Department of **Local Government, Industry Regulation and Safety**

GOVERNMENT OF WESTERN AUSTRALIA

WorkSafe Western Australia

Excavation work

Draft Code of Practice

DRAFT FOR PUBLIC CONSULTATION

WHSC
WORK HEALTH AND SAFETY COMMISSION

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Foreword

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1. Introduction

Excavation is one of the most hazardous construction operations.

Excavation failure occurs very quickly. This means that a worker has virtually no time to escape, especially if the collapse is extensive and the excavation is a trench. Normally, a slab of earth collapses off the trench face under its own weight and breaks against the opposite wall of the excavation. This can lead to crushing and burying any person in its path, which can result in suffocation or potentially fatal injuries.

This code of practice is designed to assist a person conducting a business or undertaking (PCBU) to meet their legal duties under the *Work Health and Safety Act 2020* (WHS Act). The *Excavation work: Code of practice* (Code) also presents material which, while not legally required, will help PCBUs minimise risks related to excavation. Among these measures are:

- not having people in excavations when they are not required to be there
- minimising the time people spend in excavations
- ensuring adequate measures are in place to allow for a quick exit from the excavation
- mechanising work to be carried out in excavations so far as is reasonably practicable
- providing adequate induction, training and information for those involved in excavation work by implementing peer-to-peer training within the workforce and using documented procedures, such as a formal safe work method statement (SWMS), even though vocational education and training (VET) courses are not available for excavation work
- using this Code as a learning tool for those who will be involved in excavation work
- using a geotechnical engineer or other competent person to assess risks associated with ground conditions if there is any uncertainty.

1.1. What is excavation work?

Excavation work means work to make an excavation or to fill or partly fill an excavation. Excavation work commonly includes work involving the removal of soil or rock from a site to form an open face, hole or cavity, including trenches, shafts and tunnels. Excavation work is generally carried out using tools, machinery or explosives.

Under the Work Health and Safety (General) Regulations 2022 and Work Health and Safety (Mines) Regulations 2022 (WHS Regulations), excavation work is considered to be ‘construction work’.

Some work connected to excavation work may be a type of high risk construction work. Regulation 291 of the WHS Regulations outlines high risk construction work, which includes work that:

- involves a risk of a person falling more than 2 metres
- takes place in or near
  - a shaft or trench with an excavated depth greater than 1.5 metres
  - a tunnel
- involves the use of explosives
- occurs on or near pressurised gas distribution mains or piping
- takes place on, in or adjacent to a road, railway, shipping lane or other traffic corridor used by traffic other than pedestrians
- occurs in an area at a workplace where powered mobile plant operates.

High risk construction work requires the preparation of a safe work method statement (SWMS). PCBUs may want to consider also preparing a SWMS for tasks which do not legally require one. This will help to minimise risk in the workplace.

Under the WHS Regulations, the definition of an excavation does not include a mine, a bore to which the *Water Services Act 2012* applies, or a trench used as a place of interment (such as a grave). Work involving minor testing related to a structure (such as soil testing and geotechnical work) and mining or the exploration for or extraction of minerals is not considered construction work.

1.2. Who has health and safety duties in relation to excavation work?

Duty holders who have a role in managing the risks of excavation work include:

- a PCBU
- designers, manufacturers, importers, suppliers and installers of plant, substances or structures
- WHS service providers
- officers.

Workers and other persons at the workplace also have duties under the WHS Act, such as the duty to take reasonable care for their own health and safety and that of others at the workplace.

A person can have more than one duty and more than one person can have the same duty at the same time. For example, the principal site contractor may have the general duty of care at the same time individual contractors may also hold that duty. Under the WHS Act, duties are not transferable.

Early consultation and identification of risks can allow for more options to eliminate or minimise risks and reduce the associated costs. This is particularly important in workplaces where multiple contractors may be working at one time. For example, a large housing development or the construction of a retirement village.

Person conducting a business or undertaking

WHS Act section 19

Primary duty of care

A PCBU must eliminate risks arising from excavation work, or if that is not reasonably practicable, minimise the risks, so far as is reasonably practicable.

The WHS Regulations include more specific obligations for PCBUs to manage the risks of hazardous chemicals, airborne contaminants and plant, as well as other hazards associated with excavation work, including trenches.

PCBUs have a duty to consult workers about work health and safety and may also have duties to consult, cooperate and coordinate with other duty holders.

For more information on PCBUs, see *The meaning of 'person conducting a business or undertaking' (PCBU)*: Interpretive guideline.

Principal contractors

WHS Regulation 292

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WHS Regulation 293

Meaning of principal contractor

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WHS Regulation 314

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WHS Regulation 315

Further health and safety duties—specific risks

The principal contractor for a construction project has a specific duty under the WHS Regulations to document the arrangements in place for consultation, cooperation and coordination between the PCBUs at the site. These arrangements must be recorded in the project's WHS management plan.

A construction project is a project that involves construction work where 5 or more persons are or are likely to be working at the same time at a construction site. Additional duties apply to principal contractors of construction projects.

Designers, manufacturers, suppliers and importers of plant, substances or structures

WHS Act Part 2 Division 3

Further duties of persons conducting businesses or undertakings

WHS Act section 22

Duties of persons conducting businesses or undertakings that design plant, substances or structures

WHS Act section 23

Duties of persons conducting businesses or undertakings that manufacture plant, substances or structures

WHS Act section 24

Duties of persons conducting businesses or undertakings that import plant, substances or structures

WHS Act section 25

Duties of persons conducting businesses or undertakings that supply plant, substances or structures

WHS Act section 26

Duties of persons conducting businesses or undertakings that install, construct or commission plant, or structures

Excavation ground collapse prevention systems such as trench boxes, shoring, ground anchors and steel sheet piling are 'structures' under the WHS Act, and in most cases the provider will be a 'designer'. PCBUs should be aware of this in the planning phase of an excavation.

Designers, manufacturers, importers, suppliers and installers of plant or structures used in excavation work must ensure, so far as is reasonably practicable, the plant or structure they design, manufacture, import or supply is without risks to health and safety. This duty includes carrying out testing and analysis as well as providing specific information about the plant or substance.

To assist in meeting these duties, the WHS Regulations require:

- manufacturers to consult with designers of plant
- importers to consult with designers and manufacturers of plant
- the person who commissions construction work to consult with the designer of the structure.

WHS service provider

WHS Act s. 26A

Duty of persons conducting businesses or undertakings that provide services relating to work health and safety.

Any WHS service provider must, so far as is reasonably practicable, ensure the WHS services are provided so that any relevant use will not put at risk the health and safety of persons who are at the workplace.

For further information, see the *Duty of persons conducting business or undertakings that provide services relating to work health and safety*: Interpretive guideline.

Officers

WHS Act section 27

Duty of officers

Officers, for example company directors, have a duty to exercise due diligence to ensure the PCBU complies with the WHS Act and WHS Regulations. This includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to eliminate or minimise risks to health and safety from excavation work. Further information on who is an officer and their duties is available in *The health and safety duty of an officer*: Interpretive guideline.

Workers

WHS Act section 7

Meaning of worker

WHS Act section 28

Duties of workers

WHS Regulation 46

Duties of workers

Workers have a duty to take reasonable care for their own health and safety and to not adversely affect the health and safety of other persons. Workers must comply with reasonable instructions, as far as they are reasonably able, and cooperate with reasonable health and safety policies or procedures that have been notified to workers.

If personal protective equipment (PPE) is provided by the business or undertaking, the worker must so far as they are reasonably able, use or wear it in accordance with the information, instruction and training provided.

Other persons at the workplace

WHS Act section 29

Duties of other persons at the workplace

Other persons at the workplace, like visitors, must take reasonable care for their own health and safety and must take care not to adversely affect other people's health and safety. They must comply, so far as they are reasonably able, with reasonable instructions given by the PCBU to allow the PCBU to comply with the WHS Act.

1.3. What is involved in managing risks associated with excavation work?

WHS Regulation 305

Management of risks to health and safety associated with excavation work

WHS Regulation 34

Duty to identify hazards

WHS Regulation 35

Managing risks to health and safety

WHS Regulation 36

Hierarchy of control measures

WHS Regulation 37

Maintenance of control measures

WHS Regulation 38

Review of control measures

This Code provides guidance on how to manage the risks associated with excavation work in the workplace using the following systematic process:

- identify hazards—find out what could cause harm
- assess the risks, if necessary—understand the nature and potential severity of the harm a hazard could cause and how likely it is to occur—unless the risk is already known and well-controlled
- eliminate risks, so far as is reasonably practicable
- control risks—if it is not reasonably practicable to eliminate the risk, implement the most effective control measures that are reasonably practicable in the circumstances in accordance with the hierarchy of control measures, and ensure they remain effective over time
- review control measures to ensure they are working as planned.

Additional duties apply to the PCBU to manage the health and safety risks associated with excavation work before the work starts, including the risk of a person:

- falling into an excavation
- being trapped by the collapse of an excavation
- being struck by a falling thing
- being exposed to an airborne contaminant.

To manage the risks, all relevant matters must be considered including the:

- nature of the excavation
- nature of the excavation work including the range of possible methods of carrying out the work
- means of entry into and exit from the excavation, if applicable.

Further guidance on the risk management process is available in the *How to manage work health and safety risks*: Code of practice.

Consulting workers

WHS Act section 47

Duty to consult with workers

WHS Act section 48

Nature of consultation

WHS Act section 49

When consultation is required

A PCBU must consult, so far as is reasonably practicable, with workers who carry out work for the business or undertaking and who are, or are likely to be, directly affected by a health and safety matter.

This duty to consult is based on the recognition that worker input and participation improves decision-making about health and safety matters and assists in reducing work-related injuries and disease.

The broad definition of a ‘worker’ under the WHS Act means a PCBU must consult with employees and anyone else who carries out work for the business or undertaking. This may include contractors and sub-contractors and their employees, on-hire workers, outworkers, apprentices, trainees, work experience students, volunteers and other people who are working for the PCBU.

Workers are entitled to take part in consultations and to be represented in consultations by a health and safety representative who has been elected to represent their work group.

By drawing on the experience, knowledge and ideas of workers, excavation work hazards are more likely to be identified, and effective control measures implemented.

In many cases, decisions about construction work and construction projects are made prior to engaging workers, therefore it may not be possible to consult with workers in these early stages. However, it is important to consult with them as the planning and construction work progresses.

Consultation may include discussions about:

- excavation methods
- types of risk control measures
- interaction with other trades
- access to documentation, such as SWMS, original manufacturer manuals for equipment, safety policies and procedures and the WHS Act and Regulations
- SWMS
- provision of appropriate amenities
- procedures to deal with emergencies
- proposing changes that may affect the health and safety of workers
- procedures for consulting with workers
- resolving work health and safety issues
- monitoring the health of workers
- monitoring the conditions at any workplace under the management or control of the PCBU
- providing information and training for workers
- when carrying out any other activity prescribed by the regulations for the purposes of this section.

Consulting, cooperating and coordinating activities with other duty holders

WHS Act section 46

Duty to consult with other duty holders

The WHS Act requires a PCBU to consult, cooperate and coordinate activities with all other persons who have a work health or safety duty in relation to the same matter, so far as is reasonably practicable.

There is often more than one business or undertaking involved in excavation work, who may each have responsibility for the same health and safety matters, either because they are involved in the same activities or share the same workplace.

In these situations, each duty holder should exchange information to find out who is doing what and work together in a cooperative and coordinated way so risks are eliminated or minimised, so far as is reasonably practicable.

For example, civil engineers and contractors should consult with other duty holders about the risks associated with the excavation work including traffic and plant movements near the excavation area.

Duty holders should co-operate with each other to ensure that each of their activities do not create risks for other workers during the excavation work.

This is particularly important in large and complex workplaces where a number of workers and contractors may be working, some under a SWMS.

Further guidance on consultation is available in the *Work health and safety consultation, cooperation and coordination*: Code of practice.

1.4. Information, training, instruction and supervision

WHS Act section 19

Primary duty of care

WHS Regulation 39

Provision of information, training and instruction

WHS Regulation 317

Duty to ensure worker has been trained

The WHS Act requires that a PCBU ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out.

The PCBU must ensure that information, training or instruction provided to a worker are suitable and adequate having regard to the:

- nature of the work carried out by the worker
- nature of the risks associated with the work at the time of the information, training and instruction
- control measures implemented.

The PCBU must also ensure, so far as is reasonably practicable, that information, training and instruction are provided in a way the person can easily understand.

Workers must be trained by a competent person and have the appropriate skills to safely perform their tasks. This includes site-specific and task-specific training, particularly for those operating plant or carrying out excavation work.

Information, training, instruction provided to workers who carry out excavation work should include the proper use, wearing, storage and maintenance of PPE.

In addition to general WHS supervision duties, the PCBU must ensure adequate supervision to prevent WHS risks is provided in specific situations, such as when a worker:

- uses, generates or handles hazardous chemicals
- operates, tests, maintains, repairs or decommissions a storage or handling system for a hazardous chemical
- is likely to be exposed to a hazardous chemical.

Training and education can be delivered by experienced works, through a SWMS or by using this Code and other codes of practice as learning tools.

Supervisors, such as leading hands or foremen, should be experienced and trained in excavation work to ensure the work is carried out in accordance with the SWMS.

2. The risk management process

WHS Regulation 34

Duty to identify hazards

WHS Regulation 35

Managing risks to health and safety

WHS Regulation 36

Hierarchy of control measures

WHS Regulation 37

Maintenance of control measures

WHS Regulation 38

Review of control measures

WHS Regulation 297

Management of risks to health and safety

WHS Regulation 299

Safe work method statement required for high risk construction work

WHS Regulation 305

Management of risks to health and safety associated with excavation work

A risk assessment is not mandatory for excavation work under the WHS Regulations.

However, a duty holder must identify reasonably foreseeable hazards that could pose health and safety risks. In managing those risks a risk, a risk assessment, including the use of a SWMS, will be the best way to determine the measures that should be implemented to control risks.

Excavation work which falls under 'high risk construction work' will require a SWMS. The SWMS will help to:

- identify which workers are at risk of exposure
- determine what sources and processes are causing that risk
- identify if and what kind of control measures should be implemented
- check the effectiveness of existing control measures.

Risk management is a systematic process to eliminate or minimise the potential for harm to people.

2.1. Identifying the hazards

The first step in the risk management process is to identify all hazards associated with excavation work. This involves finding things and situations that could potentially cause harm to people. Hazards generally arise from the following aspects of work and their interaction:

- physical work environment
- equipment, materials and substances used
- work tasks and how they are performed
- work design and management.

Hazards may be identified by looking at the workplace and how work is carried out. It is also useful to talk to workers, manufacturers, suppliers and health and safety specialists and review relevant information, records and incident reports.

Examples of excavation specific hazards include:

- underground essential services including gas, water, sewerage, telecommunications, electricity, chemicals and fuel or refrigerant in pipes or lines
- the fall or dislodgement of earth or rock
- falls from one level to another
- falling objects
- inappropriate placement of excavated materials, plant or other loads
- the instability of adjoining structures caused by the excavation
- previous disturbance of the ground including previous excavation
- the instability of the excavation due to persons or plant working adjacent to the excavation
- the presence of or possible in-rush of water or other liquid (for example, the proximity to the water table or the influence of rainfall)
- hazardous manual tasks
- hazardous chemicals, which may be present in the soil where excavation work is to be carried out (for example, perfluoroalkyl and polyfluoroalkyl substances (PFAS) or oil contamination)
- hazardous substances such as asbestos or silica
- naturally occurring hazards such as naturally occurring asbestos containing material or naturally occurring radioactive material
- hazardous atmosphere in an excavation, which could result from practices like using methyl ethyl ketone (MEK) solvent for PVC pipes in poorly ventilated trenches
- vibration and hazardous noise
- overhead essential services, such as powerlines
- ground-mounted essential services such as transformers, gas and water meters.

