excavation at horizontal spacing not exceeding 2.4m.

In all cases a strut should be placed not more than 300mm from the ends or joints of the walings.

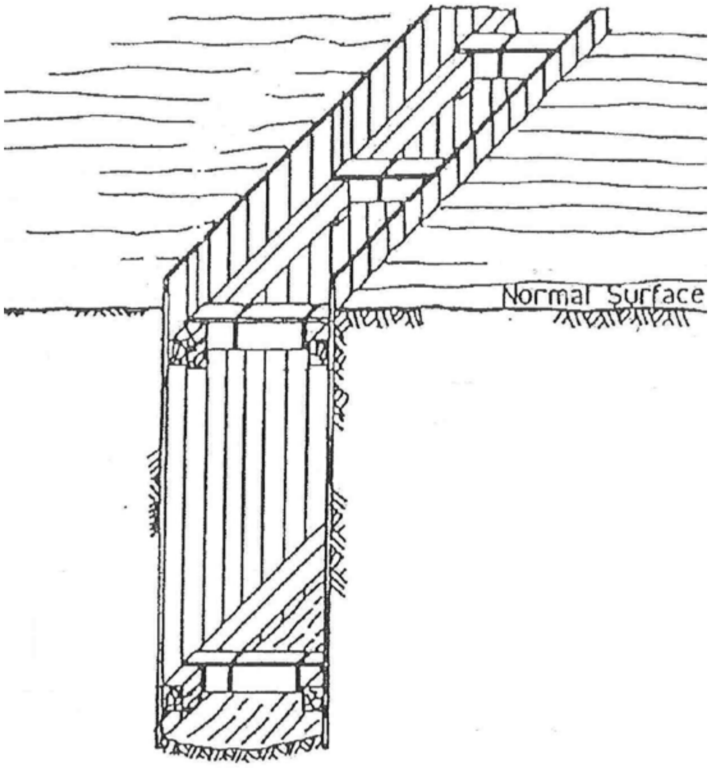


Fig. 4.2 Typical timber closed sheeting shoring installation

Note: Timber shoring MUST be carried out under the supervision of a trained and experienced timber shoring installer.

4.2 METAL SHORING SYSTEMS

As for timber, there are also two principal methods of metal shoring, open sheeting (also called vertical shoring) and closed sheeting. An addition method is also available to contractors and this is the use of sheet piling. This type of shoring is used in difficult soil conditions and is often left in-situ at the completion of the project.

4.2.1 *Open Sheeting*

Open Sheeting (vertical shores) are generally made from aluminium and consist of 2 verticals and 2 adjustable cross braces (See Fig 4.4). Being light weight, they are the quickest, simplest and safest way to shore a trench. They are designed to shore vertically, in stable soil conditions, as fast as excavation can proceed. The spacing between consecutive vertical shores is dependent on the stability of the trench walls and needs to be assessed during the pre-construction survey and confirmed during the trench excavation. Hydraulic toms **MUST** have a manual locking arrangement.

Most units are manufactured as hinged assemblies and can be installed by one person. All units, regardless of size are installed and removed from above ground thereby avoiding worker exposure to un-shored trenches.

Figure 4.4 Metal Open Sheeting (Vertical Shores)

Note: For extra safety aluminium plating can be placed against the trench wall prior to installing the vertical shores.

4.2.2 *Closed Sheeting*

Closed sheeting provides a method of ground support where unstable ground conditions are encountered (see Figure 4.5). Where excavation depths exceed 3 m in wet sand or clay, a multi-stage system may be required.

The current trend is toward the use of metal shoring with hydraulic bracing, this system involves a prefabricated strut and/or waler system manufactured of aluminium or steel. This type of shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install or remove the shoring. Other advantages of most hydraulically operated systems are that they:

- Are light enough to be installed by one worker (with lifting equipment);
- Are gauge-regulated to ensure even distribution of pressure along the trench line;
- Can have their trench faces "preloaded" to use the soil's natural cohesion to prevent movement; and
- Can be adapted easily to various trench depths and widths.

All shoring should be installed from the top down and removed from the bottom up. Hydraulic systems should be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

Capping should be placed over the toms to extend the full width of the trench.

The double, vertical sheeted, trench support system requires considerable expertise to safely support a deep excavation.

It is recommended only where highly experienced personnel supervise the excavation.

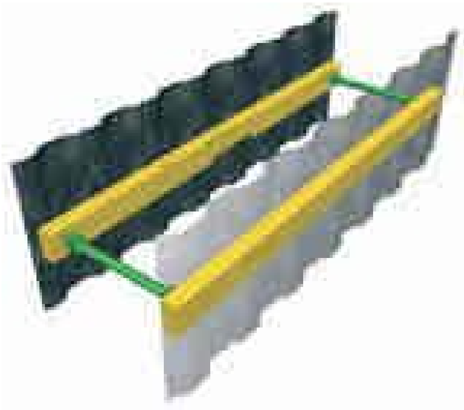


Figure 4.5 Metal Closed Shoring
(multiple horizontal supports may be required)

4.2.3 *Sheet Piling*

Sheet piling is a similar method of trench support as many others, but does not require as much time or level of expertise as the other methods previously described (see Figure 4.6).

This particular method is suitable in areas of instability where the side walls are likely to collapse immediately after excavation. Because the sheeting is not normally removed it is a much more expensive method.

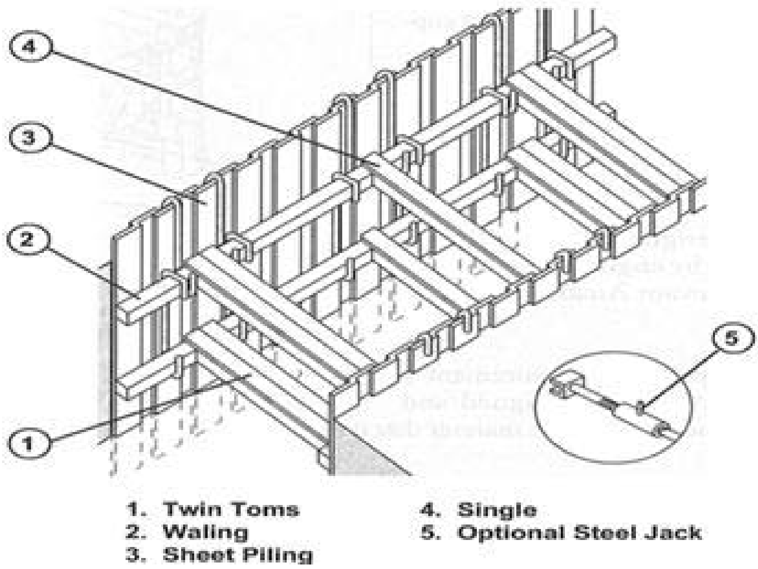


Figure 4.6 Sheet piling

4.2.4 *Pre-driving Sheet Piling*

In extreme cases pre-driving may be necessary where there is a considerable length of trench to be dug through poor ground such as loose or running sand (see Figure 4.7).

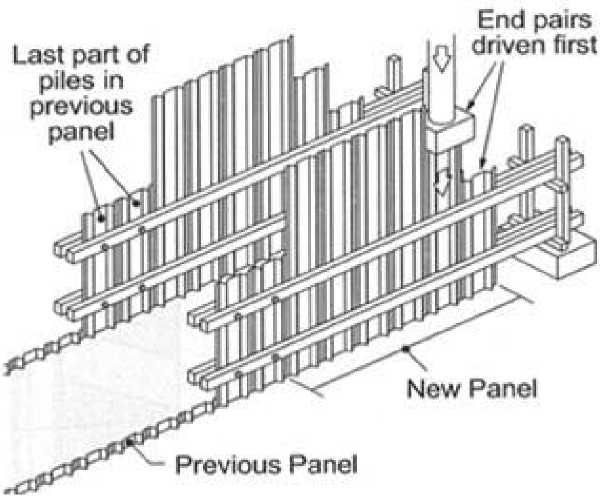


Figure 4.7 Pre-diving sheet piling

4.3 METAL SHIELDING SYSTEMS

Shields are designed to ensure worker safety without actually providing support for the trench sides or preventing the ground from collapsing. If a trench wall collapses, it does so against the side of the shield, leaving the worker safe inside. Shields are used in all types of ground and are particularly useful where long or large diameter pipes are to be installed and in variable ground conditions where timber supports are difficult to install (see Figure 4.8). Special shields are also for shoring Maintenance Hole excavations.

