Christchurch City Council

TRENCH SUPPORT
BEST PRACTICE GUIDELINE

Version	TRIM	Phase	Date	By
1	16/1315602	Final	3 November 2016	SCIRT 1001-CN-GE-GL-0002
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Contents

Revision History

Revision	Date	Name	Brief Description
1	16 Dec 2015	Ian Froggatt/Tony Gordon	First issue
2	21 February 2017	Yvonne McDonald	CCC letterhead

1 Scope

This document is intended to guide the selection of an appropriate system of trench support for pipe laying works in Christchurch and is to be used during Concept Design, Detailed Design, planning and Construction stages. **Early Contractor Involvement** (ECI) should not be undervalued even at Concept stage; working collaboratively throughout the project development only adds value to the **Risk Register** outcomes. The selected **methodology** for excavation support will have a bearing on the construction cost and must be considered when setting the estimate for the Project.

This document is far too brief to provide in-depth guidance on the design and installation of the various temporary works systems associated with trenches. The reader is referred to CIRIA Report 97 Trenching Practice (2001 Revision).

All trenching work is potentially hazardous and trench collapses can result in injury and death. The many Health & Safety considerations and requirements pertaining to the excavation and support of trenches and to working within / adjacent to trenches are not within the scope of this document. The reader must consult the Worksafe Excavation Safety Good Practice Guideline available from the WorkSafe New Zealand website.

2 Methods of Trench Support

2.1 Techniques Available

1. Trenchless (“No-dig” solutions)
2. Sloped or stepped excavations
3. Trench shields (or trench boxes)
4. Drag shields
5. Trench shoring systems (including sheet piling)

At the outset it must be stated that there are trenchless techniques being employed in Christchurch for pipe installation that remove the requirement for trenches and therefore trench support, e.g. directional drilling. A Designer may also consider rehabilitation of the pipe which again mitigates the need for a trench altogether. This guide does not cover trenchless techniques, however consideration should always be given to their use, especially for deep installations and/or in poor ground conditions, where pipe laying in an open trench is likely to be expensive and /or hazardous.

2.2 Sloped or Stepped Excavations

These methods are usually only viable on greenfield sites. However, there will be occasions when these ‘open-cut’ solutions are viable e.g. where pipes are laid across reserves.

If these methods are to be used then the safe angle of repose (and step height where applicable) must be determined by a qualified person, e.g. a Chartered Civil or Geotechnical Engineer.

Note that moisture affects slope stability and a safe slope in dry conditions may become unsafe after exposure to water from any source such as rainfall, groundwater ingress, broken water mains, run off etc. The excavation must therefore be inspected daily by a competent person prior to permitting man entry.

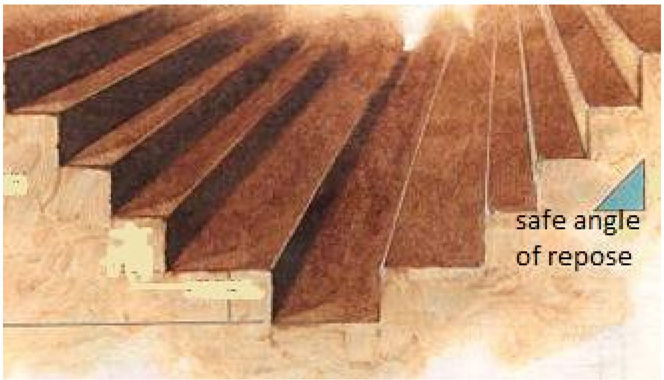
<u>Advantages:</u>

- No shoring or trench support required

<u>Disadvantages:</u>

- Additional volume of excavation and backfill are required.
- In poor soils in Christchurch, the safe angle of repose can be so shallow as to render this methodology impractical.
- Temporary works may be required to protect adjacent and crossing utilities.