2.2. Assessing the risks

A risk assessment involves considering what could happen if someone is exposed to a hazard and the likelihood of it happening. A risk assessment can help you determine:

- how severe a risk is
- whether any existing control measures are effective
- what action you should take to control the risk
- how urgently the action needs to be taken
- hazards that have the potential to cause different types and severities of harm, ranging from minor discomfort to a serious injury or death.

Many hazards and their associated risks are well known and have well established and accepted control measures. In these situations, the second step to formally assess the risk is unnecessary. If after identifying a hazard you already know the risk and how to control it effectively, you may simply implement the controls.

In some circumstances, a risk assessment will assist to:

- identify which workers are at risk
- determine what sources and processes are causing that risk
- identify if and what kind of control measures should be implemented
- check the effectiveness of existing control measures.

The nature and severity of risks will depend on various factors, including the:

- local site conditions including access, ground slope, adjacent buildings and structures, surface and underground water courses and trees
- depth of the excavation
- soil properties including variable soil types, stability, shear strength, cohesion, presence of groundwater and effect of exposure to the elements
- fractures or faults in rocks including joints, bedding planes, dip and strike directions and angles, and clay seams
- specialised plant or work methods required, for example ground support
- the method(s) of transport, haul routes and disposal
- what exposures might occur, for example noise, ultraviolet radiation or hazardous chemicals
- the number of people involved
- the possibility of unauthorised access to the work area
- local weather conditions
- the length of time the excavation will be open.

Review available information

Information and advice about hazards and risks relevant to particular industries and types of work is available from regulators, industry associations, unions, technical specialists and safety consultants.

Manufacturers and suppliers can also provide information about hazards and safety precautions for specific substances (safety data sheets), plant or processes (instruction manuals).

Analyse health monitoring records, workplace incidents, near misses, worker complaints and inspection and investigation results to identify hazards. If a task has caused harm, it indicates an existing hazard that could harm others. These incidents need to be investigated to find the cause.

2.3. Controlling the risks

The hierarchy of control measures

The WHS Regulations require duty holders to work through the hierarchy of control measures when managing certain risks; however, the hierarchy can be applied to any risk. The hierarchy ranks control measures from the highest level of protection and reliability to the lowest.

Figure 1 *Hierarchy of control measures*

Eliminating the risk

Always aim to **eliminate the risk**. For example, undertake work, such as pipe joining, above ground to eliminate the need to have people in trenches.

If eliminating the hazards and associated risks is not reasonably practicable, PCBUs must minimise the risk by one or more of the following:

- **substitution**—substitute or replace a hazard or hazardous work practice with something less risky, such as using an excavator with a rock breaker instead of manual methods
- **isolation**—isolate or separate the hazard or hazardous work practice from people, for example, by using concrete barriers to keep pedestrians away from powered mobile plant to reduce the risk of a collision
- **engineering controls**—use physical control measures to reduce risk, such as benching, battering or shoring the excavation sides to reduce the risk of ground collapse.

If risk remains, it must be minimised by implementing **administrative controls**, so far as is reasonably practicable, for example, by installing warning signs near the excavation, SWMS and work procedures.

Any remaining risk must be minimised with suitable **PPE**. For example, by providing workers with hard hats, hearing protectors and high visibility vests.

Administrative control measures and PPE do not control the hazard at the source. They rely on human behaviour and supervision and used on their own tend to be the least effective in minimising risks.

Combining control measures

A combination of control measures may be used to minimise risks, so far as is reasonably practicable, if a single control is not sufficient for the purpose. In most cases, a combination of the control measures will provide the best solution to minimise the risk to the lowest level reasonably practicable.

PCBUs should also ensure the control measures selected do not create new hazards. For example, electrical risks from contact with overhead power lines from plant like elevating work platforms. If any new hazards are created, they must also be controlled.

2.4. Maintaining and reviewing control measures

WHS Regulation 38

Review of control measures

Control measures must be maintained so they remain fit for purpose, suitable for the nature and duration of work and installed, set up and used correctly.

The control measures put in place to protect health and safety should be regularly reviewed to make sure they are effective. If the control measure is not working effectively, it must be revised to ensure it is effective in controlling the risk.

PCBUs must review and as necessary revise control measures to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety. For example:

- when the control measure does not control the risk, so far as is reasonably practicable
- before a change at the workplace that is likely to give rise to a new or different health and safety risk that the measure may not effectively control
- a new or relevant hazard or risk is identified
- the results of consultation indicate a review is necessary
- a health and safety representative requests a review.

Common review methods include workplace inspection, consultation, testing and analysing records and data. Where excavation work is high risk construction work, a SWMS must also be reviewed and revised where necessary.

PCBUs can use the same methods as in the initial hazard identification step to check control measures. PCBUs must also consult with workers and their health and safety representatives.

If problems are found, go back through the risk management steps, review the information and make further decisions about risk control.

3. Planning the excavation work

Excavation work should be carefully planned before work starts so it can be carried out safely. Planning involves identifying the hazards, assessing the risks and determining control measures in consultation with all relevant persons involved in the work. This includes the principal contractor for a construction project, excavation contractor, designers and mobile plant operators. Structural or geotechnical engineers may also need to be consulted at this stage.

Consultation should include discussions on the:

- nature and condition of the ground and working environment
- weather conditions
- nature of the work and other activities that may affect health and safety
- static and dynamic loads near the excavation
- interaction with other trades
- site access
- SWMS
- management of surrounding vehicle traffic and ground vibration
- types of equipment used for excavation work
- public safety
- existing services and their location
- the length of time the excavation is to remain open
- importance of not having people in excavations when they are not required to be there
- importance of minimising the time people spend in excavations
- scope for mechanising work to be carried out in excavations as far as is reasonably practicable
- amount and types of training, induction, information and supervision needed
- providing facilities
- procedures to deal with emergencies.

3.1. Principal contractor for a construction project

WHS Regulation 292

Meaning of construction project

WHS Regulation 293

Meaning of principal contractor

A construction project is a project where 5 or more people are or are likely to be present at one time on a construction site. Additional duties apply to principal contractors of construction projects. There can only be one principal contractor for a construction project. This will be either the person commissioning the construction work, or a person appointed as the principal contractor by the person commissioning the construction work.

The principal contractor has a range of duties for a construction project including:

- preparing and reviewing a WHS management plan
- preparing or taking all reasonable steps to obtain a SWMS that has already been prepared by another person before high risk construction work starts
- putting in place arrangements to manage the work environment including facilities, first aid, an emergency plan and traffic management

- securing the construction workplace.

The construction work may appoint the excavation contractor as the principal contractor for the site preparation phase of the project and then replace them with a building expert after this phase is completed. If the excavation contractor is appointed as the principal contractor, then the excavation contractor must comply with principal contractor duties during this phase.

In the case of the owner of a residential premises commissioning work, the PCBU commissioned assumes the duties of the principal contractor.

3.2. Designers

WHS Act section 22

Duties of persons conducting businesses or undertakings that design plant, substances or structures

WHS Regulation 295

Designer must give safety report to person who commissions design

In the case of excavation, designers may include geotechnical engineers and those designing ground support systems.

Designers must ensure, so far as is reasonably practicable, the structures intended for use as or at a workplace are designed to pose no health and safety risks to those who construct them.

Designers must give the person who commissioned the design a written safety report specifying any design-related hazards that, so far as the designer is reasonably aware, create risks to those carrying out construction work.

This written report must specify the hazards relating to the design of the structure that, so far as the designer is reasonably aware:

- create a risk to the health and safety of persons who are to carry out construction work on the structure or part
- are associated only with the particular design of the structure.

Designers of structures should consider possible excavation work methods and health and safety control measures when producing final design documents and the safety report for the structure.

A person commissioning the construction work must consult, so far as is reasonably practicable, with the designer of the whole or part of the structure about eliminating and controlling risks. If the person commissioning the construction work did not commission the design, they must take all reasonable steps to obtain the designer's safety report.

The person commissioning the construction work must give the engaged principal contractor information they have about hazards and risks associated with the work.

For further guidance on the duties of designers refer to the *Safe design of structures*: Code of practice.

3.3. Geotechnical engineers

Geotechnical engineers have skills which can reduce the risks associated with excavation. These include:

- geotechnical investigation and reporting
- deep excavation design
- slope and excavation stability assessment
- shoring and slope stabilisation
- groundwater management.

While the involvement of a geotechnical engineers is not mandatory for an excavation, PCBUs may want to consider such a person if there is any uncertainty around the ground conditions where the excavation is to take place.

3.4. Safe work method statements

WHS Regulation 299

Safe work method statement required for high risk construction work

Some work associated with excavation work is high risk construction work. This work requires a SWMS. High risk construction work includes construction work when carried out where:

- where there is a risk of a person falling more than 2 metres
- near a trench with an excavated depth greater than 1.5 metres
- where there is a risk of mobile powered plant colliding with pedestrians or other powered mobile plant
- work is on or near:
  - pressurised gas distribution mains or piping
  - chemical, fuel or refrigerant lines
  - energised electrical installations.

The primary purpose of a SWMS is to help PCBUs, supervisors and workers implement and monitor the control measures established at the workplace to ensure high risk construction work is carried out safely.

The SWMS must:

- identify the type of high risk construction work being done
- specify the health and safety hazards relating to the high risk construction work and risks arising from those hazards
- describe how the risks relating to the high risk construction work will be controlled
- describe how the control measures will be implemented, monitored and reviewed
- be developed in consultation with workers and their representatives who are carrying out the high risk construction work.

A SWMS is not required for other excavation work. However, a PCBU may want to consider using a SWMS to manage risks to health and safety.

More information on SWMS can be found in the *Safe work method statement for high risk construction work*: Information sheet. This information sheet contains an example of a completed SWMS. A SWMS template is available on the WorkSafe website.

There may be situations where there are different types of high risk construction work occurring at the same time at the same workplace.

In these cases, one SWMS may be prepared to cover any high risk construction work activities being carried out at the workplace. Alternatively, a separate SWMS can be prepared for each type of high risk construction work. If separate SWMS are prepared,

consider how the different work activities may impact on each other and whether this may lead to inconsistencies between control measures.

Retain a copy of the SWMS for the period that the high risk construction work is being carried out. The SWMS must be retained for 2 years if an incident occurs during the work it covers. SWMS must be made available to those involved in the work and inspectors.

Who is responsible for preparing a SWMS?

A PCBU must prepare a SWMS, or ensure a SWMS has been prepared, before high risk construction work starts.

The person responsible for carrying out the high risk construction work is best placed to prepare the SWMS in consultation with workers directly involved in the task.

If more than one PCBU has the duty to ensure a SWMS is or has been prepared, they must consult and cooperate with each other to coordinate who will be responsible for preparing it. For example, one may PCBU may be commissioning overhead power lines while another is carrying out excavation work.

Complying with a SWMS

WHS Regulation 300

Compliance with safe work method statement

If high risk construction work is not carried out in accordance with the SWMS for the work, the PCBU must ensure the work is stopped immediately or as soon as it is safe to do so. The work is only allowed to resume in accordance with the SWMS.

Reviewing a SWMS

WHS Regulation 302

Review of safe work method statement

A SWMS must be periodically reviewed and amended if it found the control measures are not adequately managing the risks or after an incident has occurred.

3.5. Inspection and maintenance

Plant and machinery

A competent person must regularly inspect, maintain and test powered mobile plant (whether leased, hired or owned) in line with the manufacturer's recommendations. If none are available, a competent person's guidance must be followed. Both mechanical and electrical testing should be done.

The following checks should also be carried out:

- daily pre-start checks by the plant operator on the general condition and maintenance of the plant
- regular inspections of the plant by a competent person in accordance with the manufacturer's or supplier's specifications or relevant Australian Standards.

Plant defects should be reported immediately to the PCBU. Where a defect is likely to pose an immediate risk to health and safety the plant should be removed from service until the defect is rectified.

Owners of plant should keep logbooks and inspection check sheets containing a full service and repair history. These records should include reported defects, be kept current and retained for the life of the plant. If the plant is sold, the records should form part of the documentation forwarded to the purchaser of the plant upon its sale.

Mobile phone apps are available for many of these inspection processes.

Inspecting ground conditions

The condition of soil surrounding excavations can change quickly due to the soil drying out, changes in the water table or water saturation of the soil. The soil condition and the state of shoring, battering and trench walls should be frequently inspected by a competent person for signs of earth fretting, slipping, slumping or ground swelling. Where necessary, repair the excavation or strengthen the shoring system from above before allowing work below ground to continue.

3.6. Previously excavated ground

Previously dug excavations include underground utilities. These have a weakening effect on a trench wall if they are near the excavation face. The hazards of working close to previously disturbed ground are considerably increased when the ground is either very wet or very dry. Under these conditions, it may be necessary to use a steel shield or sheet piling to ensure safe working conditions.

3.7. Excavated material and loads near excavations

Mechanical plant, vehicles and storage of materials including excavated material or other heavy loads should not be in the ‘zone of influence’ of an excavation unless the ground support system installed has been designed by a competent person, for example a geotechnical engineer, to carry such loads.

The zone of influence will depend on the ground conditions. It is the zone in which there may be an influence on the excavation including possible ground collapse**.**

The top diagram within Figure 2 shows an excavation with shoring designed to carry vehicle and material loads—this may be required where there is limited space around the excavation for vehicle movement and material storage. The bottom diagram shows an excavation with shoring designed only to carry the load of the excavated faces and the related zone of influence.

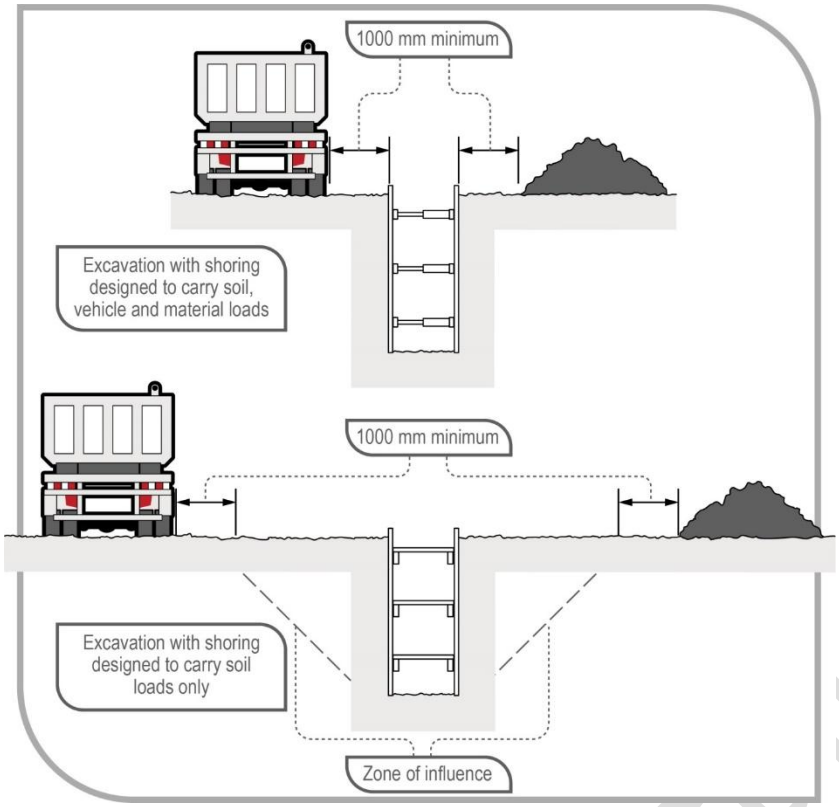


Figure 2 *Excavated material and loads near excavations*

Any material will add a load to the area where it is placed. It is important materials are not placed or stacked near the edge of an excavation as this would put persons working in the excavation at risk, including by potentially causing a collapse of the side of the excavation.