Shields can be used in all type of soils and are particularly valuable when timber or steel supports are difficult to install. They are designed and installed so that they remain intact when impacted and/or pressured by a fall of ground. Because of their versatility they are available for hire at a relatively low cost.

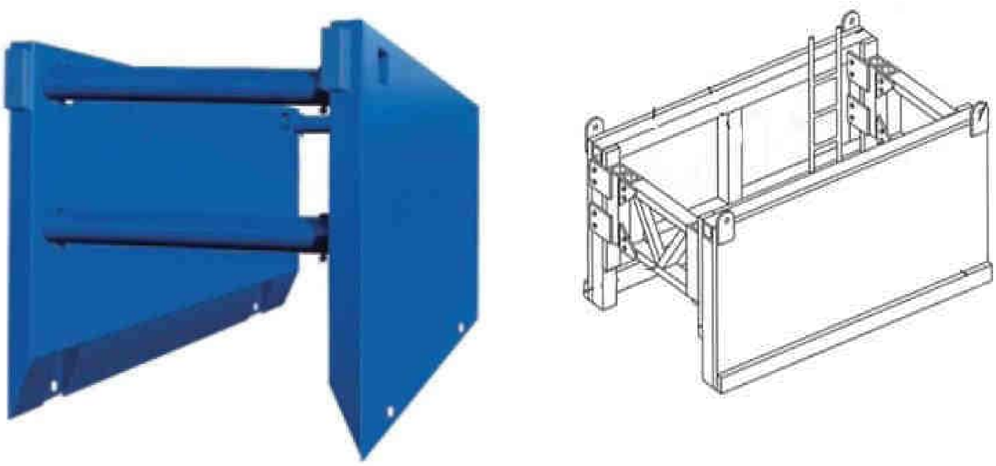


Figure 4.8 Typical metal shields

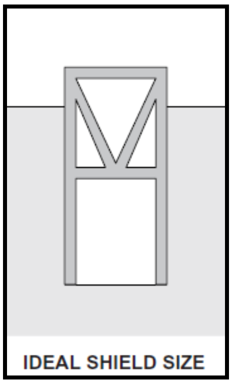
The installation of shields should be conducted by suitably qualified crane/ excavator and dogger personnel.

When working in trenches with shields, it should be remembered that shields are the only means of protection. Workers should not:

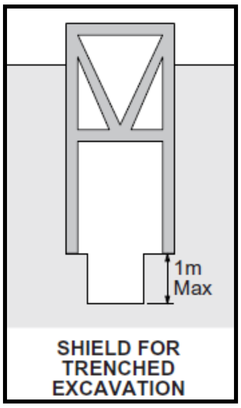
- enter the excavation area prior to the installation of the shield
- work outside the shield area
- enter an excavation after the shields have been removed
- enter a shield other than by a ladder.

4.3.1 *Shield Installation*

Ideally, when shields are installed, they should rest on the bottom of the excavation and extend above the surface, giving total protection to those within the shield.

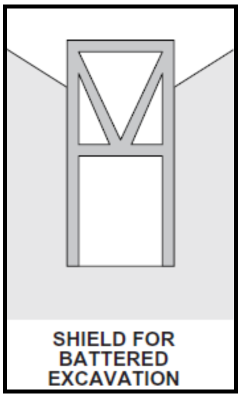


An alternative method may be used if the trench is narrowed. When using this method, the shield must be supported and tightly wedged into the trench. It must still extend above the surface to give the correct protection.

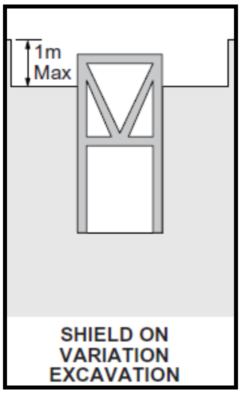


When installing undersized shields, the top of the trench must be stabilised by battering. If this not carried out, the sides may collapse, resulting in material spillage over the top of the shield onto the workers below.

In the battered trench, the angle of batter must equal the angle of repose of the soil pile. The height of the shields above the bottom of the batter should not be less than 0.3 m.



A variation to this is the step battered trench. A one metre stepped trench is dug, ensuring the height of the shield extends above the height of the trench.

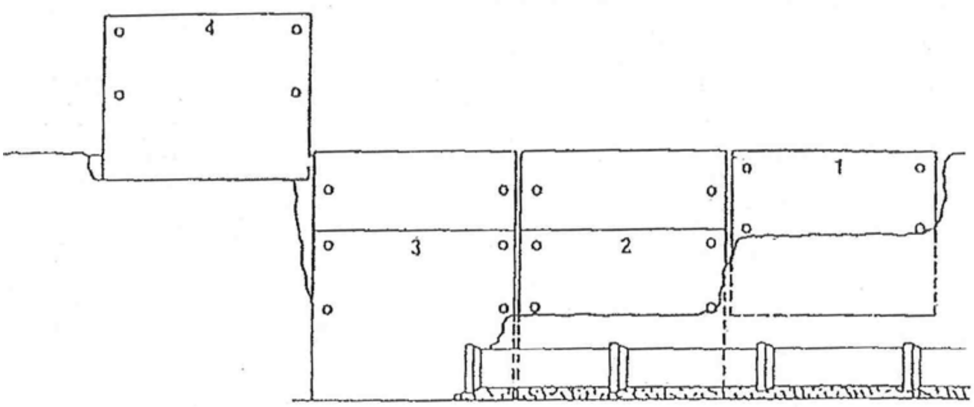


4.3.2 *Multiple Shields*

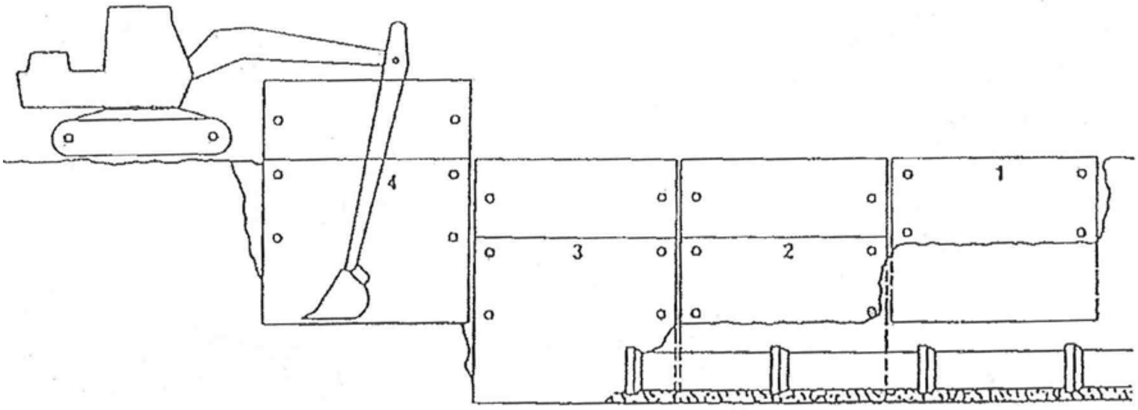
Where there is a requirement to have a longer length of open trench the shields offer a method of progressively digging the trench and installing shields while the completed section can be backfilled, compacted and shield removed for reuse.