Figure 2-1 Sloped Excavation



Source: OSHA Excavation Standard Handbook

Figure 2-2 Stepped Excavation

2.3 Trench Shields

The function of trench shields (also known as trench boxes) is to protect workers in case of a trench collapse. Trench shields should not be confused with trench shores. Shields are not usually intended to shore up or otherwise provide positive support to the walls of the trench.

Trench shields must be inspected and certified by an Authorised Person as safe for use and fit for purpose.

<u>Advantages:</u>

- Readily available and commonly used
- Protect workers effectively, without additional cost of supporting the trench walls

<u>Disadvantages:</u>

- In general, trench walls are not positively supported, which can lead to collapse / slumping / subsidence of native soil, especially if the trench is left open for an extended period
- The trench shield must be lifted progressively to ensure full-width compaction of backfill layers

Due to the prevalence of poor ground conditions across much of Christchurch, the use of trench shields, though commonplace, is often not appropriate. In cohesionless soils, such as silty sands, the trench walls will not be self-supporting. Although workers within the shield will be protected, collapsing trench sides will undermine any adjacent services as well as the road pavement above. In the case of trench 'cave-ins' in the public road, reinstatement costs can be very expensive. At ECI and planning stage, the risks should be assessed and it may be prudent to budget for a proper shoring system, perhaps a sheet piled solution.

Figure 2-3 Shields protect workers but they do not necessarily support the trench walls

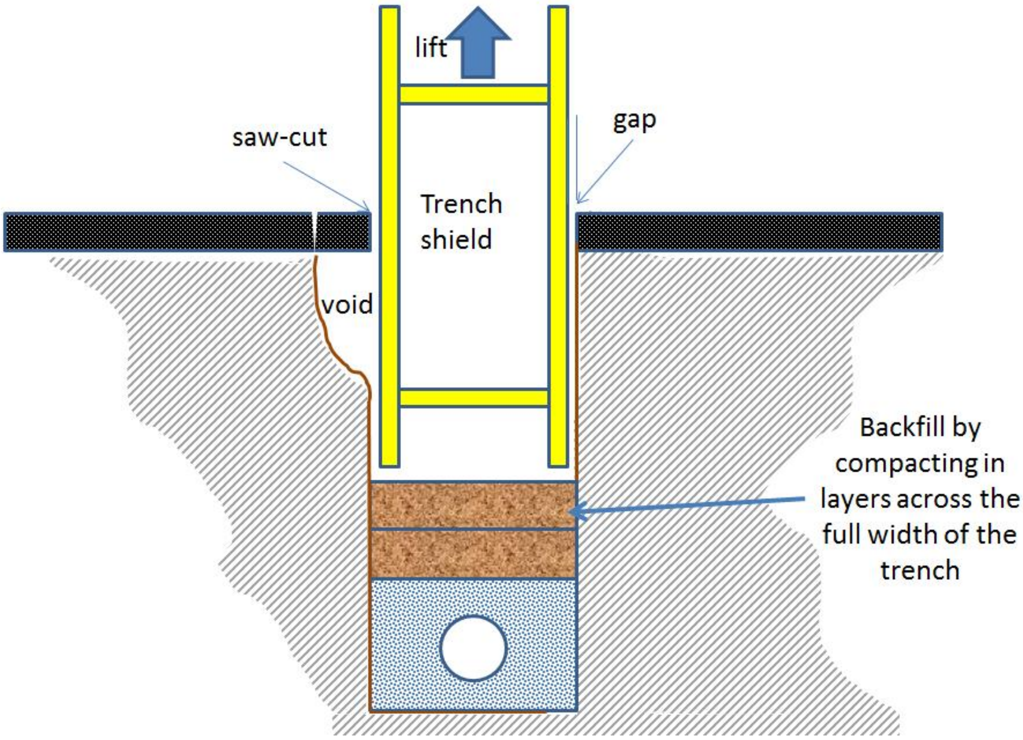


Figure 2-4 The shield must be withdrawn progressively to all allow full width compaction

When using trench shields, a methodology must be devised for backfilling the full width of the trench. Backfilling in compacted layers *within* the shield is pointless if the shield is pulled out afterwards causing the material to relax (see Figure 2-6 below). Instead, the shield must be withdrawn progressively as backfill progresses. The shield may have to be propped or otherwise safely supported to allow for removal in stages.