To minimise the risk of ground collapse, excavated or loose material should be stored away from the excavation. Excavated material should be placed outside the zone of influence. Alternatively, a ground support system should be designed and installed to carry the extra loads including groundwater pressures, saturated soil conditions and saturated materials.

If excavating in sloping ground, decide which side of the excavation to place the excavated material. Things to consider include:

- ground conditions
- access to the excavation
- existing underground services
- the need for earthmoving machinery or vehicles to work or move beside the excavation
- service installation and backfilling requirements
- manual work being carried out in the excavation.

Placing material on the lower side of the excavation will reduce the effective height of the excavation and reduce the risk of material falling or being washed into the excavation.

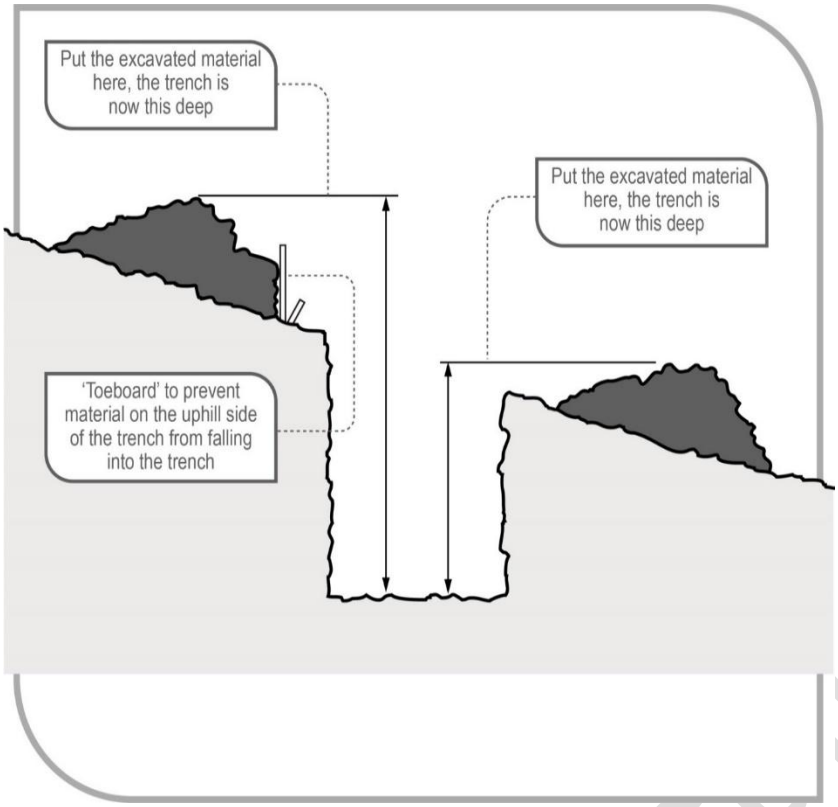


Figure 3 *Excavated material impact on effective excavation depth*

Care should be taken to ensure material placed on the high side of the excavation does not increase the risk of ground collapse, or flooding by ponding or holding back run-off water. Excavated material should be placed so it channels rainwater and other run-off water away from the excavation.

When a trench is being excavated beside an old service line or any other previous excavation, the excavated material should be placed on the side opposite the old service line or previous excavation to prevent excessive loading on previously weakened ground.

If excavated material is placed close to a trench due to obstructions, for example fences, buildings or trees, the weight of the excavated material may overload the sides of a trench. In this case, the ground support system should be strengthened at these locations and barriers, for example toe boards may need to be provided to prevent the material falling into the excavation.

When dumped in heaps, different soils will assume a characteristic shape and settle naturally at different slopes. The angle which a sloping face of loose earth makes with the horizontal is sometimes referred to as the angle of repose. However, it is poor practice to relate the safe slope of an excavation to the angle of repose, even though the safe slope may be similar in some types of soil to the angle of repose.

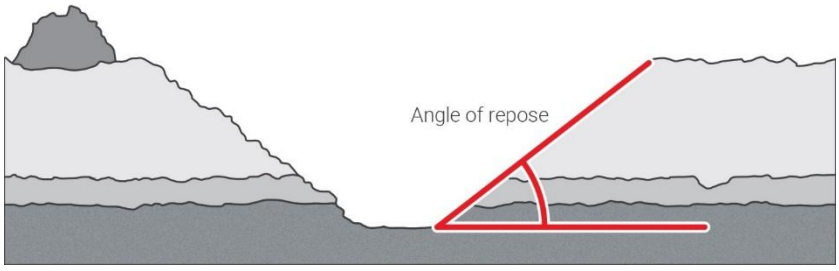


Figure 4 *Angle of repose*

3.8. Dewatering systems

Workers should not work in excavations where water has accumulated or where water is accumulating from any source, unless adequate precautions have been taken.

Water may accumulate from a number of sources, such as:

- high ground water table seeping into the excavation
- storm water drains
- surface run off after heavy rain
- the excavation being adjacent to a swamp, dam, lake or river.

Excavation in water bearing ground is always troublesome. Steel sheet piling or closed sheeting are not always a practicable solution, and often the most effective way is to drain the ground before excavation begins to enable work to be carried out in the dry.

The precautions necessary to protect workers adequately will vary with each situation, and include water removal and special support or shield systems to protect from cave-ins.

If water is controlled, removed or prevented from accumulating using dewatering systems or other equipment, a competent person should monitor the operation to ensure its effectiveness.

Water control may involve the relatively simple removal of small amounts of water at the bottom of an excavation by electrically driven sludge pumps.

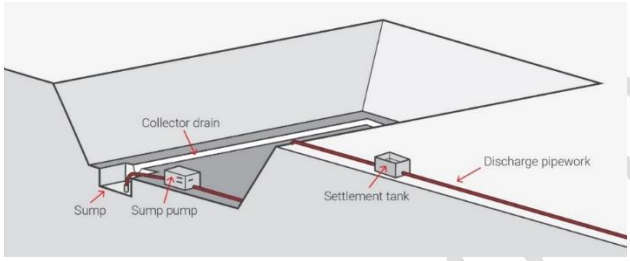


Figure 5 *Dewatering systems*

Water control may also involve the control of large quantities of water in situations where an excavation is below the level of the ground water table.

In this situation, dewatering systems consisting of pumps and suction points, or ‘wellpoints’ connected to pipelines are located around an excavation or alongside a trench to pump the water to waste and lower the water table below the bottom of the trench or excavation.

A wellpoint is a pipe at the bottom of which is a ball valve and nozzle arrangement which opens when water is pumped down the pipe and closes when the pipe is under suction. The lower part of the pipe is perforated with holes, and these are in turn covered with a fine mesh screen.

The area to be dewatered is surrounded with wellpoints. The spacing depends on the nature of the ground and the volume of ground water flowing. In narrow trenches, one line of wellpoints adjacent to one side of the excavation will usually suffice.

The wellpoints are connected to a header or ring main which is connected to the pumping plant. Duplicate pumps should be on standby, if the dewatering system fails, as rapid ingress of water can lead to cave-ins.

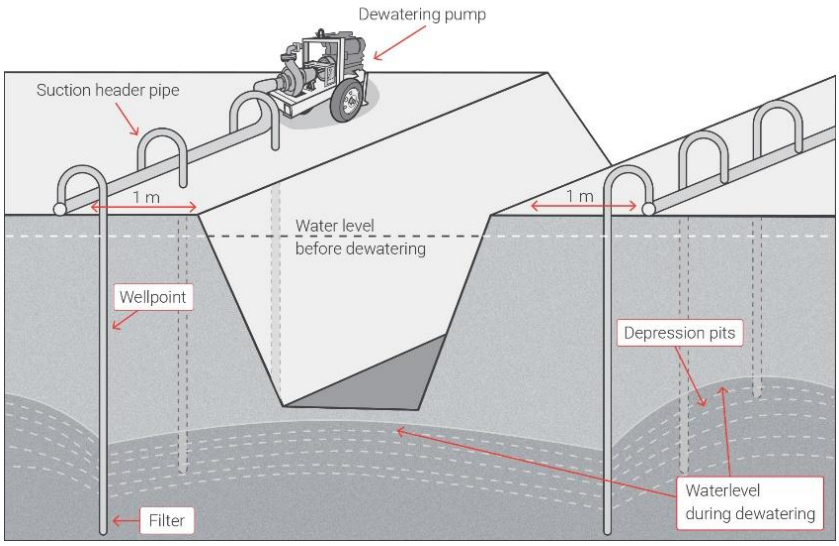


***Figure** 6 Dewatering systems*

Environmental issues may arise where it is necessary to lower groundwater levels, particularly for lengthy periods. This is a matter which should be addressed by the PCBU before work commences.

In addition, the disposal of large quantities of water from an excavation may present problems which require careful planning.

When work is finished, wellpoints can be recovered by pumping water down each point to loosen it in the ground and then withdrawing it.

3.9. Underground essential services

WHS Regulation 304

Excavation work—underground essential services information

One of the most important elements of pre-excavation planning is the location and disconnection of all essential services.

Essential services include the supply of gas, water, sewerage, telecommunications, electricity, chemicals, fuel and refrigerant in pipes or lines. The principal contractor must ensure, so far as is reasonably practicable, that risks associated with essential services at the workplace are.

Any underground service plans that are obtained, including information on underground essential services, must be provided to the principal contractor and/or the excavation contractor.

Other relevant parties, including any subcontractors and plant operators carrying out the excavation work, should also be provided with information about essential services and other plans so the information is considered when planning all work in the area.

Underground essential services information obtained must be:

- made available to any worker, principal contractor and subcontractors
- readily available for inspection, as required under the WHS Act
- retained until the excavation work is completed or, if there is a notifiable incident relating to the excavation work, two years after the incident occurs.

All electric, gas, water, sewer, steam and other service lines should be controlled, at or outside the excavation site before work is started and the network provider (for example, Western Power) involved should be notified in advance and its approval or services, if necessary, obtained.

In the case of electricity, complete isolation of the service eliminates the risk and is a preferred course of action.

A SWMS must be prepared for managing the risks associated with excavation work involving underground services. This must occur prior to the work commencing. Before directing or allowing work to start, a person with management or control of the workplace must take all reasonable steps to get current information about underground essential services in the areas at the workplace where the excavation work is to be carried out. They must also get information about underground essential services in areas adjacent to the site of excavation and have regard for all the information.

If excavating in a public place, the PCBU must take all reasonable steps to identify all electrical cables present. Information may be obtained by contacting:

- Before You Dig Australia via their website (www.byda.com.au) to obtain free information on utility assets near the site
- workplaces, such as mine sites, who may have their own information on the location of underground services.

Available information about existing underground essential services may not be accurate. Therefore, it is important that excavation methods include an initial examination of the area to be excavated, for example sampling the area by exposing a short section of underground services usually using water pressure and a vacuum system to excavate or ‘pothole’ the area.

If the exact location of an underground cable cannot be determined, potholing should be used to carefully identify the cable location and avoid accidental contact with the cable. Potholing involves digging with insulated hand tools or using a vacuum pump to get to a pre-determined depth to verify if assets exist in the immediate location.

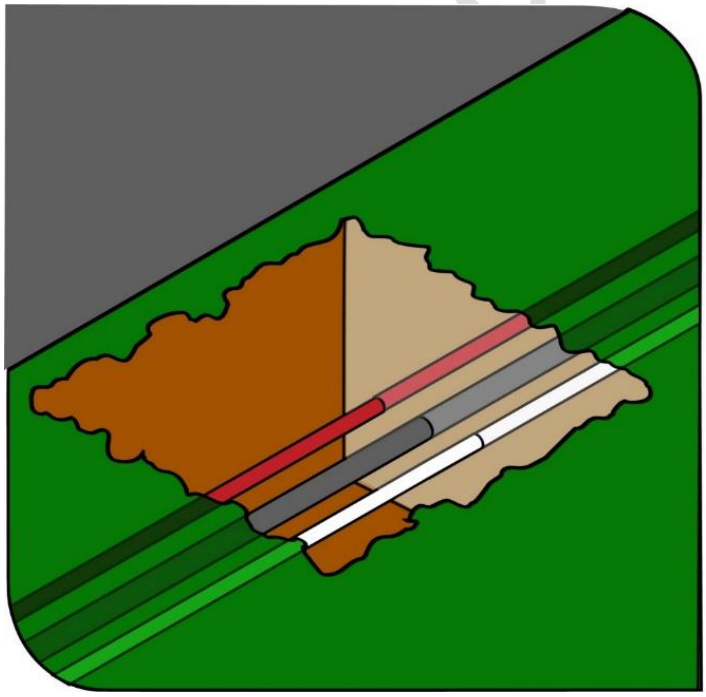


Figure 7 *Underground essential services exposed by potholing*

Underground essential services can also be located using underground locators, for example electromagnetic cable locators and ground penetrating radar. The PCBU must ensure workers operating such equipment have undergone the relevant training and are competent in their use.

3.10. Securing the work area

WHS Regulation 306

Additional controls - trenches

A person conducting a business or undertaking who proposes to excavate a trench at least 1.5 metres deep must ensure, so far as is reasonably practicable, the work area is secured from unauthorised access, including inadvertent entry.

In securing the trench or excavation, PCBUs must consider the risks to health and safety arising from unauthorised access to the work area, as well as the likelihood of unauthorised access occurring.

This requirement aims to protect other workers on site who may be at risk. It does so by restricting access to the excavation area. The requirement applies in addition to the duty the person with management or control of the construction site must ensure the site is secured from unauthorised access from members of the public.

Barriers and warning signs

A hoarding is a substantial and fully sheeted fence or screen. A barricade is a temporary fence consisting of rigid vertical and horizontal members.

The decision as to whether a hoarding, barricade or simple barrier of reflective tape or mesh is used will depend on the nature of the excavation work being carried out. Factors to consider include:

- unauthorised entry to the site including by members of the public
- falls into an excavation
- items dropped into an excavation
- movement of mobile plant near the excavation
- the placement of loads adjacent to an excavation.

The location of the barrier from the edge of the excavation will also depend on the nature of the excavation work being carried out. In deep excavations, the barrier may need to be placed well back from the edge of the excavation to protect the edge from collapse and allow work to be carried out around the edge of the excavation.

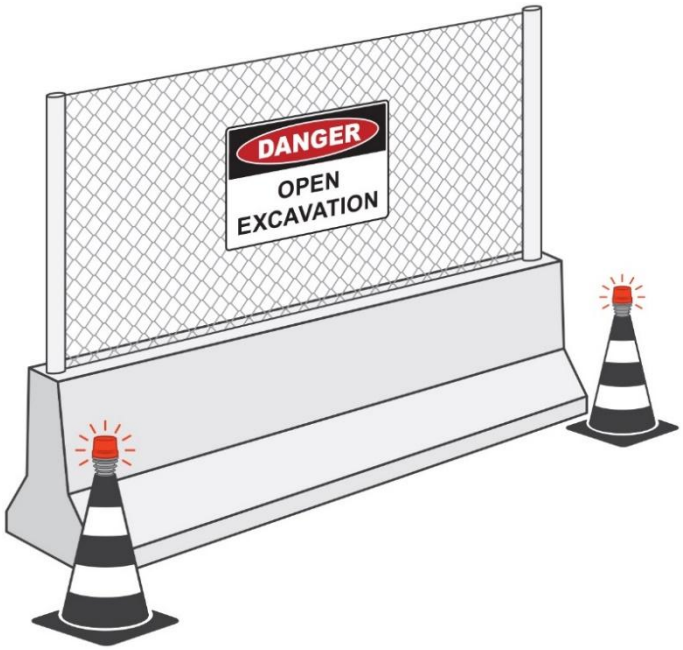


Figure 8 *Barrier fencing and signage*

Many excavations are of considerable depth. For example, sewer trenches may exceed a depth of 5 metres and simple barriers will not provide adequate protection to the public or workers. In these situations, hoardings may be required to provide protection for the public, and careful attention given to the provision of barriers and edge protection needed at the edge of the excavation.