The method normally used is as follows:

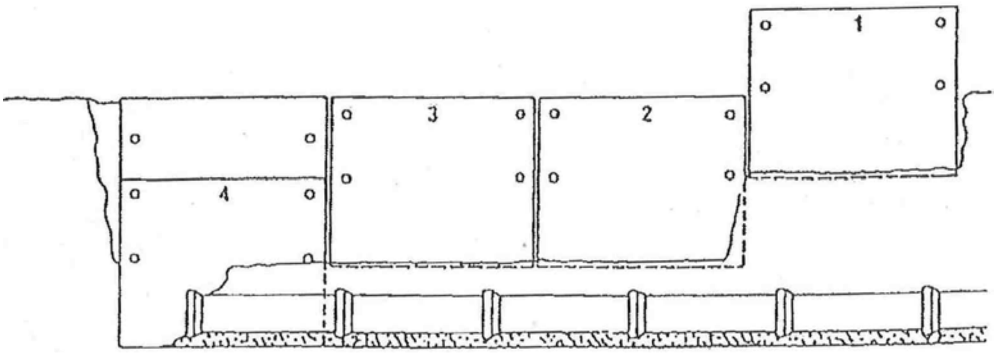
1. Excavate a shallow section of trench slightly wider than required for the next in-line unit for the shield (in this case under Unit 4).



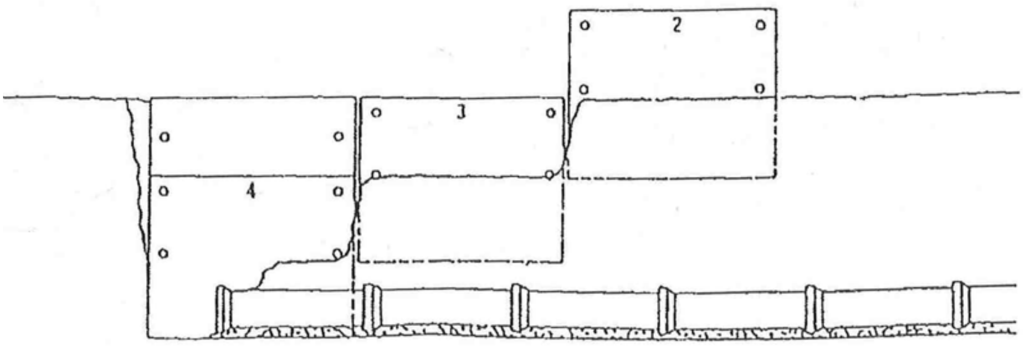
2. By alternately digging within the unit and pushing down on the corner post the shields are sunk to the required depth. (Note: additional top units are added when the lower unit reaches ground level).



3. Place bedding and lay pipes. Place embedment in layers of 300 mm and compact. Continue laying in 300 mm layers until pipe embedment is 300 mm above top of pipe.(units 2 & 3). Raise units so that the cutting edge is just visible (Units 1, 2 & 3). Compact back fill as required. (Note: remove top sections when clear of ground level).



4. Carry out further backfilling, raising units and compacting in required depth stages until backfilling reaches the required level and units can be removed. (Unit 1 removed and Unit 2 ready for lifting clear). Units are now ready to commence another cycle. (Note: Backfilling and compacting can be carried out while excavation is in progress so that direct recycling of excavated material can take place).

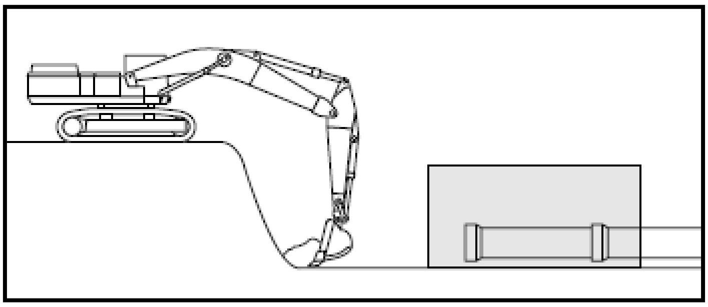


4.3.3 *Drag Boxes*

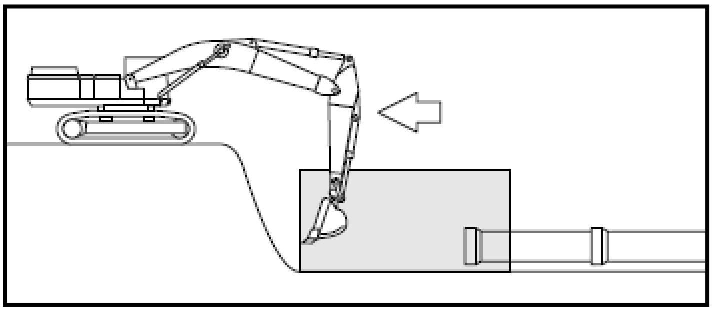
For ease of construction some shields (boxes) are designed so that they can be used as drag boxes.

The normal method used for drag boxes is as follows:

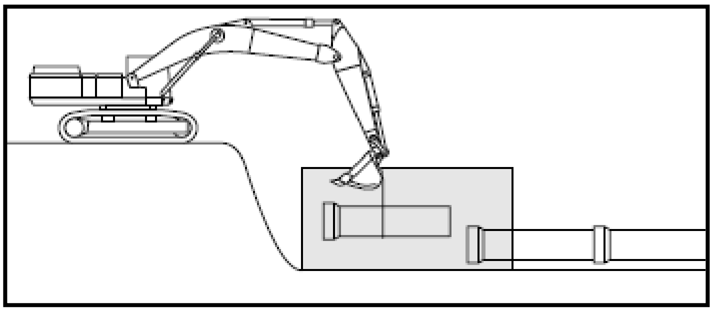
1. Excavate in front of the box. Excellent access and visibility allows for accurate digging and thus minimises hard work after the excavator has finished.



2. Pull the box forward. This is carried out by putting the bucket behind the front strut and pulling it forward using the digging action of the excavator.



3. Position the pipe. After pouring and levelling the pipe bedding material, the driver again has good visibility for safe handling of the pipe. Some backfilling may be carried out before the box is moved forward.



Section 5: Trench Rescue Procedures

The regulations require that while a person is in a trench, there should be at least one other person at ground level. It is essential that, in the event of a collapse, the rescue team have some idea where the trapped worker is located.

In the advent of a collapse the following procedure should be adopted:

- Send someone immediately to telephone or radio for the emergency services that may be needed. **If there are problems with the emergency system use:**
  - **PHONE dial 000**
  - **MOBILE dial 112 (International 911)**
- Ensure the person sent knows where the telephone or radios are located and that they can communicate clearly.
- Try to locate where the victim is and clear the area of all unwanted personnel.
- Look for evidence as to where the victim may be: - tools safety helmet etc.
- If possible, batter the sides of the trench in the collapsed area.
- Remove the collapsed soil with shovels or if it is very deep trench carefully use a machine to remove the top layers of collapsed soil.
- EXTREME CAUTION must be exercised if a machine is used that further injuries to the victim does not occur.
- Never have anyone on top of the collapsed soil that may be above the victim as this will exert extra pressure on the victim.
- Install shoring where possible to protect victim and rescuers.
- If the trench is over 1.5m in depth rescuers should wear safety harnesses with lifelines attached securing them to the surface.
- When in close proximity to the victim continue excavating using hands to remove material.
- If shovels have to be used, extreme care must be taken not to cause further injury to the victim.
- On locating the victim, clear soil from the head and chest areas, check for breathing response and a pulse.
- If breathing has stopped - commence expired air resuscitation.
- Where breathing has stopped and no pulse is present - commence expired air resuscitation (E.A.R.) and cardio pulmonary resuscitation (C.P.R.). Continue until Emergency Services arrive.