2.4 Drag Shields

A drag shield is a type of trench shield that is *dragged* horizontally by an excavator (Figure 2-5), often by means of certified chains attached to the shield and secured to the dipper arm of the excavator.

Drag shields (like all trench shields) must be inspected and certified by an Authorised Person as safe for use.

Figure 2-5 A Drag Shield can cut its way through native soil providing Positive Support

<u>Advantages:</u>

- Drag shields, in appropriate ground conditions, can facilitate quicker progress than ordinary trench shields, which must be lifted vertically in and out of the trench.
- A drag shield can provide positive support to the native soil when used in a trench that has been deliberately excavated to be slightly narrower than the shield itself.

<u>Disadvantages:</u>

- Cannot be used where existing services cross the path of the trench
- In many soils, the amount of force required to overcome friction on the shield walls makes this method impractical, i.e. the shield cannot cut through the native soil and larger equipment is generally required to overcome the frictional forces exerted between shield and the trench sides.
- There is a temptation to excavate the trench somewhat wider than the shield so that dragging the shield is not difficult, however this method is *not recommended.* Due to the voids outside the shield wall it becomes impossible to backfill the full width of the trench in compacted layers (refer to Figure 2-6).
- As the shield moves forward the positive support of the native soil is removed and trench collapse could follow the rear of the box.

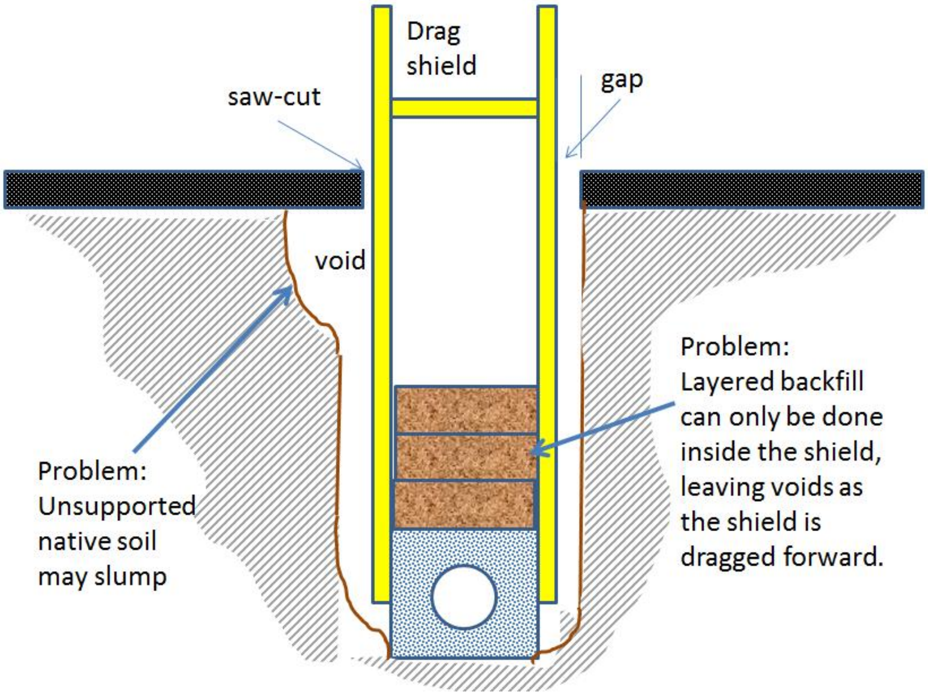


Figure 2-6 Do not use a drag shield in a trench that is wider than shield

2.5 Trench Shoring Systems

2.5.1 Categories

By definition, shoring systems support the trench walls. Shoring systems can be categorised as follows:

- Sheeting, waling and strutting
    - Traditional methods
    - Systems incorporating hydraulic struts
- Proprietary shoring systems
- Sheet Piling

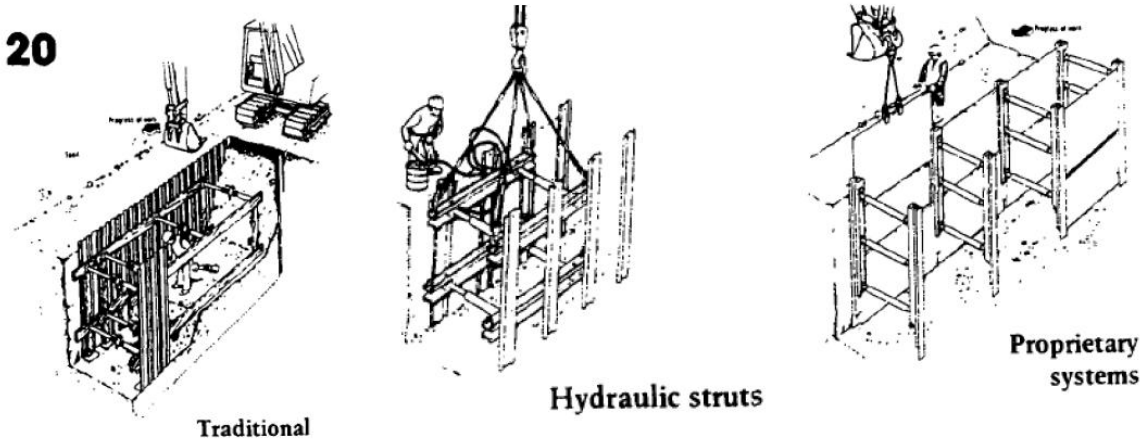


Figure 2-7 Trench Shoring Systems *Source: CIRIA R97*

All shoring methods require a **temporary works design** by a competent Engineer. CIRIA Report 97 provides basic design guidelines. In the case of proprietary systems, the suppliers usually offer a design service.

2.5.2 Sheeting, Waling and Strutting

Sheeting: Nowadays, steel trench sheets are used but traditionally, timber boards were common. In poorer soils, sheeting needs to be continuous in the trench ('full sheeting'), and should be toed-in especially where ground water was an issue. In good ground however, intermittent sheeting or 'half sheeting' may be considered.

Walings: Generally stout timbers or steel sections are used. They act as beams, transferring the horizontal loads from the soil/sheeting to the struts.

Struts: Traditionally timber but nowadays adjustable steel props (e.g. *'Acrow* props') or hydraulic props are often used.

<u>Advantages</u>: Adaptable, particularly when working around existing services. Actively support the native soil. Quick to install especially in shallow excavations

<u>Disadvantages</u>: Traditional 'timbering' system requires considerable experience and skill to install. Each arrangement requires a bespoke design. Deeper excavations require Temporary Work design calculations.

Source: Ischebeck

Figure 2-8 Traditional Shoring

Traditional shoring methods should not be used unless the persons at the workface are highly competent and experienced in the installation, inspection and maintenance of such systems. Instead the use of standard proprietary shoring systems and sheet piles should be considered.

2.5.3 Proprietary Shoring Systems

There are many different proprietary shoring systems available. These include modular trench box systems and hydraulic frames. Local suppliers include Mabey/Lite Shore NZ and Trench Shoring New Zealand.

Advantages: Standard components and uniform installation methodologies can reduce risks inherent with bespoke shoring arrangements. Design service available from supplier.

Disadvantages: Some systems may lack flexibility e.g. to accommodate existing utilities crossing the trench.