Suitable signs warning of the risk can be erected where excavation work is carried out. Signs should be placed at appropriate locations around the perimeter of the excavation where they can be easily seen.

Figure 9 *Appropriate signage*

Other forms of visual warning should also be considered and may be appropriate dependent on the nature of the excavation work. Traffic cones and reflective mesh may be suitable to warn of low-level hazards on an excavation site and bollards and earth mounds could be used in association with these visual items.

3.11. Plant and equipment

WHS Regulation 206

Proper use of plant and controls

A person with management or control of plant at a workplace must:

- take all reasonable steps to ensure the plant is only used for the purpose for which it is designed, unless the person has assessed the proposed use does not increase the risk to health and safety
- in determining whether or not the proposed use of plant increases the risk to health and safety, ensure the risk associated with the proposed use is assessed by a competent person
- take all reasonable steps to ensure all safety features, warning devices, guarding, operational controls, emergency stops are used in accordance with instructions and information provided by the person.

Excavation work cannot be carried out safely unless the plant being used is appropriate for the work and maintained in good condition. A range of plant and equipment may be used for excavation work including:

- powered mobile plant
- air compressors
- electric generators
- jackhammers
- hydraulic jacks
- oxyacetylene, for example in gas cutting or welding
- scaffolding
- ladders
- many types of handheld plant, for example shovels, picks, hammers and pinch or lever bars.

A person with management or control of plant at a workplace should ensure:

- plant is used and operated by a competent person
- the safe working load is displayed and load measurement devices are operating correctly
- the ground is prepared to place plant, especially if the terrain is uneven
- plant is maintained in accordance with the manufacturer's or supplier's instructions or relevant Australian Standards
- plant and equipment are not used in a manner which can pollute the respirable atmosphere in an excavation.

Further general guidance on plant can be found in the *Managing risks of plant in the workplace*: Code of practice.

3.12. Powered mobile plant

A wide range of powered mobile plant, including earthmoving machinery, may be used for excavation work. To select plant for the task, you should consider:

- site access and restrictions
- site hazards, for example overhead powerlines and underground services
- the ground conditions

- the type and depth of excavation
- the volume of material to be excavated and transported
- where the excavated material is to be located and stored.

A high risk work licence is required to operate some types of powered mobile plant, such as forklifts, cranes and hoists. A SWMS must be prepared for excavation work involving the use of powered mobile plant.

Earthmoving machinery operators should hold suitable qualifications certifying they are competent to operate the specific type of plant being used and attachments fitted to the plant.

Traffic management arrangements must be implemented at the workplace when powered mobile plant is to be used for excavation work, to prevent collision with pedestrians or other mobile plant.

Earthmoving machinery

Bulldozers and scrapers are often used to prepare a work area for further specific excavation.

Bulldozers typically excavate and move large amounts of material short distances. Bulldozers can be equipped with hydraulically operated rippers at the back of the machine which are capable of loosening rock. This material may then be bulldozed away. This method frequently proves more economical than drilling and blasting softer rock.

Self-propelled rubber tyred scrapers enable very large quantities of material to be excavated and hauled over long distances economically and at relatively high speed. Because of the large potential output and speeds of modern scrapers, careful attention should be given to job layout, haul roads, vehicle pathways and overall traffic management to achieve a healthy and safe workplace.

Temporary haul roads should be well constructed and maintained to enable plant operators to complete the work safely. A traffic management plan should be developed when powered mobile plant is being used.

Operating near excavations

Powered mobile plant should not operate or travel near the edge of an excavation unless the ground support system installed has been designed by a competent person to carry such loads. Physical barriers, for example wheel stoppers, can be one way of restricting plant movement near an excavation.

Mobile plant should approach square to the excavation not parallel to it.

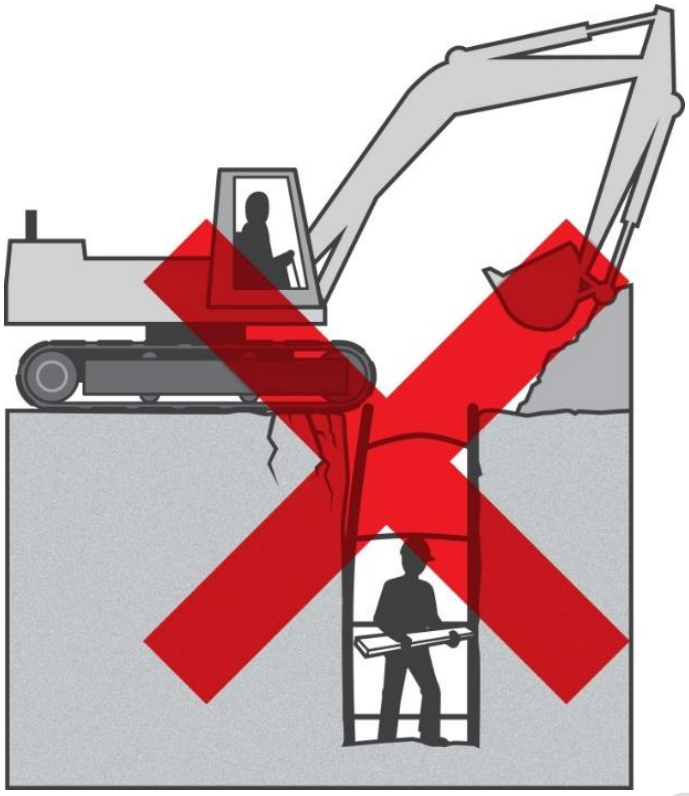


Figure 10 *Large earthmoving machinery should not be operated close to an excavation*

Using mobile plant for lifting

Earthmoving machinery, such as excavators, can be fitted with lifting equipment and used to suspend a load, somewhat like a crane.

The WHS Regulations require a high risk work licence (HRWL) in order to operate earthmoving machinery as a crane (i.e. to suspend a load) where the machinery has a safe working load (SWL) exceeding 3 tonnes.

In this context, the SWL is taken to be the maximum mass the machine is rated to lift, in its strongest configuration. For more information, see *Using earthmoving machinery as crane to suspend a load*: Information sheet.

In addition to holding a HRWL, operators of earthmoving machinery must be competent for the tasks they are required to conduct and have suitable training and experience.

3.13. Emergency plan

WHS Regulation 43

Duty to prepare, maintain and implement emergency plan

A PCBU, such as an excavation contractor, must ensure an emergency plan is in place for the workplace and implement it in the event of an emergency.

An emergency plan is a written set of instructions outlining how workers and others should respond to emergencies such as ground slips, engulfment, flooding, gas leaks and rescuing workers from an excavation.

An emergency plan must provide for the following:

- emergency procedures for effective response

- evacuation procedures
- prompt notification of emergency service organisations
- medical treatment and assistance
- effective communication between the emergency coordinator and all people on site
- testing of the emergency procedures, including frequency
- information, training and instruction for relevant workers on implementing the procedures.

When preparing the emergency plan, consider:

- the type of work being carried
- workplace hazards
- the nature of the hazards at the workplace
- the size and location of the workplace, for example, remoteness and proximity to health services
- the number and types of people on site, including workers, contractors and other persons such as visitors.

To ensure a coordinated response, incorporate the excavation emergency plan into the principal contractor's broader construction project emergency plan.

Practical features of the plan may include:

- a designated person to take control during an emergency
- a site map or designated access route for emergency vehicles, with no-parking areas to maintain access
- dedicated emergency equipment (such as shovels, basket stretcher, working at heights equipment such as harnesses and ropes, torches and helmet lights and a suitable trench shield which can be put in place to prevent further engulfment) stored near the excavation, checked daily and used only for emergencies.

Workers must never enter a collapsed excavation as it increases the risk to their safety and may worsen the situation or delay emergency response.

Emergency plans should be included in site inductions and practiced regularly to ensure they remain current to workplace emergency needs.

Reviewing emergency plans

For emergency plans to remain current and effective they must be reviewed and revised on a regular basis, for example:

- when there are changes to the workplace such as a new scope of work for excavations
- when there are changes in the number or composition of staff including an increase in the use of temporary contractors
- when new activities have been introduced
- after the plan has been tested
- after any incident or near miss.

4. Preventing ground collapse

Ground collapse is one of the primary risks to be controlled in excavation work. Ground collapse can occur quickly and without warning, giving a worker virtually no time to escape, especially if the collapse is extensive. Trench collapses of this nature can cause fatal injuries. A buried worker is likely to die from suffocation before help arrives, either because their head is buried, or their chest is so restricted by the weight of ground that the worker can no longer breathe.

Figure 13 shows a typical example of ground failure where material collapses onto a worker pinning them against the wall of a trench.

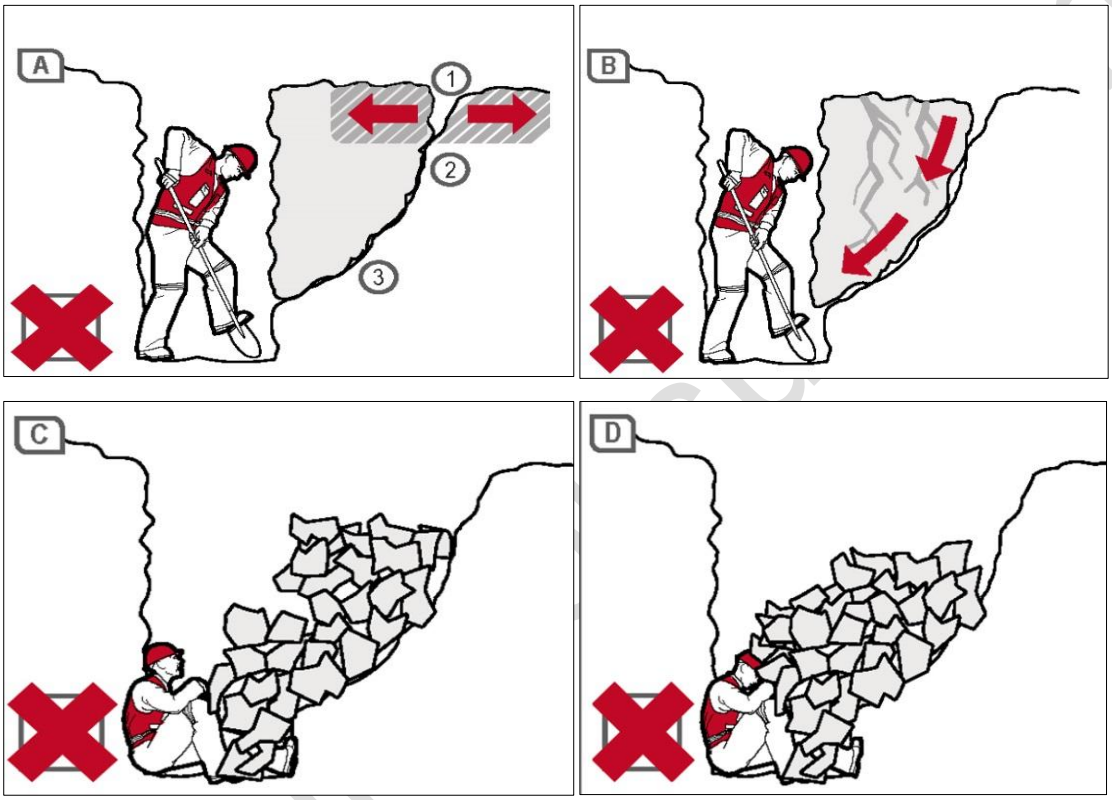


Figure 11 *Trench collapse and associated ground forces*

Figure A - *This is a very dangerous situation, requiring ground support. No worker should be in a trench deeper than 1.5 metres unless support has been installed.*

- *Area of tension, as all starts to collapse*
- *Slipping plane*
- *Seepage along the slipping plane further reduces the stability of the wall. Water seeping into the excavation, tension cracks on the surface and building side walls are all signs of imminent collapse.*

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

Figure B - *Shear plane failure along the seepage (slippage) plane.*

Figure C - *Worker trapped and crushed against the trench wall by the quick collapse.*

Figure 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 a one metre length of trench 2 metres deep is about three tonnes.*

The following factors should be considered when deciding upon a system of support for an excavation:

- nature of the ground:
  - soil or rock type
  - presence of any faults or bedding planes in the soil or rock
  - made-up ground
  - previous excavations at the site
  - moisture content of the soil or rock—cohesiveness of the soil or rock may change, depending on whether the material is wet or dry
  - height of the face
- proximity of underground services, such as electricity, gas, sewer, water mains, drains or telephone cables and other hazards including fuel lines, soak wells and underground tanks
- hazards, natural or artificial, such as:
  - intersecting existing service excavations
  - telephone and electricity supply poles
  - manholes and other shafts
  - bends in an excavation
  - leaking water, drainage or sewerage services
  - corners created by the joining of pipe systems, i.e. ‘T’, ‘Y’ or ‘square’ junctions
  - trees
- static loads near an excavation, including:
  - the excavated material. An excavation in wet clay, 3 metres deep and one metre wide, will create a heap weighing approximately six tonnes per linear metre of excavation. These factors need to be considered when designing a support system if the excavated material is located near the trench
  - buildings, including garages, sheds, outbuildings, etc.
  - concrete slabs for new plant and equipment
  - water tanks or towers
  - brick or stone walls
  - embankments
- dynamic loads near an excavation, such as:
  - traffic (highway and rail)
  - excavation equipment
- ground vibration – the collapse of a trench may be caused by ground vibration accompanying dynamic loads. Such vibration may come from:
  - heavy traffic
  - rail stock passing close to an excavation
  - excavation and compaction machinery
  - construction works in the immediate vicinity, for example, pile driving
  - rock breakers
  - use of explosives.

4.1. Benching and battering

An excavated slope is safe when the ground is stable. That is, the slope does not flatten when left for a considerable period, there is no movement of material down the slope and the toe of the slope remains in the same place. One fairly simple way of controlling the risk of ground collapse is to bench or batter the excavation walls.

Benching is the creation of a series of steps in the vertical wall of an excavation to reduce the wall height and ensure stability.

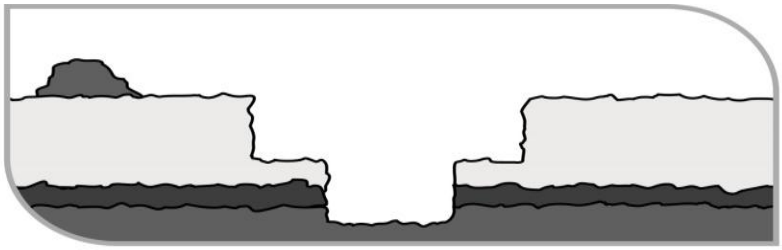


Figure 12 *Benching*

Battering is where the wall of an excavation is sloped back to a predetermined angle to ensure stability Battering prevents ground collapse by cutting the excavated face back to a safe slope. Battering should start from the bottom of the excavation**.**

Figure 13 *Battering*

In some circumstances it may be appropriate to use a combination of benching and battering on an excavation.