Section 6: Further Information

For further information concerning this document, contact:

Infrastructure Standards Manager
Telephone (08) 7424 2009
Facsimile (08) 7003 2009
SA Water Infrastructure Division
Level 7, SA Water house, 250 Victoria Square, ADELAIDE, SA 5000
ivor.ebdell@sawater.com.au

Section 7 – Referenced Documents

Includes pipe laying requirements

WSAA Codes

WSA 02 Sewerage Code of Australia
WSA 03 Water Supply Code of Australia

Australian Standards

AS 2550.1 - Cranes, hoists and winches - Safe use - General requirements
AS 1742.3 - Traffic Control Devices to be used when working on roads.

SA Water References:

Construction Manual

- Water Supply Construction Manual
  (http://www.sawater.com.au/SAWater/DevelopersBuilders/NetworkInfrastructureStandards/Water+Manual.htm)
- Sewer Construction Manual
  (http://www.sawater.com.au/SAWater/DevelopersBuilders/NetworkInfrastructureStandards/Sewer+Manual.htm)

Safe Working Procedures (SWP)

SWP 70132 'Excavation and Trenching'
SWP 70133 'Excavator and Backhoe Operation'
SWP 70134 'Installation of Ground Support Systems'
SWP 75012 'Cranes/Earthmoving Plant near Power Lines',
SWP 75014 'Operation of Tipper Trucks near Power Lines'
(http://im1.sawater.sa.gov.au/ohsw/Lists/Standard%20Work%20Procedures/Standard%20Work%20Procedures.aspx)

SafeWork

SafeWork Australia (see Appendix D)

- Code of Practice for Excavation Work (Draft)

SafeWork SA

Information Sheets

- Safeguards – Trenching and Excavation (Nov 2006)

Victorian Government

Code of Practice – (No. 8) – Safety Precautions in Trenching Operations (1988)
(http://www.worksafe.vic.gov.au/wps/wcm/connect/2c713f004071f5f7aaf4fee1fb554c40/COP8_trenching.pdf?MOD=AJPERES)

Appendix A: Extracts from OHS&W Regulations (2010)

Extracts from South Australian Government's

Occupational Health, Safety and Welfare Regulations 2010

under the *Occupational Health, Safety and Welfare Act 1986*

See (*http://www.safework.sa.gov.au/show_page.jsp?id=2474*)

South Australian Government
Occupational Health, Safety and Welfare Regulations 2010 — 13.1.2011
Part 6 ....Hazardous work
Division 5 ....Excavation work

Division 5—Excavation work

245—Preliminary

(1) The purpose of this Division is to ensure—

(a) that risks to the safety of persons involved in the performance of excavation work, or in the vicinity of an excavation or excavation work, are identified before the work begins; and

(b) that measures are taken to eliminate or minimise those risks before, during and after the performance of the work; and

(c) that the work is carried out in a safe manner.

(2) This Division applies to excavation work if an excavation formed by the work is (or will be) more than 1.5 metres high when measured from the bottom of the excavation and—

(a) the excavation is capable of permitting the entry of a person; or

(b) there is a possibility that a person involved in the performance of the work, or in the vicinity of any excavation or excavation work, could be injured from a fall or dislodgment of soil or rock.

(3) This Division does not apply to mines that are subject to the application of the *Mines and Works Inspection Act 1920*.

(4) In this Division—

engineer means a person who holds a tertiary qualification in engineering and who has experience in excavation work in the building, construction or mining industries;

engineer's report means a report prepared by an engineer under this Division.

NOTES

The new approach is based on a requirement for an engineer's assessment of proposed excavations. This is more practical than listing detailed prescriptive requirements because of the wide variety of factors which affect the safety of an excavation in any particular situation.

This Division is in addition to the relevant sections of Parts 1,2,3 and 4 of the OHS&W regulations as they apply to excavation work.

Reg 245 (2) limits the application of this regulation. Tunnels, cofferdams, caissons and the sinking of shafts or wells are included where they fall into the ambit of this regulation (except if they are located on mining sites).

246—Site report

(1) Before excavation work to which this Division applies is commenced, an engineer must assess all site conditions that could affect the excavation and prepare a written report on—

(a) those site conditions; and

(b) the safety precautions that should be taken or observed during and after the performance of the excavation work, including recommendations as to the use of—

(i) temporary support systems; and

(ii) battering; and

(iii) other forms of retaining structures (whether of a temporary or permanent nature); and

(c) any other matter that may be relevant to protecting the safety of persons involved in the performance of the work, or in the vicinity of the excavation.

(2) The report (or a copy of the report) must be kept at the site at all times during the performance of the excavation work (but need not be maintained after the excavation work is completed).

(3) This regulation does not apply in relation to trenching.

NOTES

Trenching work is excluded from the requirement for an engineer's report. Instead, detailed requirements for safety of trenching operations are included in this document.

247—Daily inspection

(1) Where excavation work to which this Division applies has commenced, a competent person must, at least once a day, carry out an inspection to ensure that conditions at the site are safe and that the work is being performed in accordance with any relevant engineer's report.

(2) A competent person who carries out an inspection under subregulation (1) must, immediately after completing the inspection, prepare and sign a written record of the inspection and that record (or a copy of the record) must be kept at the site until the completion of the excavation work.

A competent person in this instance could vary from a suitably qualified engineer in the case of large and complex excavations, to a person appropriately trained and authorised to carry out the work by an employer, in the case of less hazardous excavations.

Further guidance on daily inspections is provided in the Victorian Code of Practice for Safety Precautions in Trenching Operations.

248—Performance of work

In relation to the performance of excavation work—

(a) suitable materials must be provided and used to ensure that conditions at the site are safe; and

(b) systems of work must be employed to ensure that conditions at the site are safe; and

(c) the work must be carried out in accordance with any directions or recommendations given or made by a competent person after an inspection under this Division or contained in a relevant engineer's report (unless there is an emergency, or to do so would be dangerous due to a change in site conditions); and

(d) the site must be left in a safe condition when work is not in progress

Reg.248 (d) refers to the need to secure the site at the end of each working day, as well as the need to ensure continued safety of the site at the completion of the excavation work (eg. It may be necessary to ensure the site is safe for the passage of vehicles in the vicinity.

Division 10—Construction work

277—Preliminary

(1) The purpose of this Division is to ensure that, on account of the mobile nature of work in the construction industry, there is a degree of continuity in the implementation of these regulations in order to eliminate or minimise risks to the health or safety of any person who is involved in the performance of construction work, or who is in the vicinity of construction work.

(2) In this Division—

construction site means a site where 1 or more of the following activities are carried on:

(a) the construction, erection, alteration, repair, equipping, finishing, painting, cleaning, marking or demolition of a building, structure or ship;

(b) excavating, shaft sinking or tunnelling;

(c) the construction or maintenance of—

(i) roadworks; or

(ii) the permanent way of a railway, busway or tramway;

(d) dredging;

(e) the placing, laying or maintenance of pipes or cables (whether the pipes or cables are placed or laid above or below ground level);

(f) earth moving by power driven equipment.

278—Appointment of safety supervisors

(1) An employer must ensure that a person holds the position of safety supervisor in respect of a construction site if 20 or more people could be involved in the performance of work at a particular time.

(2) An appointment to the position of safety supervisor must be made within 24 hours after the commencement of work at the construction site, and within 24 hours after the position of safety supervisor becomes vacant.

(3) An employer must ensure that a safety supervisor appointed for the purposes of this Division is present on the construction site if 20 or more people are at work on the site.

NOTES

Previous Requirement

The requirements found previously in the construction Safety Regulations have been generalised and are now referred to under each particular hazard eg. scaffolding under Plant: and hard hats under PPE.

The new requirements relate primarily to the position of safety supervisor on a construction site.