2.5.4 Sheet Piling

A sheet piled shoring system is often used in poor ground for deep drainage and is considered by many as the best and safest solution for installing structures or pipes below ground.

Advantages:

- Interlocking sheets prevent water ingress
- Native soils and adjacent utilities and/or structures can be adequately supported
- One advantage of Christchurch's relatively poor soils is that sheet piles can often be driven with relatively little effort by excavator mounted equipment e.g. Movax (Figure 2-9). Rarely is installation impeded by boulders or bed rock. These ground conditions can allow relatively lightweight sheets to be driven.
- Can add dewatering systems by preventing water migration under the toe of the excavation

Disadvantages:

- Expensive – but should be viewed in overall context of mitigation of risks to the road pavement and adjacent utilities and properties
- Vibrations during installation (and removal) may liquefy native soil and lead to settlement
- May be difficult when coping with crossing services

Figure 2-9 Installing Sheet Piles

Figure 2-10 Sheet Piled Trench

3 Selection of Appropriate Method

3.1 Developing the Concept Design

Early Contractor Involvement (ECI) should commence during the Concept Design stage of any pipeline project in poor ground or high risk areas e.g. adjacent to the river etc. This should help Designers focus on any issues his or her design may cause for the contractor.

Things to be considered could be:

- Trenchless alternatives, both for pipe replacement or rehabilitation of existing infrastructure
- Alignment changes to help with installation, access, traffic management etc.
- Appropriate trench support systems required given ground conditions anticipated

The following non-exhaustive list should be used to guide decisions regarding the design of both the temporary and the permanent works:

- Depth of dig
- Underlying geology
- Water table (and likely fluctuation, artesian pressure, etc.)
- Location (adjacent to water courses, buildings, structures, existing utilities, etc.)
- Likely traffic loading and road hierarchy adjacent to trench
- Historical evidence (EQ damage experienced)
- Likely timing of works (seasonal / daily variations)
- Strategic importance (e.g. for overall network stability, priority CBD works, etc.)

3.2 Detailed Design Stage

At this stage of the process the Designer should have made use of the variety of information that is available from other disciplines, e.g. geotechnical and maintenance providers. Roading engineers should have access to borehole information detailing carriageway makeup and underlying ground conditions adjacent to any proposed trench excavation. This type of information may help the contractor tailor their install methodology during ECI and design development, which then develops a more robust Risk Register. Having a fuller understanding of any issues helps to manage or mitigate risks earlier in the process leading to more certainty when the estimate is finalised.

3.3 Delivery

Development of a clear understanding of the ground conditions and constraints facing the contractor in carrying out any restorative works to the piped system can only culminate in a more robust solution. By tailoring and managing risk together, the Designer and contractor learn from each other and develop well managed outcomes.

Trench support is only one part of the overall Delivery phase of installing new pipes in the ground. Other considerations will be:

- Dewatering requirements
- Bedding material types
- Proximity of adjacent infrastructure
- Availability of suitably qualified and experienced subcontractors

The matrix table below aims to aid the Designer and contractor better manage both the Design development as well as the ECI/ITP process.

Table 1 Acceptable Trench Support Methods for Various Ground Conditions

Ground Condition	Sheet Pile	Trench Box (Hydraulic)	Trench Box (fixed)	Trench Box +Shield	Drag Box	Open Cut
Rock	N	Y	Y	Y	N	Y
Non-cohesive soils	Y	Y	Y	Y	Y	N
Cohesive soils	Y	Y	Y	Y	Y	Y
Organic soils	Y	Y	Y	Y	N	N
Granular (fine)	Y	Y	Y	Y	Y	N
Granular (course)						N

Additional reading:

Worksafe Excavation Safety Good Practice Guideline

CIRIA Report 97 – Trenching Practice (second edition)

Trenching Safety – Introduction to Trenching Hazards, Health and Safety Ontario. http://www.csao.org/images/pfiles/27_M026.pdf

http://www.haviland-drainage.com/installation_guide.pdf