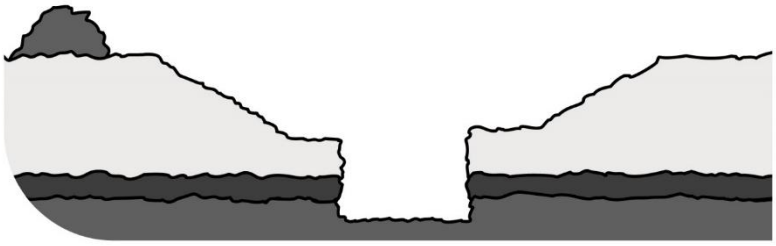


Figure 14 *Combination of benching and battering controls*

Benching and battering should be designed by a competent person, for example a geotechnical engineer.

It is not necessary to bench or batter the face of excavations which a competent person determines are in stable rock or has assessed there is no risk of collapse. When benching or battering the walls of an excavation, an angle of repose of 45 degrees should not be exceeded unless designed by a competent person and certified in writing.

4.2. Shoring

Shoring is the provision of support for an excavated face to prevent the movement of soil and therefore ground collapse. It is a common method of ground support in trench excavation where unstable ground conditions are often encountered, for example soft ground or ground liable to be wet during excavation.

Where ground is not self-supporting and benching or battering are not practical or effective control measures, shoring should be used. Shoring should also be used when there is a risk of a person being buried, struck or trapped by dislodged or falling material which forms the side of, or is adjacent to, the excavation work. It should always be designed for the specific workplace conditions by a competent person, for example an engineer.

Shoring the face of an excavation should progress as the excavation work progresses. Where earthmoving machinery is used risk assessment should be used to determine whether a part of the trench may be left unsupported.

The system of work included in the SWMS should ensure workers do not enter a part of the excavation that is not protected. They should not work ahead of the shoring protection if it is being progressively installed.

The use of metal shoring has largely replaced timber shoring because of its ability to ensure even distribution of pressure along a trench line, and it is easily adapted to various depths and trench widths.

Some of the common types of shoring are:

- hydraulic systems
- steel sheet piling
- steel trench sheeting
- timber systems, for example soldier sets
- prefabricated concrete panels
- ground anchors.

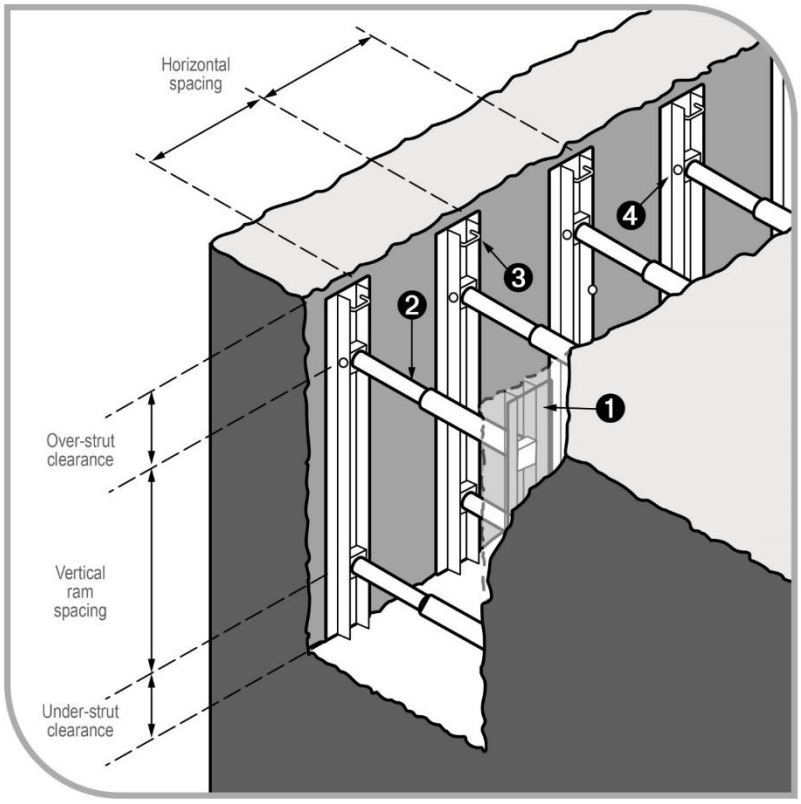
Hydraulic systems

Hydraulic support systems are commonly used to provide temporary or mobile ground support while other ground supports are being installed. Ground pressures should be considered prior to installing hydraulic supports. The hydraulic support system should be designed by a competent person in consultation with the geotechnical engineer. The hydraulic capacity of the temporary ground support system must be designed to resist the expected ground pressures and potential for collapse.

Hydraulic support systems may become unreliable if not properly maintained and properly used. Frequent inspections of pressure hoses and rams are necessary to detect abrasion, fatigue or damage, for example bent or notched rams.

When a trench has been fully supported the hydraulic support systems should be dismantled to prevent costly damage. The hydraulic supports should be inspected, repaired if necessary and carefully stored prior to re-use.

Further information on hydraulic shoring is available in AS 5047–2005: *Hydraulic shoring and trench lining equipment* (withdrawn but can be referenced).



1. Soldier rail
2. Hydraulic soldier strut
3. Lifting/handling point
4. Pin

Figure 15 *Hydraulic shoring (soldier set style)*

4.3. Steel sheet piling

Steel sheet piling is generally used on major excavations, for example, large building foundations or where large embankments are to be held back and can be installed prior to excavation work commencing. It is also used where an excavation is near adjoining buildings.

Sheet piling may also be used when the ground is so unstable that side wall collapse is likely to occur during excavation, for example, in loose and running sand. In such cases, sheet piling should be installed before excavation starts.

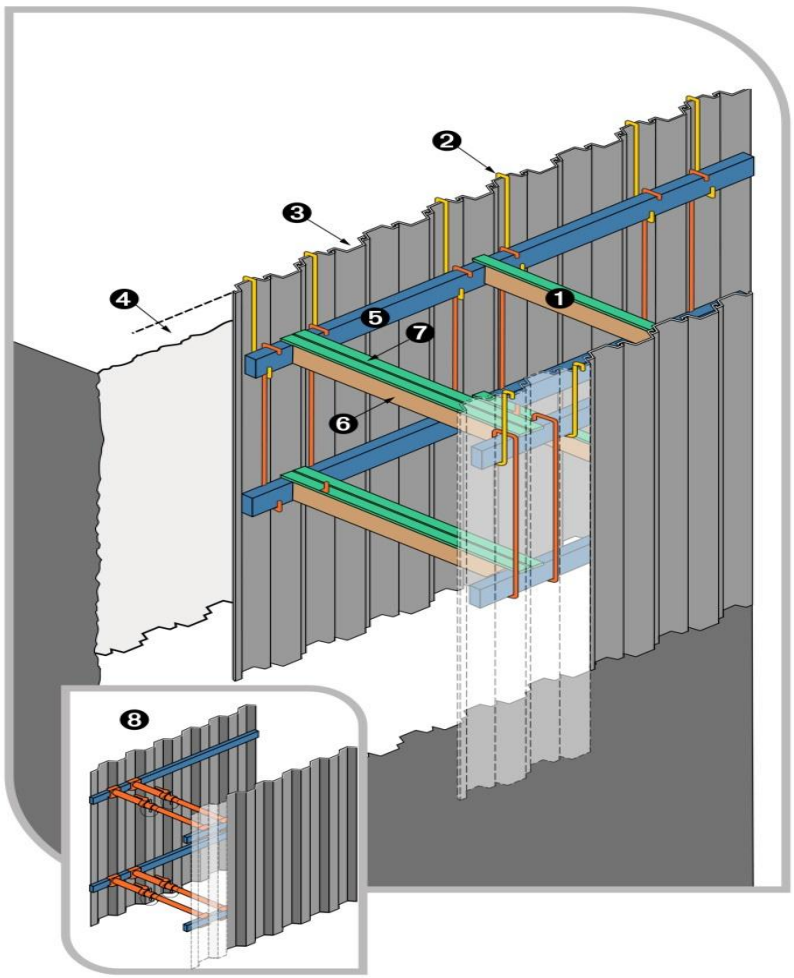


Figure 16 *Steel sheet piling*

1. *Centre capped single tom*
2. *Hanging bar*
3. *Sheet piling*
4. *Minimum height of sheet piling above surface: 300mm*
5. *Waling*
6. *Twin toms*
7. *Twin capping*
8. *Twin steel jacks should be used where extra strength is required due to heavy loading.*

4.4. Steel trench sheeting

Other methods of excavation may require the use of steel trench sheeting or shoring. It is positioned and pneumatically driven in to final depth. Toms and walings are placed into position as the soil is excavated. Although timber can be used, it is more efficient to use adjustable jacks or struts.

Steel trench sheeting is lighter weight than normal sheet piling and, in some circumstances, may be driven by hand-held pneumatic hammers or electrically operated vibrating hammers. The potential for manual handling injuries to occur in this operation is very high, as is the risk of lacerations due to sharp metal protrusions. These risks should be addressed before the driving of the steel sheet starts. Projections on the underside of the anvil of jackhammers should be removed to prevent damage to the driving cap and potential injury to the operator.

During driving operations, if it is likely workers may be exposed to noise levels more than the exposure standard, a method of controlling the noise exposure is required.

Further information on exposure to noise levels is available in the *Managing noise and preventing hearing loss at work*: Code of practice.

Steel shoring and trench lining equipment should be designed by a competent person. Further information on steel shoring can be found in AS 4744.1–2025: *Steel shoring and trench lining – Design.*

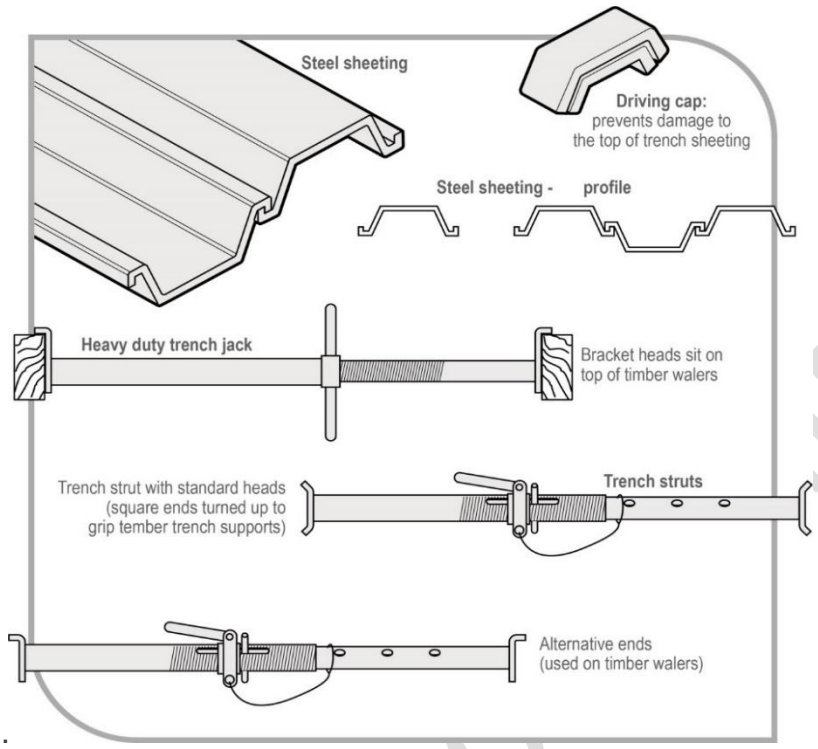


Figure 17 *Steel trench sheeting and jacks*

Timber soldier sets

The soldier set is a simple form of trench support set which can be formed with steel or timber. This system is mostly used in rock, stiff clays and in other soil types with similar self-supporting properties.

Unlike closed sheeting sets, soldier sets retain the earth where there may be a fault in the embankment. Soldier sets only provide ground support at regular intervals and do not provide positive ground support to the whole excavated face. Open soldier sets are only suitable for use in stable soil types.

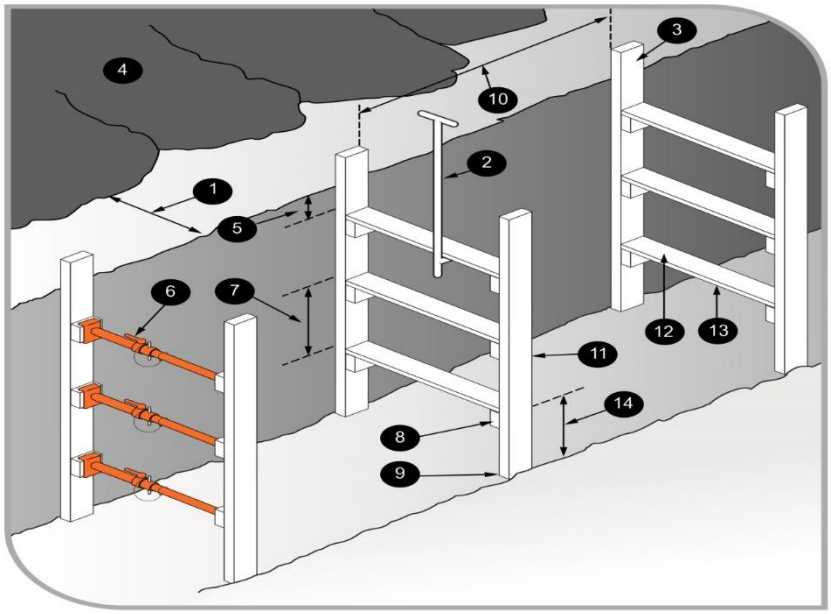


Figure 18 *Timber soldier sets*

1. *Spoil heap at least 1000 mm clear of excavation allows access along the side of the trench top and prevents material from the heap rolling into the trench.*
2. *Toms placed from surface with special timbering tongs.*
3. *Soldiers protrude 500 mm above the top of the trench.*
4. *Spoil heap or pile*
5. *Top tom no lower than 300 mm from the trench top*
6. *For added side support, steel jacks may replace timber toms.*
7. *Maximum spacing of toms no more than 750 mm*
8. *Cleats securely nailed to soldiers before placing soldiers in trench.*
9. *Soldier resting securely on trench bottom.*
10. *Maximum spacing between soldier sets: 1.5 metres*
11. *Soldier: minimum size 150 mm × 38 mm*
12. *Tom: minimum size 150 mm × 38 mm*
13. *Tom should be long enough to force soldiers firmly against trench sides. To prevent excessive bowing of soldiers against irregular trench sides, wood packing, between the trench wall and the soldier, may be used.*
14. *Space between the bottom tom and trench floor should be sufficient to allow installation of a pipe— normally, no more than 1000 mm.*

Closed sheeting

Closed sheeting is where vertical timber or metal members are used to fully cover and support a trench wall, and which are in turn supported by other members of a ground support system.