(4) The employer must ensure that the name of the safety supervisor is posted on a notice board at the site within 24 hours after the appointment is made, and that the notice is kept on display during the term of the appointment.

(5) A person is not eligible for appointment as a safety supervisor unless the person—

(a) is generally recognised as being competent in the work which is being undertaken at the construction site; and

(b) has attended a course on occupational health and safety of not less than 12 hours duration; and

(c) has at least 5 years experience in the building and construction industry; and

(d) has an adequate working knowledge of these regulations.

279—Responsibilities

(1) A safety supervisor must—

(a) generally supervise, consult with and assist any employer, health and safety representative, health and safety committee or other person on site in relation to the general observance of these regulations; and

(b) promote the safe performance of work on the site.

Maximum penalty: Division 7 fine.

(2) An employer must provide a reasonable response to any reasonable request by a safety supervisor in relation to the health, safety or welfare of a person on site.

Maximum penalty: Division 6 fine.

(3) An employee, or any other person, on a site must, so far as it is within his or her control, comply with any reasonable request by a safety supervisor in respect of compliance with these regulations.

Maximum penalty: Division 7 fine.

280—Additional duties

(1) An employer may assign any additional duty to a safety supervisor (but any such duty may not be such that the safety supervisor is prevented from exercising the responsibilities of a safety supervisor under these regulations).

(2) 2 or more employers must appoint the same person as a safety supervisor for the purposes of these regulations.

Note—

The following are approved codes of practice under the Act and are relevant to the subject-matter of this Division:

(a) NOHSC's *National Code of Practice for Induction for Construction Work*

(b) NOHSC's *National Code of Practice for Precast, Tilt-Up and Concrete Elements in Building Construction*

South Australian Government
Occupational Health, Safety and Welfare Regulations 2010 — 13.1.2011
Part 7 ....Administration—
Division 5.....Notification of commencement of certain work—

Division 5—Notification of commencement of certain work

415—Preliminary

(1) In this Division—

notifiable work means—

(a) work involving the construction, alteration, repair, maintenance or cleaning of a structure where a crane or scaffolding is used in connection with the performance of that work; or

(b) work involving the demolition or partial demolition of a structure that is more than 6 metres high; or

(c) excavation work if an excavation formed by the work is more than 1.5 metres high when measured from the bottom of the excavation and—

(i) the excavation is capable of permitting the entry of a person; or

(ii) there is a possibility that a person involved in the performance of the work, or in the vicinity of any excavation or excavation work, could be injured from a fall or dislodgment of soil or rock;

NOTES

This regulation specifies the requirement for notification where excavations are deeper than 1.5 m.

Remaining part of Clause 415 omitted as it is not considered relevant

416—Requirement to give notice of commencement of work

(1) Subject to these regulations, if notifiable work is to be undertaken, notice of the proposed commencement of the work must be given to the Director at least 24 hours before the work is commenced.

This regulation specifies the requirement to notify **SafeWork SA** at least 24 hours before commencing excavations deeper than 1.5 m.

(2) The notice required under subregulation (1) must be given (either personally or through an agent)—

(a) if a person has been engaged to perform all of the work—by that person; or

(b) in any other case—by the owner or occupier of the place where the work is to occur.

(3) A notice given under subregulation (1) in relation to notifiable work must—

(a) be in writing; and

(b) set out—

(i) the date on which it is proposed to commence the work; and

(ii) the location of the relevant workplace; and

(iii) the name and business address of the person giving the notice.

(4) A person who—

(a) fails to give a notice that he or she is required to give under this regulation; or

(b) gives a notice that he or she knows to be false or misleading in a material particular,

is guilty of an offence.

Maximum penalty: Division 6 fine.

Appendix B: Identification and Field Testing of Soils

From: WSAA Sewer Code - Drg SEW-1200
SA Water Geo-technical Instructions

PREPARING THE TEST AREA:
All *field identification tests* must be done on a freshly exposed, damp, hand-trimmed area of the trench wall. Care must be taken to ensure that the soil in the exposed test area was not compacted or loosened during trench excavation. If the soil in the trench floor and wall is very dry at the time the trench is opened then the test area must be flooded and time allowed for the water to be absorbed by the soil before it is trimmed and tested.

IDENTIFYING CLAY SOILS:
A lump of clay soil will be difficult to break when dry. It will be sticky and need some effort to mould with the fingers when wet. Clay will not wash off easily. Most soils in the Adelaide area will have enough clay in them to be considered as clay soils for the purpose of anchor and thrust block design.

TESTING CLAY SOIL:
Clay soils are best tested in the wall of the trench. The fist, the thumb or the thumbnail is used to determine the consistency (strength) of the clay (see table).

IDENTIFYING CLEAN SAND SOILS:
The individual grains in sand will be visible to the eye. A lump of clean sand, if it can be picked up at all, will crumble with very little effort. Clean sand washes off easily. Sandy soils are mostly found in the beach suburbs and in creek channels.

TESTING CLEAN SAND SOILS:
Clean sand soils are best tested in the floor of the trench, by pushing with the whole bodyweight on one foot. The depth of the depression left by the boot is related to the density of the sand (see table). Care must be taken to ensure that the sand in the trench floor was neither compacted nor loosened during the excavation of the trench or the trimming of the test area.

TESTING ROCK:
The recommended field identification tests for rock rely on observing the ease with which the rock can be dug with a pick, and estimating the spacing of the *joints* in the rock. (Joints are commonly called cracks or breaks.) The spacing between joints is important because the allowable bearing pressure on rock is usually controlled by the joints in it, rather than by the strength of the *blocks of rock* themselves. Joints may be tightly closed (like hairline cracks, but can also be open (filled with air) or filled with soft clay or other soil.

SOIL CLASSIFICATION		FIELD IDENTIFICATION TEST	AHBP kPa
CLAY SOILS	Very Soft Clay	Easily penetrated 40 mm with fist.	<50 *
	Soft Clay	Easily penetrated 40 mm with thumb.	<50 *
	Firm Clay	Moderate effort needed to penetrate 30 mm with thumb.	<50 *
	Stiff Clay	Readily indented with thumb but penetrated only with great effort.	50
	Very Stiff Clay	Readily indented by thumbnail.	100
	Hard Clay	Indented with difficulty by thumbnail.	200
SAND & GRAVEL	Loose Clean Sand	Takes footprint more than 10 mm deep.	<50 *
	Medium-Dense Clean Sand	Takes footprint 3 mm to 10 mm deep.	50
	Dense Clean Sand or Gravel	Takes footprint less than 3 mm deep.	100
ROCK	Broken or Decomposed Rock	Diggable. Hammer blow "thuds" Joints (break in the rock) spaced less than 300mm apart.	100
	Sound Rock	Not diggable with pick. Hammer blow "rings". Joints (breaks in the rock) spaced more than 300 mm apart.	200
	Uncompacted Fill Domestic Refuse	Observation and knowledge of the history of the site.	<50 *

Legend

AHBP Allowable Horizontal Bearing Pressure for:

- 10 mm Movement
- Centre of thrust 800 mm below the Natural Surface Level
- High Water Table

* Special Geo-technical Assessment Required

Appendix C: General Trenching and Pipelaying Issues

The following applies to both water supply and sewer installations unless specified otherwise.

1. TRENCH FLOORS IN SOFT CLAY

Where the trench floor is soft clay and screenings are to be used as the pipe bedding material, then an approved geotextile (Ref Note 7) shall be laid directly on to the trench floor and shall extend up the trench walls to at least mid-height of the pipe prior to placing the screenings.

Commentary:
Soft clay can be forced into the voids in the screenings after pipe laying is completed and the trench backfilled, causing a loss of lateral support for the pipe and settlement of the sewer if the geotextile material is not used.