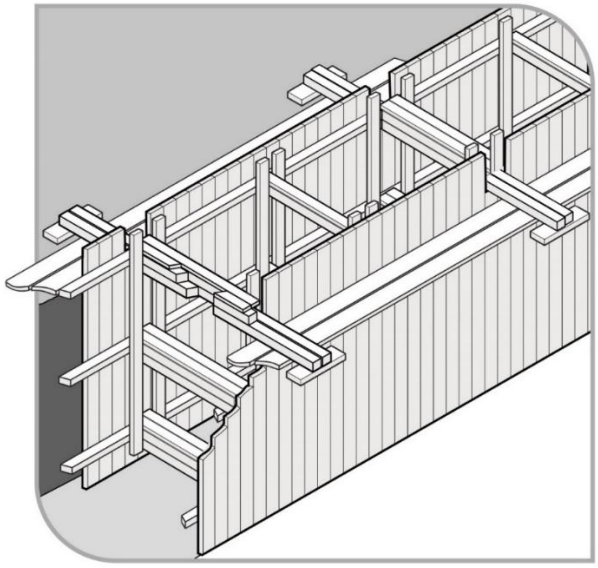


Figure 19 *Example of closed sheeting*

Side lacing is a form of closed sheeting used primarily to ensure worker safety by preventing soil from slipping by the placement of fill behind timber boards or steel plates (Figure 20). Side lacing is used in all types of ground and is particularly useful where long or large diameter pipes are to be installed and in variable ground conditions where steel or timber supports are difficult to install. Side lacing should be firmly wedged into the ground to prevent it from moving when fill is placed against it.

When closed sheeting or side lacing is used to prevent ground collapse, workers should not:

- enter the excavation prior to the installation of the sheeting or lacing
- work inside a trench, outside the protection of sheeting or lacing
- enter the excavation after sheeting or lacing has been removed
- enter an area where there is sheeting or lacing, other than by a ladder.

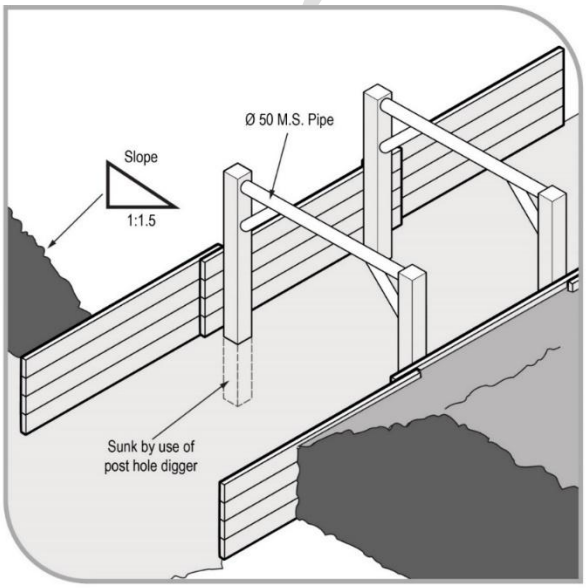


Figure 20 *Side lacing in sand trench*

4.5. Ground anchors

A ground anchor is a tie-back to the soil behind the face requiring support and is typically used with steel sheet piling.

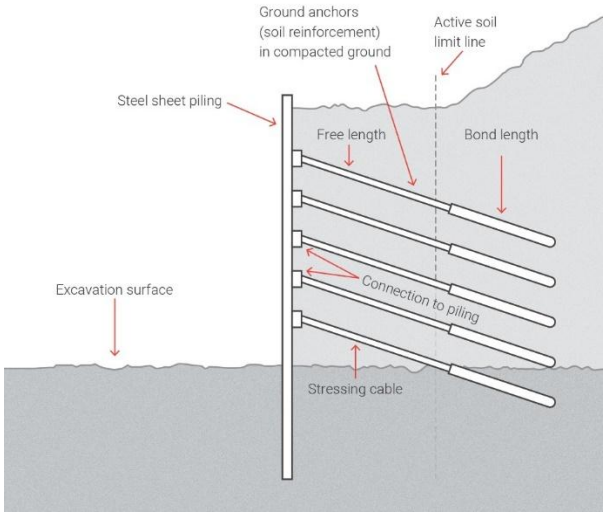


Figure 21 *Ground anchors for supporting steel sheet piling*

Ground anchors may be installed in either granular or clay soils. The design of ground anchors should be carried out by a competent person, for example a geotechnical engineer.

In granular soil, the anchorage zone is usually a plug of grout located behind the active soil limit line. This plug resists the tension force induced in the stressing cables, due to the shear and cohesion forces developed along its length.

These forces can be due, in part, to the overburden. Removal of soil above installed ground anchors should only be carried out after approval has been received from a competent person.

Removal of the soil between the retaining wall and the active soil limit line may cause sheet piling to bend. This bending will release the load in the stressing cable and render the ground anchor useless and dangerous to workers in the excavation area.

The ground anchor may not develop its original load carrying capacity on replacement of the soil. The anchorage of the stressing cable at the face of the sheet piling may be also dislodged or loosened. This depends on the type of stressing cable and the respective anchoring systems. While the ground anchoring system is operative, periodic checks with hydraulic jacks and pressure gauges are used to assess anchor behaviour over long periods.

4.6. Shields and boxes

A shield is a structure, usually manufactured from steel, which can withstand the forces which may be caused by a ground collapse**.** Trench shields and boxes differ from shoring as shoring is designed to prevent collapse while shielding and boxes are only designed to protect workers if a collapse occurs.

Shields can be permanently installed or portable and designed to move along as work progresses. Many different shield system configurations are available for hire or purchase. They incorporate specific lifting points for installation and removal.

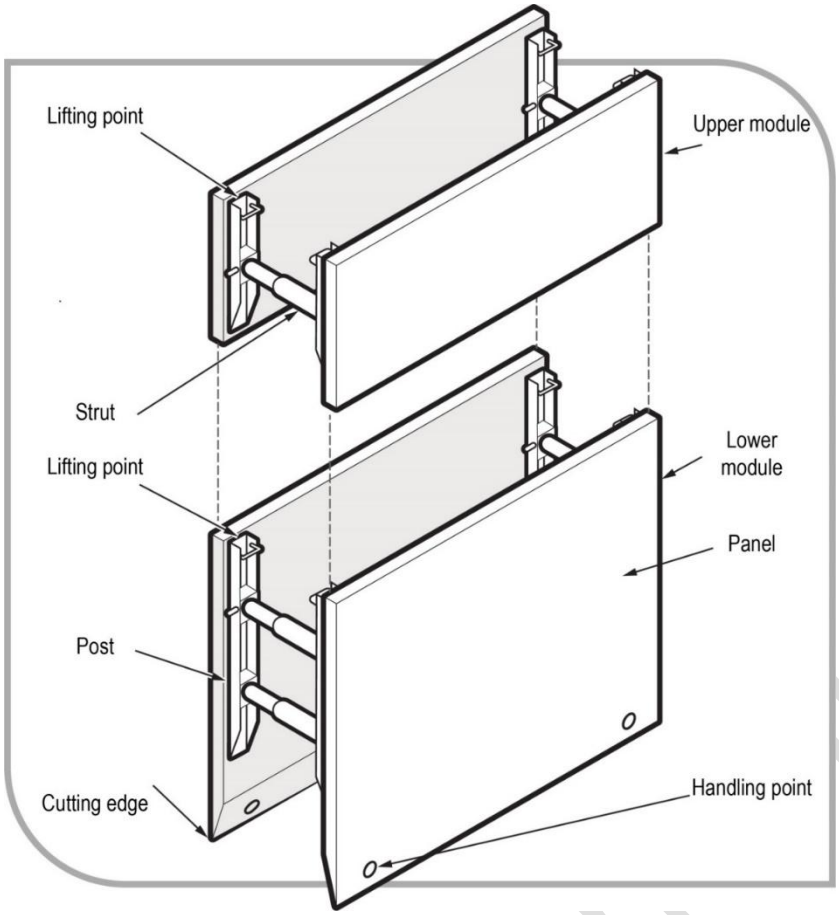


Figure 22 *A typical trench shield*

Trench shields and boxes are useful where it is not reasonably practicable to install other forms of support. They are mainly used in open areas where access is available for an excavator or backhoe to lower and raise the boxes or shields into and out of a trench. They are generally not suitable where access is difficult and ground conditions prevent the use of lifting equipment.

Steel boxes for trench work can be light or heavy-duty construction depending on the depth of the trench and ground conditions. Trench shields and boxes should be designed by a competent person, for example an engineer and be pre-manufactured to job specific dimensions.

Used correctly, shields and boxes can provide a safe workspace for workers needing to enter an excavation. Trench shields and boxes should be maintained or they may fail unexpectedly, particularly if they have been abused or misused. The manufacturer's instructions for the installation, use, removal and maintenance of shields and boxes should always be followed.

Trench boxes should not be subjected to loads exceeding those which the system was designed to withstand. Earth pressures are reduced when correct benching and battering practices are used.

Shields and boxes should be stored and transported in accordance with the manufacturer's instructions. Heavy duty equipment may require disassembly for transport.

Boxes should be regularly inspected for damage. They should only be altered or modified with the approval of a competent person.

4.7. Other ground support methods

Support to the face of an excavation can sometimes be effectively provided using chemical stabilisation techniques. These techniques involve injection under pressure of chemical solutions which bind and solidify soil. This method of stabilisation is only possible in porous soils.

5. Controlling risks in excavation work

5.1. Adjacent buildings or structures

Excavation work may seriously affect the security or stability of part of a structure at or adjacent to the location of the proposed excavation, which can lead to structural failure or collapse. Excavation work must not start until steps are taken to prevent the collapse or partial collapse of potentially affected buildings or structures.

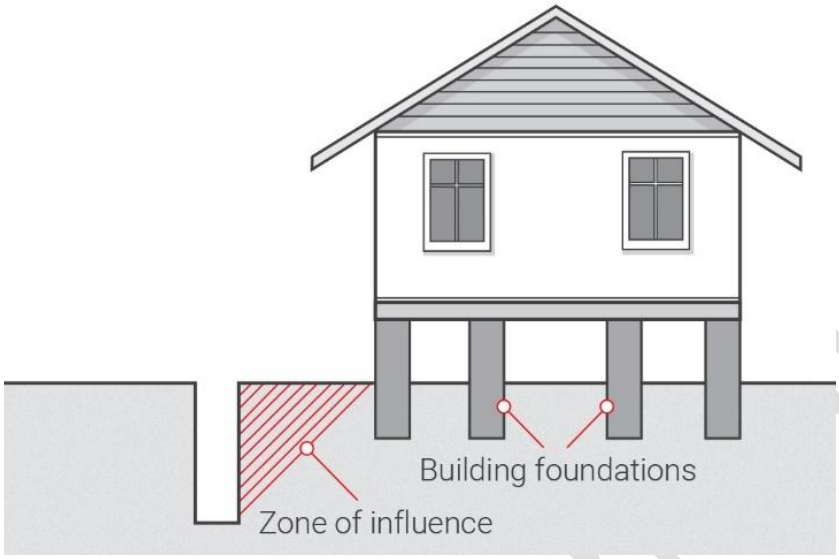


Figure 23 *Excavation near an adjacent building*

Excavation below the level of the footing of a structure, including retaining walls, that could affect the stability of the structure should be assessed by a competent person and secured by a ground support system which has been designed by a competent person. Suitable supports to brace the structure may also be required and should be identified by a competent person such as a geotechnical engineer.

It is also important other buildings in and around the excavation site are not adversely affected by vibration or concussion during the excavation work. Special precautions may need to be taken in the vicinity of hospitals and other buildings containing equipment sensitive to shock and vibration.

Care should be taken to ensure that excavation work does not cause flooding or water penetration to an adjacent building.

5.2. Overhead electric lines

WHS Regulation 166A

Duty of person conducting a business or undertaking: overhead electric lines

Specific control measures must be implemented before using excavators or other earthmoving machinery near overhead powerlines. The relevant network provider should be consulted regarding approach distances and control measures to be implemented to prevent any part of the plant or a load carried on it from coming too close or contacting overhead powerlines.

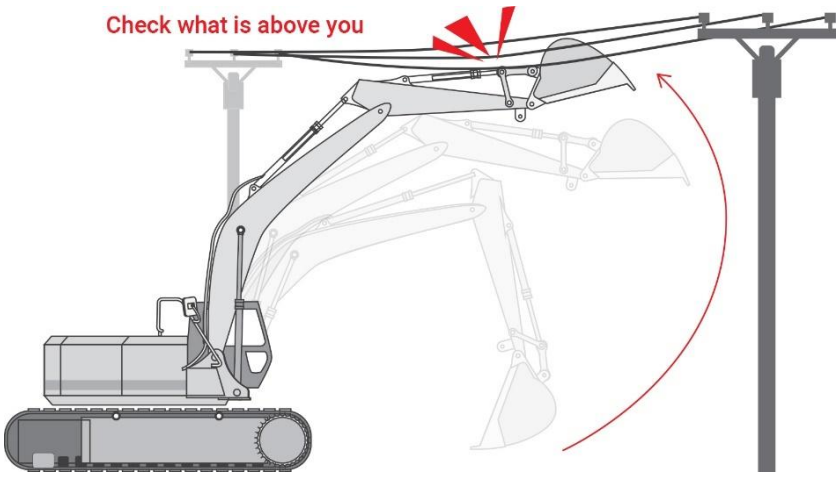


Figure 24 *Risks of overhead powerlines*

The most effective control measure for eliminating risk from overhead power lines is to have the network provider isolate the line. Other control measures may include using a spotter or insulating the power lines or deploying 'tiger tail' line marking to make the lines more visible.

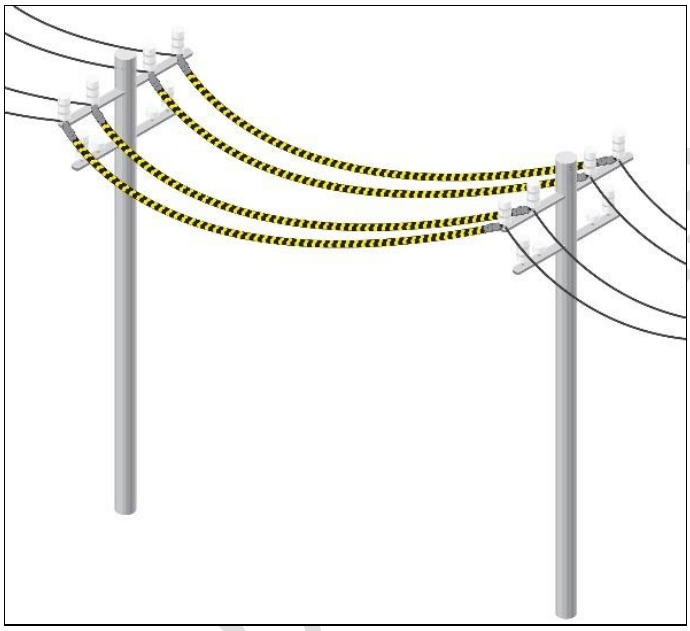


Figure 25 *'Tiger tails' on overhead power lines*

Tiger tails and other insulating devices are rated for the voltage for which they provide effective insulation. PCBUs must ensure the correct insulating device for the power line is chosen.

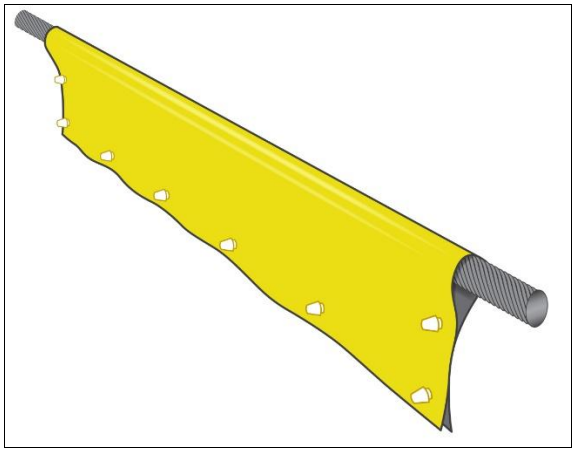


Figure 26 *Line cover insulating overhead power lines*

A PCBU or person with management or control of a workplace must ensure that a worker, or any plant or material used or controlled by a worker, does not enter the danger zone of an overhead electric line or aerial bundled conductor line. The danger zone is anywhere within:

- 0.5 metres of a live insulated overhead electric line or aerial bundled conductor line of a voltage of not more than 1,000 volts
- 1.0 metre of a live uninsulated overhead electric of a voltage of not more than 1,000 volts
- 3.0 metres of a live overhead electric line, whether insulated or not, of a voltage exceeding 1,000 volts but not more than 33,000 volts
- 6.0 metres of a live overhead electric line, whether insulated or not, of a voltage exceeding 33,000 volts.

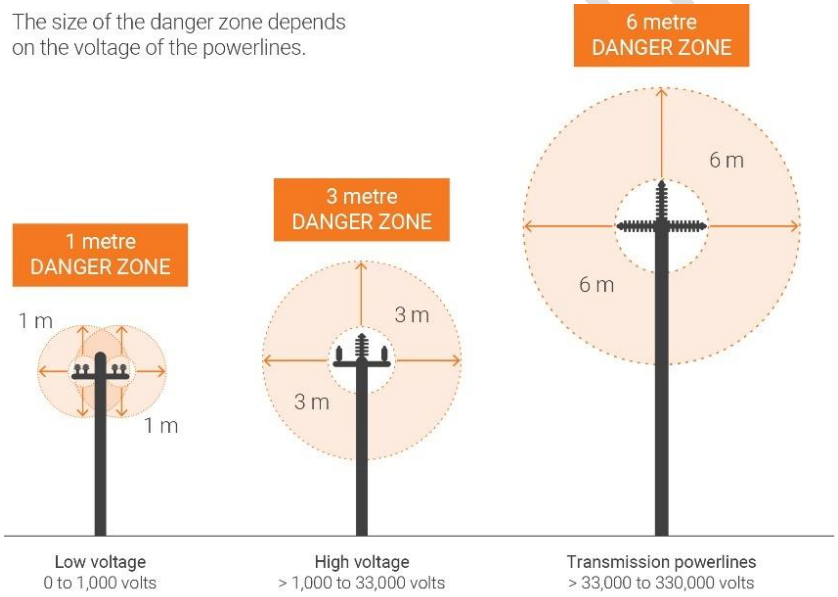


Figure 27 *Danger zones for overhead power lines*

A person who is authorised to carry out electrical work under the Electricity (Licencing) Regulations 1991 may enter a danger zone if they have proof that the overhead electric line has been adequately insulated and effectively cordoned off or otherwise made safe.

Further guidance on underground essential services and how to locate them is available in the *Managing electrical risks in the workplace*: Code of practice.

5.3. Pedestrians, other powered mobile plant and blind spots

WHS Regulation 215

Powered mobile plant—specific control measures

Operators of powered mobile plant can often have severely restricted visibility of ground workers or nearby pedestrians, particularly those close to the plant.

Figure 28 shows some of the blind spots for operators of typical excavation equipment.

Mobile plant operators and ground workers should be made familiar with the blind spots of items of plant being used. Induction training programs should emphasise the dangers of workers working near mobile plant, and supervision should be provided.

An effective system of communication should be established based on two-way acknowledgement between mobile plant operators and ground workers before work starts.

Relevant workers should also be trained in the procedures involved prior to the work commencing. The system should stop ground workers from approaching mobile plant until the operator has agreed to their request to approach. Similarly, the system should stop operators from moving plant closer than a set distance from ground workers until the operator has been advised by ground workers that they are aware of the proposed movement.

Mobile plant operators and ground workers should be provided with and required to wear high-visibility clothing.

Operators of powered mobile plant must prevent collisions with pedestrians or other powered mobile plant. Where plant operates near ground personnel or other powered mobile plant, the person with management or control of the powered mobile plant must ensure it is fitted with warning devices, such as reversing alarms and revolving lights, to alert those at risk from its movement.

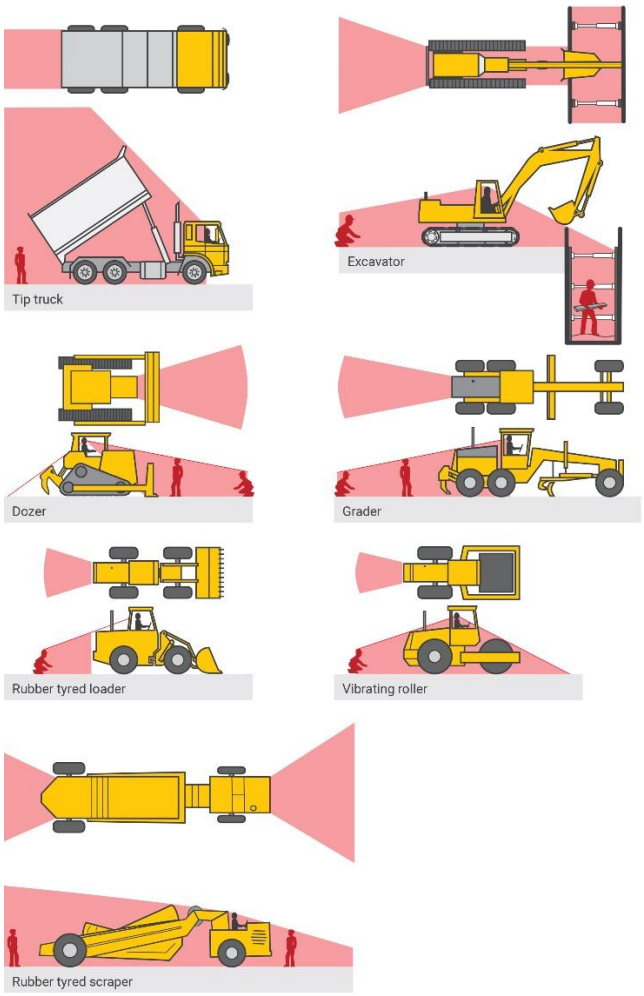


Figure 28 *Mobile plant operator blind spots*

5.4. Access and egress

The PCBU must always provide safe access and egress for all workers. This includes keeping the floor of the excavation clear of anything that would impede workers' safe egress in an emergency, including debris, loose spoil, timber or tools.

An excavation over 1.5 metres deep should be fitted with a ladder, stairway or ramp access and egress. Shallower excavations should have a ladder or stairway access and egress.

Ladders should be constructed of suitable materials, conforming to appropriate standards and maintain them in good condition.

PCBUs may want to consider developing policies and procedures such as:

- for every vertical rise of 6 metres, break up ladder runs with intermediate landings; where ladders meet a landing, offset the ladder below from the ladder above by at least 600 mm
- unless there are alternative handholds, extend ladders 1 metre above the landing or the top of the excavation
- fit landing platforms with guardrails, midrails and toe boards
- use temporary stairways in deep excavations as they provide safer access and egress than ladders

- each flight of stairs having uniform risers and provide landings of the same width as the stairs for every vertical rise of 6 metres
- if using ramps instead of stairs, the maximum slope should not exceed 1 in 6, unless traction cleats are provided at 0.5 metre spacing for 1 in 5 slopes, or at 0.4 metre spacing for 1 in 4 slopes
- ramps should not be steeper than 1 in 4.

5.5. Falls

WHS Regulation 78

Management of risk of fall

A PCBU at a workplace must manage risks to health and safety associated with a fall by a person from one level to another that is reasonably likely to cause injury to the person or any other person.

In managing the risks of falls, the WHS Regulations require the following specific control measures to be implemented:

- The first control measure is to, so far as is reasonably practicable, carry out the work on the ground or on a solid construction. A solid construction is an area that has:
  - a surface structurally capable of supporting all persons and things located or placed on it
  - barriers around its perimeter and any openings to prevent a fall
  - an even and readily negotiable surface and gradient
  - a safe means of entry and exit.
- If the risk of fall cannot be eliminated, the risk of fall must be minimised by providing and maintaining a safe system of work by implementing the following methods, in order, so far as is reasonably practicable:
  - providing a fall prevention device, such as temporary work platforms and guardrails
  - providing a work positioning system, such as industrial rope access systems
  - providing a fall arrest system, such as catch platforms.

These methods of providing a safe system of work must be implemented in order and the next control can only be implemented if the previous control is not reasonably practicable, for example the provision of a work positioning system can only be used as a method if it is not reasonably practicable to provide a fall prevention device.

Control measures include:

- the support system itself, for example using trench box extensions or trench sheets longer than the trench depth
- installing guard rails or covers on trench shields
- inserting guard rails and toe-boards into the ground immediately next to the supported excavation side
- installing landing platforms or scaffold towers inside deep excavations
- securing ladders to trench shields
- installing effective barriers or barricades
- providing clearly defined pedestrian detours
- providing alternative access and egress points to the excavation for emergency use
- backfilling the excavation as work progresses
- a suitable hoarding placed around the work site will provide protection for members of the public; barriers around the excavation may be needed to protect workers not

involved in excavation work, with a third layer of prevention is placed around the excavation itself.

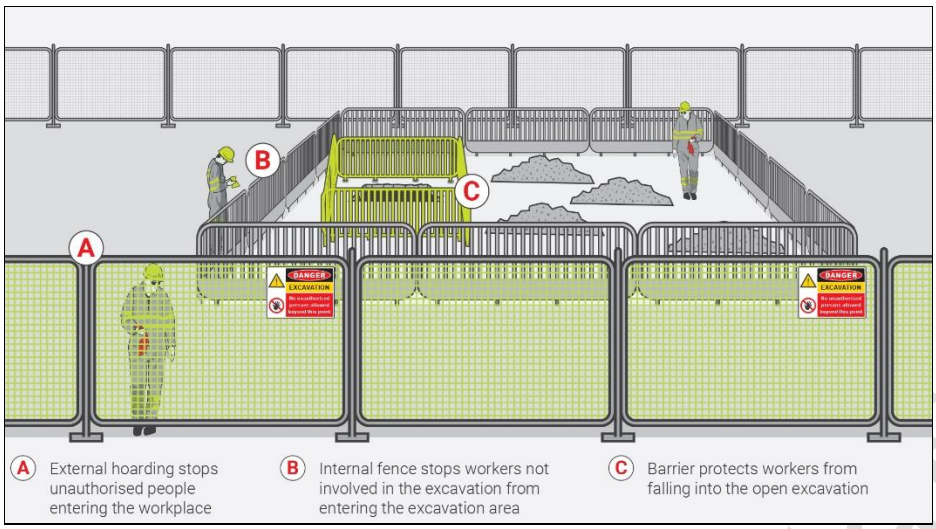


Figure 29 *Barrier fencing and barricades*

Self-closing gates further protect workers near the excavation while toe boards will prevent objects from falling into the excavation.

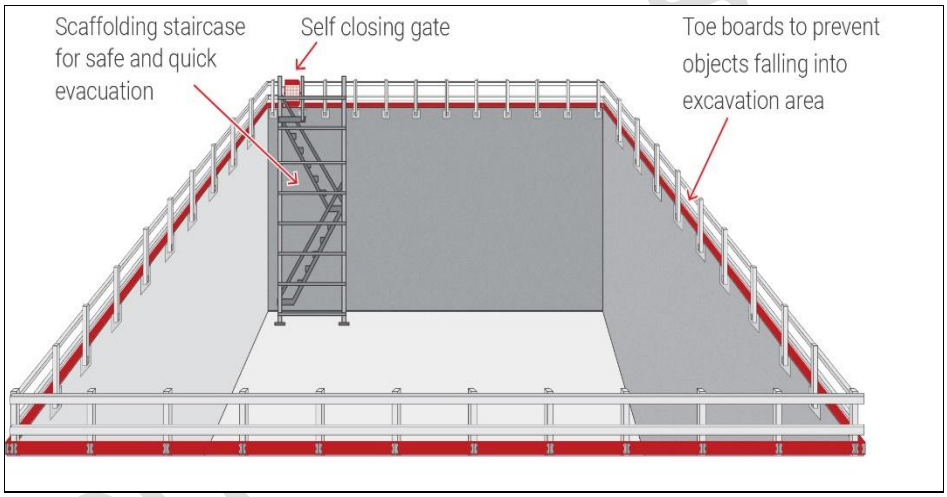


Figure 30 *Self closing gate and toe boards*

Construction work involving a risk of a person falling more than 2 metres is ‘high risk construction work’ and a PCBU must ensure that a SWMS is prepared before this work commences. Workers and supervisors in these situations must be trained to work safely at heights.

Fall prevention devices

A fall prevention device can include material or equipment, or a combination of both, designed to prevent a fall for temporary work at heights, and once in place after initial installation do not require any ongoing adjustment, alteration or operation by any person to ensure the device’s integrity. Fall prevention devices include secure fencing, edge protection, working platforms and covers.

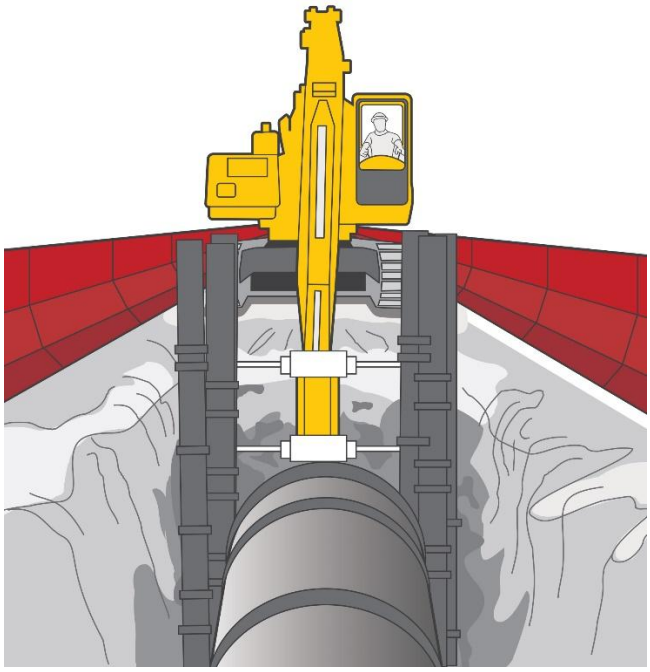


Figure 31 *Extending trench shields above the excavation*

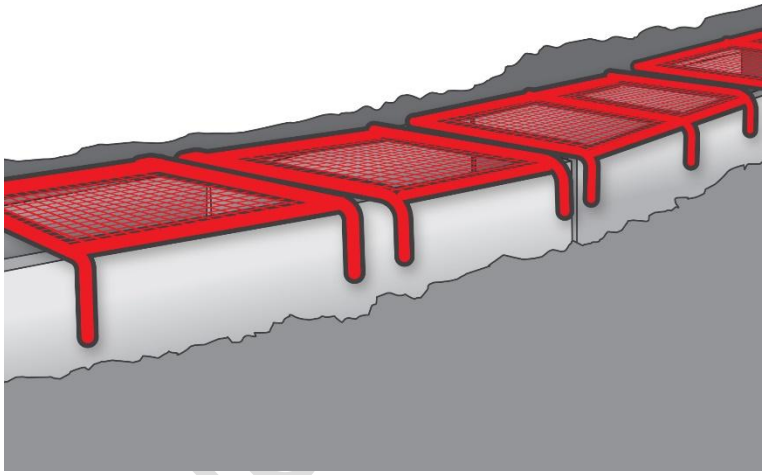


Figure 32 *Steel mesh covers over trench shields*

Further guidance on controlling the risk of falls is available in the *Managing the risks of falls in housing construction*: Code of practice and the *Managing the risks of falls in the workplace*: Code of practice.