2. TRENCH FLOORS IN SATURATED SAND

Where saturated sands may be encountered during trench excavation, the Contractor shall lower the water table to below the level of the trench floor (eg. by well pointing) before beginning to excavate the trench.

The Contractor shall install observation bores to verify and monitor the lowering of the watertable.

Commentary:
A trench floor in clean sand can 'boil', (turn to quicksand) if the trench is dug below the water table. The condition must always be avoided rather than attempting to remedy its effects once it has occurred as sand which has 'boiled'loses both its strength and density.

Trench collapse is possible in sand which has 'boiled' even with trench sheeting in place, and some settlement of the completed sewer would be inevitable.

3. OVER EXCAVATION IN ROCK AND STABLE SOILS

Over-excavation in rock, firm clay, or firm clay/sand soils shall be backfilled to the Design Trench Floor Level with imported material having the same specification as the pipe bedding material, compacted as specified on the relevant SA Water Construction Manual Drawings. (Sewer and Water Supply Manuals)

4. OVER EXCAVATION IN CLEAN SANDS

Over-excavation in clean sand shall be backfilled to the Design Trench Floor Level with the excavated sand, compacted as specified on the relevant SA Water Construction Manual Drawings.

5. OVER-EXCAVATION IN SOFT CLA Y

Where the over-excavation is in soft clay, an approved geotextile (Ref Note 7) shall be placed directly on to the over excavated trench floor, and shall extend up the trench walls to at least the mid-height of the pipe.

The over-excavation shall then be backfilled to the Design Trench Floor Level with imported material having the same specification as the pipe bedding material, compacted as specified on the relevant SA Water Construction Manual Drawings.

Commentary:

The geotextile reinforces the trench floor and helps to achieve the required compaction in the backfill and, where screenings are used as backfill, the geotextile separates the screenings from the soft clay (Ref Note l) thus preventing a loss of lateral support for the pipe and settlement of the sewer.

6 SAND TRENCH FILL OVER SCREENINGS

Where cohesionless sand trenchfill is to be placed over screenings, an appropriate geotextile (Ref Note 7) shall be placed over the screenings.

Commentary:
The purpose of the geotextile is to prevent washing of the sand into the screenings (by groundwater) which could lead to subsidence of the ground surface or pavement.

7 SELECTION OF GEOTEXTILE

The geotextile shall be a medium weight, non woven, needle-punched geotextile approved by the Superintendent's Representative.

8 LAYING MAINS THROUGH REFUSE (LANDFILL/RECLAIMED LAND)

Where mains are to be laid through domestic or industrial refuse (sometimes called Landfill), specialist geotechnical advice shall be sought from the SA Water geotechnical staff in the Infrastructure Engineering Group for SA Water funded schemes or a specialist geotechnical consultant for developer funded schemes.

Commentary:
Refuse does not provide an acceptable foundation. Several types of problems may be involved and a range of solutions might be possible.

9 LAYING MAINS IN EXISTING EARTH FILL OR 'ENGINEERED FILL'

The history of the earth fill shall be determined.

If there is evidence that the fill was placed as 'Engineered Fill' or 'Controlled Fill', compacted to not less than 95% of its Standard Maximum Dry Density (AS 1289.5.1.1), then the fill may be considered as ' good' ground for the purposes of sewer construction.

If no evidence is available, or if it is known that the earth fill was simply dumped, or placed only to ' Landscape Fill' standards, then specialist geotechnical advice should be sought as detailed in Note 8. The density of the fill below the depth of the main shall be checked, and if it is less than 95% of its Standard Maximum Dry Density (AS 1289.5.1.1), the fill shall be removed and re-compacted back in place as detailed in Note 10.

10 PROPOSED FILLING ALONG THE ROUTE OF A MAIN

Where it is necessary to fill an area before laying a main across it, or to build an embankment in which to lay a main, specialist geotechnical advice should be sought as detailed in Note 8 to ensure that the weight of the fill will not cause unacceptable long term settlement in the ground below the fill, after the main has been laid.

If the ground below the fill is deemed to be satisfactory by the Geotechnical Consultant, then the fill itself shall be placed as follows:

- Prepare the foundation for the fill by clearing away all debris, vegetation and topsoil for the full width of embankment, or for a minimum width of 3 m where the area to be filled is very extensive.
- Compact the cleared soil surface to not less than 95% of its Standard Maximum Dry Density (AS 1289.5.1.1).
- Place the fill in layers of appropriate thickness for the compaction equipment employed and compact each layer to not less than 95% of its Standard Maximum Dry Density (AS 1289.5.1.1). Bring the fill of this standard up to a height of a least 300 mm above the design top of pipe level.

The remainder of the fill shall be compacted to not less than:

- 90% of its Standard Maximum Dry Density (AS 1289.5 .1.1) in easements and reserves
- 95% of its Standard Maximum Dry Density (AS 1289.5.1.1) in roadways.

It is generally preferable that the trench is excavated after all filling has been placed to its full depth. However, in deep fill where it is proposed to lay the main before the full depth of fill has been placed, it must be demonstrated that the compaction technique used on the remainder of the fill does not result in damage to the pipe, or cause excessive deformation of the pipe (Ref Note II).

11 PIPE DEFORMATION

Deformations resulting in more than 3% ovality of the internal diameter of the pipe under any circumstances is unacceptable and shall result in the rejection of that pipe or pipeline by the Superintendent's Representative.

12 COMPACTION CONTROL IN COHESIONLESS CLEAN SAND

Where the material complies with that defined in Note I of AS 1289.E5 . 1-1977, then the Density Index (I_D) method (AS 1289.E6.1-1981) shall be used for compaction control. Where required use the following conversions:

100% of SMDD = I_D of90%	95% of SMDD = I_D of 75%
90% of SMDD = I_D of 65%	85% of SMDD = I_D of 60%

Appendix D: Benching and Battering Special Requirements

General

Where any doubt exists regarding the bearing capacity of the trench walls a Geo-technical specialist must be engaged to assess the conditions and provide a written report which should include the following:

- Details of the bearing condition of the soil,
- Benching or battering requirements,
- Any dewatering requirements

Where any excavation is greater than 5 m a Geo-technical specialist assessment **MUST** be undertaken.

Benching

Benching is a relatively safe method of working in a trench. Benching can be used to meet any depth requirement providing sufficient open land is available.

The following conditions apply"

- Up to 3 m deep 1 m wide benches can be used.
- Over 3 m deep every second bench is to be 1.5 m wide (see Fig. D1)
- Over 5 metres deep, geotechnical approval is required.

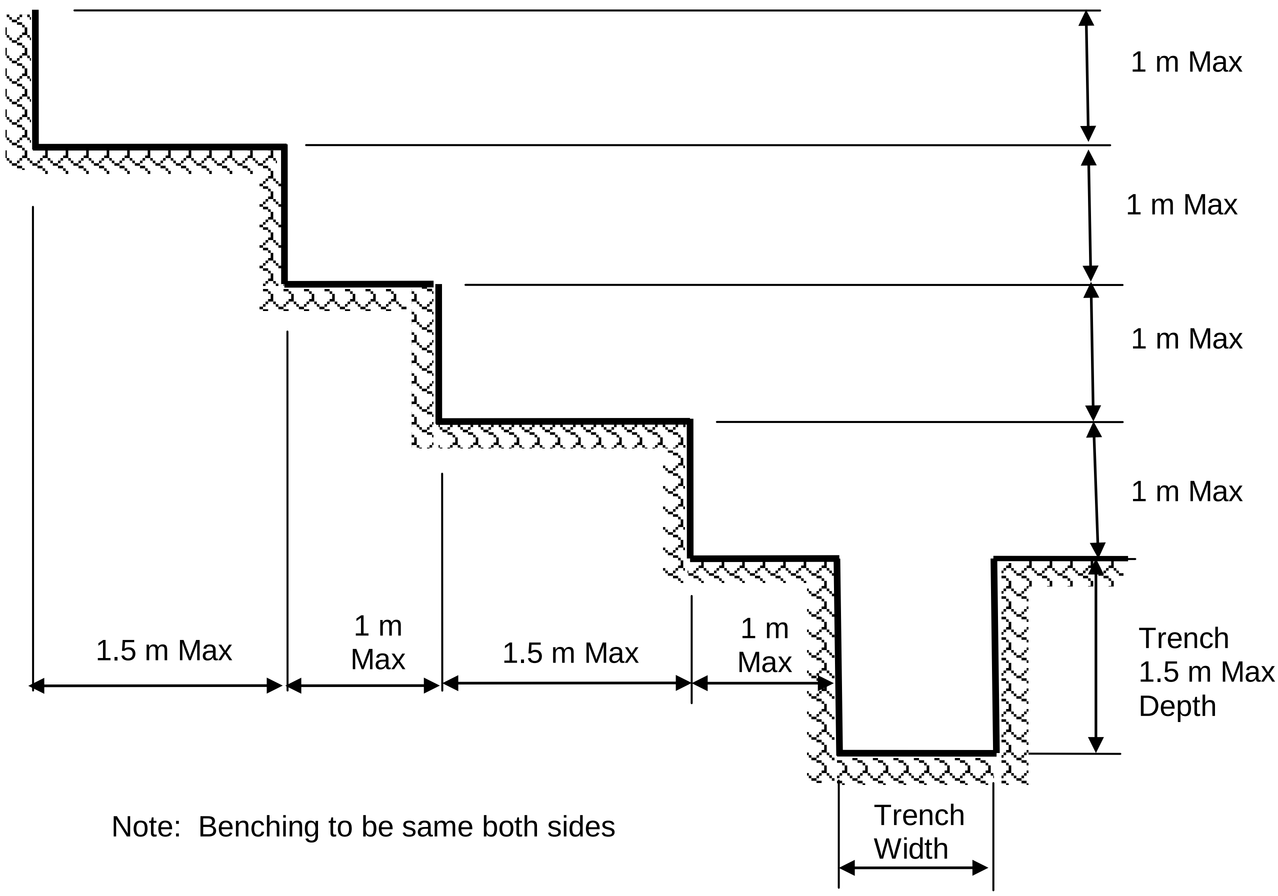


Figure D1 Benching over 3 metres deep

Battering

Particular attention needs to be paid to battering if it is carried out in sandy ground. It is recommended that a Geotechnical specialist be consulted where excavations in sand is greater than 3 m deep

Because of the loose and running nature of sand, not only does the Angle of Repose need to be greater than 45° (1 on 1) any trench material (spoil) needs to be a minimum of 2 m from the top of the batter. Shoring MUST be used where excavations are greater than 3 m deep, but may start before the batter reaches 3m deep if reqired. See Figure D2.

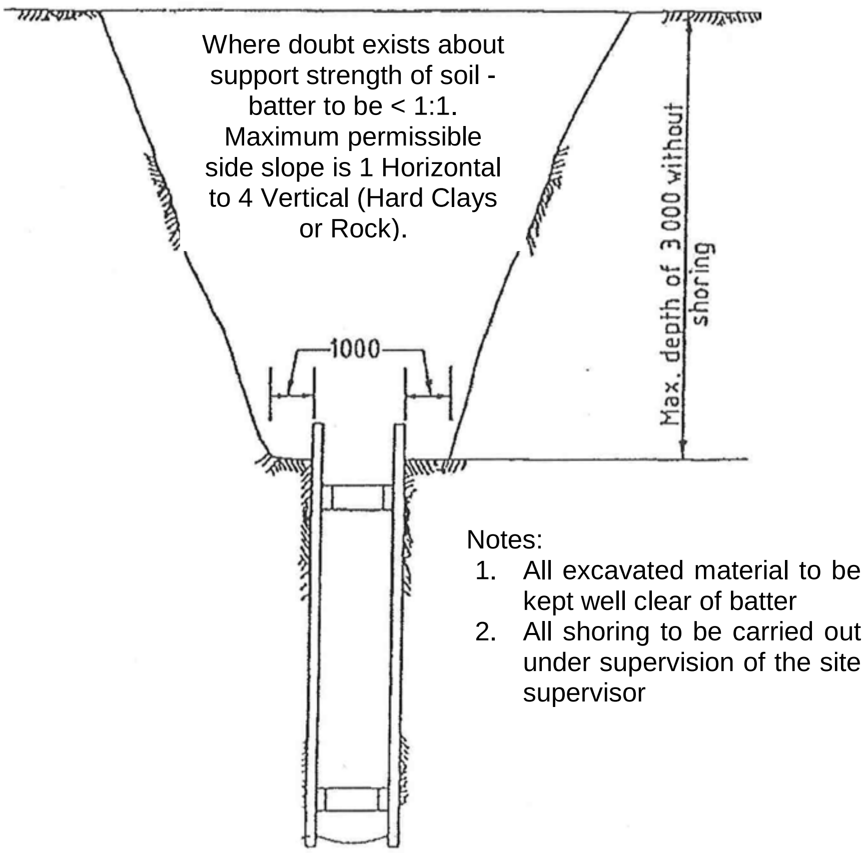


Figure D2 Battering greater than 3 m deep

Appendix E: Safe Removal of Shoring

Removal of shoring sets should be done from the surface or from a supported area of trench. Where practical all removal should be done from surface level. In some cases this is not possible and in this case there are two recommended methods of removal involving workers in the trench during dismantling.

In all methods, consideration should be given to compaction of backfill material as the work progresses.

Method 1 (see page E2)

This is the preferred method. After the pipework has been laid and the embedment is completed and without entering the excavation, workers backfill the trench along the entire length so that it is level with the bottom set of toms. They then enter the trench and remove all bottoms toms. When they leave the trench, it is backfilled to the next level to toms. The lowest toms are again removed in the same way. This is repeated until all the toms have been recovered, after which it is safe to remove the soldiers by means of back-hoe and chains or lifting lug. Backfilling is then completed. (Specified compaction must be achieved at each level)

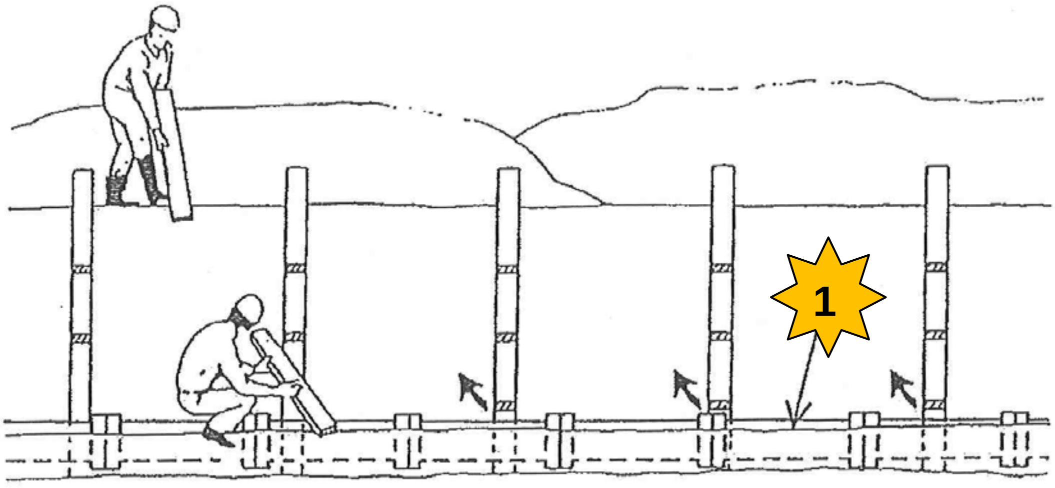
Method 2 (see page E3)

With this method, backfilling progresses from one end of the trench to the other; a useful practice when a trench has restricted access.

Backfill is placed in the trench until it reaches the bottom tom. A worker then enters the trench and removes this bottom tom. After the worker has left the trench or has gone behind a complete soldier set, more backfill is added until it reaches the next tom in the set being dismantled; this tom is then removed. The procedure is repeated until all the toms of the set have been recovered. The two soldiers are then removed and the excavation is backfilled until the fill reaches the bottom tom of the next set. The process is repeated along the whole length of the trench.

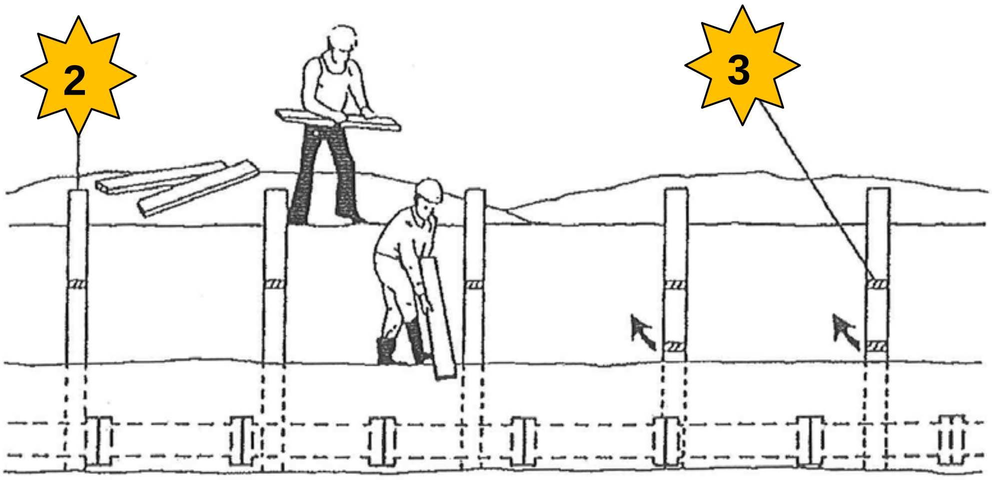
Method 2 is less satisfactory then Method 1 because the area in front of the set being dismantled only has uncompacted soil to stabilise its walls, and these walls must frequently withstand the additional weight of the excavator which backfills the trench.

The second method is also less efficient because backfill does not extend along the whole length of the trench, from bottom tom to bottom tom. This means that the area of partially unsupported ground around a worker in the trench is increased after the bottom tom has been removed.



Trench must be filled to the level of the bottom toms before workers can be allowed into the excavation to remove the bottom row of toms.

1 *Backfill must reach the level of the bottom torn.*

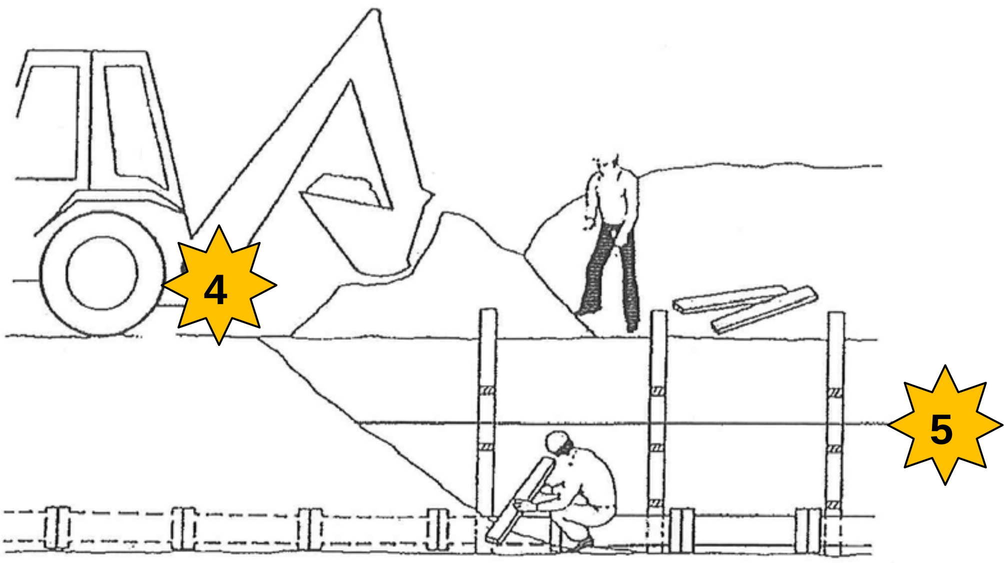


For added side support during the removal process, while workers are still in the trench, the soldiers should be left in place until all the toms have been removed, and then extracted with the backhoe.

2 *Soldiers are pulled out last, after the removal of the top tom.*

3 *The top tom is removed from the surface or from the trench after backfill has been placed to the level of the top tom.*

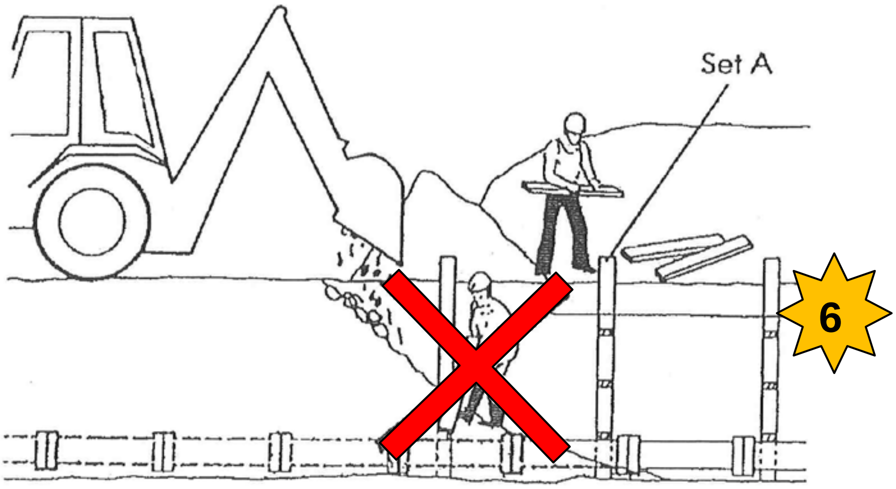
REMOVING SOLDIER SETS GROUND SUPPORTS METHOD 1



The trench must be backfilled to the level of the bottom tom before the tom is removed.

4 *A small mobile front end loader should be used for backfilling. Heavy excavators should be avoided as they place an enormous load on the trench walls and cause excessive vibration.*

5 *Partially unsupported ground.*



Since the soldier provides side-support near the set being dismantled, the set should be removed by the excavator only after the trench has been completely backfilled.

6 *The worker is in a dangerous situation. Workers should not be in front of Set A while an excavator is backfilling*

REMOVING SOLDIER SETS GROUND SUPPORTS METHOD 2

Appendix F: SAFE WORK INFORMATION

Federal and state governments have set up SAFE WORK groups to specify, regulate and police safe working conditions in the workplace.

SafeWork Australia

SafeWork Australia is an independent statutory agency responsible to improve occupational health and safety and workers' compensation arrangements across Australia

Draft Code of Practice “Excavation Work” which is open for public comment review has been used as resource information for this Technical Guideline.

More information can be found on their website:

http://www.safeworkaustralia.gov.au/

SafeWork SA

SafeWork SA is responsible for administering occupational health, safety and welfare laws and certain industrial relations laws in South Australia.

To assist in the implementation of safe work practices they have produced a series of information sheets titled “SAFEGUARDS”. The ”Trenching and Excavation” document is relevant to trenching and ground supports systems.

More information can be found on their website:

http://www.safework.sa.gov.au/show_page.jsp?id=2540