5.6. Atmospheric conditions and ventilation

WHS Regulation 50

Monitoring airborne contaminant levels

The risk of atmospheric contamination through a build-up of gases and fumes must be controlled in excavation work. Gases and fumes heavier than air can collect in tunnels and excavations, for example: gases, sulphur dioxide, engine fumes, carbon monoxide and

carbon dioxide, and leakage from gas bottles, fuel tanks, sewers, drains, gas pipes and LPG tanks.

Plant using a combustion engine should never be used in a confined excavation, for example a trench, if workers are in the trench. The build-up of exhaust gases in the excavation, particularly carbon monoxide, can cause death.

Ventilation systems help to maintain oxygen levels and can dilute or extract flammable gases, fumes and certain dusts, for example, coal and sulphide which can ignite if in its explosive limits. The use of mechanical ventilation also reduces dust, fumes and hazardous contaminants and can control air temperature and humidity.

The ventilation system should be designed by a competent person to provide ventilation levels through the excavation, for example a tunnel during construction.

This might include extra localised extraction ventilation to deal with dust production, heat or fumes from the excavation process and operating large plant, or other activities like plant maintenance. The design should allow for installing ventilation equipment or ducting as the excavation progresses to maintain air supply to the working face.

Air monitoring must also be undertaken to determine the airborne concentration of a substance or mixture at the workplace if:

- it is not certain if the airborne concentration of a substance or mixture exceeds the relevant exposure standards
- monitoring is necessary to determine whether there is a risk to health.

Other methods of controlling the risks associated with atmospheric contamination include:

- pre-start checks of atmospheric conditions
- using gas monitors including workers wearing personal monitors near their airways
- ensuring there is ventilation, either natural or mechanical
- working in pairs, with one person as a safety observer at the surface to monitor conditions
- ensuring familiarity with rescue procedures
- using PPE.

Trenches are not considered confined spaces based on the risk of structural collapse alone. However, they will be confined spaces if they potentially contain concentrations of airborne contaminants that may cause impairment, loss of consciousness or asphyxiation.

Further guidance on working in confined spaces is available in the *Confined spaces*: Code of practice.

5.7. Using explosives

Construction work involving the use of explosives is ‘high risk construction work’ and a PCBU that involves carrying out this work must ensure that SWMS must be prepared before this work starts.

A competent person experienced in the controlled application of explosives for the purpose of carrying out the excavation work should be consulted before deciding whether explosives may be used.

Prior to the use of explosives, a blast plan must be prepared in accordance with Appendix A of AS2187.2-2006. *Explosives—Storage and use Part 2: Use of explosives.*

Blast plans do not need to be submitted for approval but Local Government authorities must be notified if explosives are to be used in an urban area.

All possession, storage, handling and use of explosives must be carried out in compliance with the Dangerous Goods Safety (Explosives) Regulations 2007.

The transport of explosives must be in accordance with the Australian Code for the Transport of Explosives by Road and Rail.

Explosives must only be used by a competent person who is licensed in the use of explosives and has experience in the work to be carried out.

If explosives are used in excavation work, a licensed competent person must develop and have authorised a blast management plan prior to the blasting starting.

For further information on the use of explosives for excavation work, refer to AS 2187.2–2006: *Explosives – Storage and use – Use of Explosives*.

5.8. Manual work

WHS Regulation 60

Managing risks to health and safety

Manual excavation methods are generally used for small, shallow excavations, for example less than 1.5 metres deep in soft soils.

PCBUs must manage risks relating to musculoskeletal disorders associated with hazardous manual tasks.

When working in close proximity, workers should be kept sufficiently far apart to prevent injury from the use of picks or other hand tools. This applies particularly to work in trenches and small excavations.

Preparatory drilling activity and the use of hand drills may increase the risk of musculoskeletal disorders, including disorders associated with exposure to vibration.

Attempts could be made to minimise the time workers spend in a crouching position. Such positions can increase the risk of injury or death in the event of ground collapse.

For further guidance on controlling the risks of musculoskeletal disorders, refer to the *Hazardous manual tasks*: Code of practice.

5.9. Asbestos

WHS Regulation 422

Asbestos to be identified or assumed at workplace

WHS Regulation 458

Duty to ensure asbestos removalist is licensed

During excavation work you may encounter material contaminated with asbestos, for example underground water pipes and telecommunications pits, or naturally occurring asbestos in the material being excavated. Work must stop immediately and the asbestos removed by a licenced contractor.

Table 1 Licence requirements for asbestos removal work

Type of licence	What asbestos can be removed?
Class A	Can remove any amount or quantity of asbestos or asbestos containing material (ACM) including: • any amount of friable asbestos or ACM • any amount of asbestos containing dust (ACD), and • any amount of non-friable asbestos or ACM.
Class B	Can remove: • any amount of non-friable asbestos or ACM • any amount of ACD associated with the removal of non-friable asbestos or ACM.
No licence required	Can remove: • up to 10m^2 of non-friable asbestos or ACM • ACD that is: – associated with the removal of less than 10m2 of non-friable asbestos or ACM – not associated with the removal of friable or non-friable asbestos and is only a minor contamination.

More information on this topic can be found in *How to safely remove asbestos*: Code of Practice and *How to manage and control asbestos in the workplace*: Code of practice.

5.10. Lasers

Lasers must be designed, constructed and installed so no person is exposed to accidental irradiation. Laser equipment on plant must also be protected so that any operator of the plant or any other person is not exposed to direct radiation, radiation produced by reflector or diffusion of secondary radiation. Also, any visual equipment that is used for the observation or adjustment of laser equipment on plant must not create a health and safety risk from the laser rays.

Lasers capable of producing hazardous diffuse reflections or that may constitute a fire hazard, that is laser classes 3B and 4 within the meaning of AS 2397–2015: *Safe use of lasers in the building and construction industry*, must not be used in construction work.

A worker operating a laser must be trained in the use of the equipment. Further information on the safe use of lasers is available in AS 2397–2015: *Safe use of lasers in the building and construction industry*.

6. Excavation methods

The nature of the excavation work being carried out will affect the selection of an excavation method and a safe system of work. Careful consideration should be given to health and safety issues when planning the work where the excavation involves anything other than shallow trenching and small quantities of material.

6.1. Trenching

WHS Regulation 306

Additional controls—trenches

PCBUs who propose to excavate a trench must minimise the risk to any person arising from the collapse of the trench.

Where there is a risk of engulfment when a worker enters a trench, these control measures should be implemented regardless of the depth of the trench.

A report from a geotechnical engineer may be required to provide information on the stability and safety of a trench excavation. The report should include details of the soil conditions, shoring or trench support requirements, dewatering requirements and longer-term effects on the stability and safety of the excavation. A competent person, for example an engineer should design support systems or be involved in selecting other ground collapse control measures, for example trench shields.

Shoring, benching and battering may not be required if written advice is received from a geotechnical engineer that all sides of the trench are safe from collapse. The advice should state the period of time it applies to and may be subject to a condition that specified natural occurrences may create a risk of collapse.

6.2. Tunnelling

The nature of tunnelling work is complex and highly specialised, requiring high levels of engineering expertise during the planning, investigation, design and construction stages.

Design

WHS Regulation 295

Designer must give safety report to person who commissions design

Safe tunnel construction depends on an adequate pre-construction engineering investigation of the ground and site and accurate interpretation of the information obtained.

Designers should:

- obtain or be provided with all available relevant information
- be advised of gaps in the information for planning and construction
- undertake or be involved in data acquisition for the site investigation program
- have on site involvement during the engineering investigation.

The information obtained from the engineering investigation and the anticipated excavation methods should be considered in preparing a tunnel design. The design should include:

- details on the tunnel dimensions and allowable excavation tolerances
- temporary and final support and lining requirements for each location within the tunnel
- details of expected tunnel drive lengths and shaft location
- other requirements for the finished tunnel.

Designers must also give the PCBU who commissioned the design a written report that specifies the hazards relating to the design of the tunnel that, so far as the designer is reasonably aware:

- create a risk to the health or safety of persons who are to carry out any construction work on the tunnel
- are associated only with the particular design and not with other designs of the same type of structure.

The design should also include information on the excavation methods and ground conditions considered in the design. This will allow the design to be reviewed if another excavation method is chosen or the ground conditions differ from that expected as the excavation proceeds.

The design also needs to consider the construction methods used to construct the tunnel so that a safe design for construction purposes is achieved.

Tunnelling hazards and risks

Common hazards and risks in tunnel construction generally relate to the confines of working underground including. PCBUs must identify hazards and implement control measures.

Hazard	Control measure
Tunnel stability—rock or earth falls and rock bursts	• Ground support, for example tunnelling shields, mesh, rockbolts and shotcrete
Changing ground conditions—strata and stress fluctuations	• Use of a geotechnical engineer
Limited space and access, with possible confined spaces involved	• Preparation of a SWMS • Use of the *Confined spaces*: Code of practice
Air contamination or oxygen depletion	• Natural or mechanical ventilation • Use two workers, one of whom is outside the excavation • Appropriate PPE • Air quality monitoring
Fire or explosion	• Natural or mechanical ventilation • Appropriate training and firefighting equipment
Use of fixed and powered mobile plant	• Plant and vehicle traffic management systems

Interaction of people and powered mobile plant	• Plant and vehicle traffic management systems • Effective communication between mobile plant operators and ground workers
Temporary electrical supplies and circuits including loss of power for lighting and ventilation	• Emergency plan including evacuation routes • Battery powered lighting on standby
Compressed air use and high pressure hydraulics	• Appropriate training • Correctly designed and installed 'whip arrestor'
Large scale materials and equipment handling	• Designated haul routes • Plant and vehicle traffic management systems
Overhead seepage, ground and process water	• De-watering systems • Emergency plan
Uneven and wet or other slippery surfaces	• Use of *Managing the risk of falls at workplaces*: Code of Practice
Falls of people or objects	• Use of *Managing the risk of falls at workplaces*: Code of Practice • Use of toe boards with scaffolding and barriers
Noise	• Appropriate PPE • Noise monitoring
Vibration	• Use of the *Hazardous manual tasks*: Code of practice • Appropriate PPE
Heat and humidity	• Natural or mechanical ventilation
Hazardous substances.	• Use of *Managing risks of hazardous chemicals in the workplace*: Code of practice

Using ground support designed for the unique circumstances of the work is essential to control the risk of a collapse or tunnel support failure. All excavation for tunnelling should be supported.

6.3. Shafts

Shafts are often constructed to provide access or ventilation to a tunnel. Comparatively, shallow shafts can be sunk for investigating or constructing foundations, dewatering or providing openings to underground facilities. Shafts vary greatly in design and construction

technique, depending on their purpose and the local conditions. They may be vertical or inclined, lined or unlined, various shapes, and excavated using various techniques.

Shaft sinking involves excavating a shaft from the top, with access and spoil removal from the top. Other construction methods include raise-boring, which is a method of constructing a shaft or raise where underground access has already been established. Raise bored shafts can be from the surface or from one horizon to another underground.

Control access to shaft openings by using a lockable, secure cover accessible only to a designated person. Alternatively, use a suitable guardrail and toe board with a gate for access and support the sides with steel frames, sets of timber, or in special cases, precast concrete or steel liners.

Shafts can have special features so design and construction advice should be obtained from a competent person, for example an engineer, before excavation and installation. In some cases, special ventilation facilities may be required.

Common hazards and risks involved in shaft construction include:

- shaft dimensions limiting work space
- the potential for ground instability for lifting and removing spoil
- falls and falling objects including fine material and water from the shaft wall
- hoisting equipment such as a winch, ropes and hooks
- hoisting and winching people, materials, spoil and plant
- water in-flow, in-rush and dewatering
- airborne contaminants and ventilation
- confined space work
- manual tasks
- hazardous materials
- fire or explosion
- inadequate communication systems
- mobile plant
- noise.

Control measures include:

- stabilising the ground at the head of the shaft and removal of spoil
- continuously lining or supporting the shaft
- providing fall protection, for example temporary work platforms
- providing and maintaining hoisting equipment
- installing dewatering systems
- installing mechanical ventilation to control airborne contaminants and air temperature/humidity
- isolating access to moving parts of plant and equipment
- guiding the working platforms and material
- avoiding overfilling material kibbles and cleaning kibbles before lifting
- closing shaft doors before tipping, and
- cleaning the spillage off doors, stage and steelwork
- providing emergency exits.

Further guidance on confined spaces is available in the *Confined spaces*: Code of practice.

7. Removal of ground support

7.1. Shoring

Shoring and all support systems should be removed in a manner that protects workers from cave-ins, structural collapse or being struck by structural members. Before removal begins, it may be necessary to install other temporary structural members to ensure worker safety.

A trench wall is very unstable when ground supports are being removed or dismantled and there is no guarantee the sides will not collapse at this time.

When a ground support system is being dismantled where the excavation was not properly backfilled, the trench walls may not withstand the increase in side pressure that was previously taken by the ground supports.

Removal should begin at, and progress from, the bottom of the excavation. Members should be released slowly to note any indication of possible failure of the remaining support members or possible cave-in.

Backfilling and compaction should progress together with the removal of support members. Removal of sets should be done from the surface or from a supported area of trench.

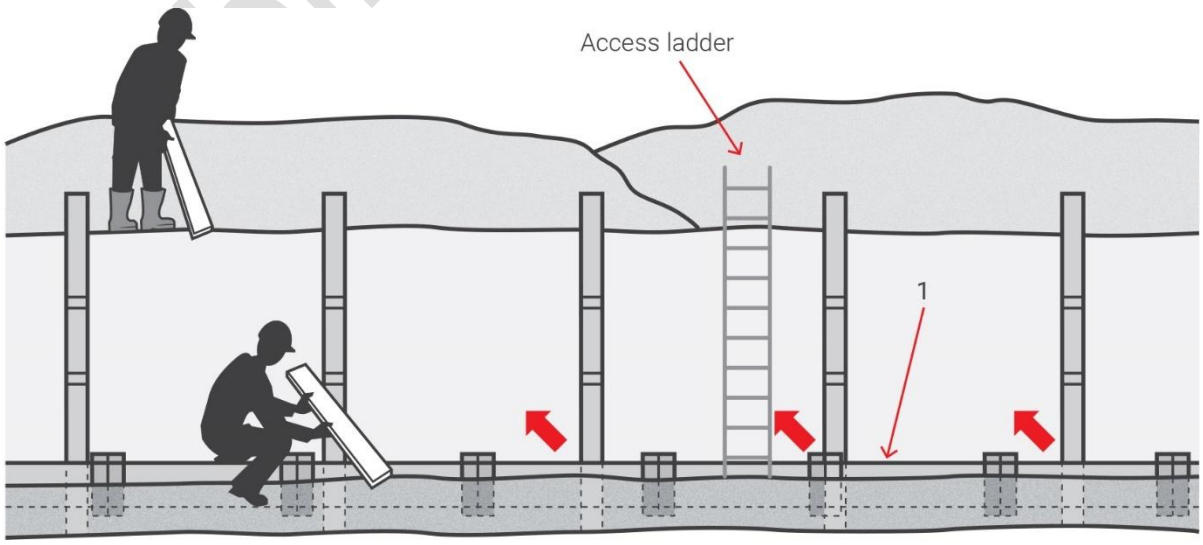
No ground supports should be removed from a section of a trench where persons are working.

Under no circumstances should shoring be partly removed unless it is for the purpose of complete removal and backfilling.

There are two recommended methods for removal of sets, both of which require workers in the trench during dismantling.

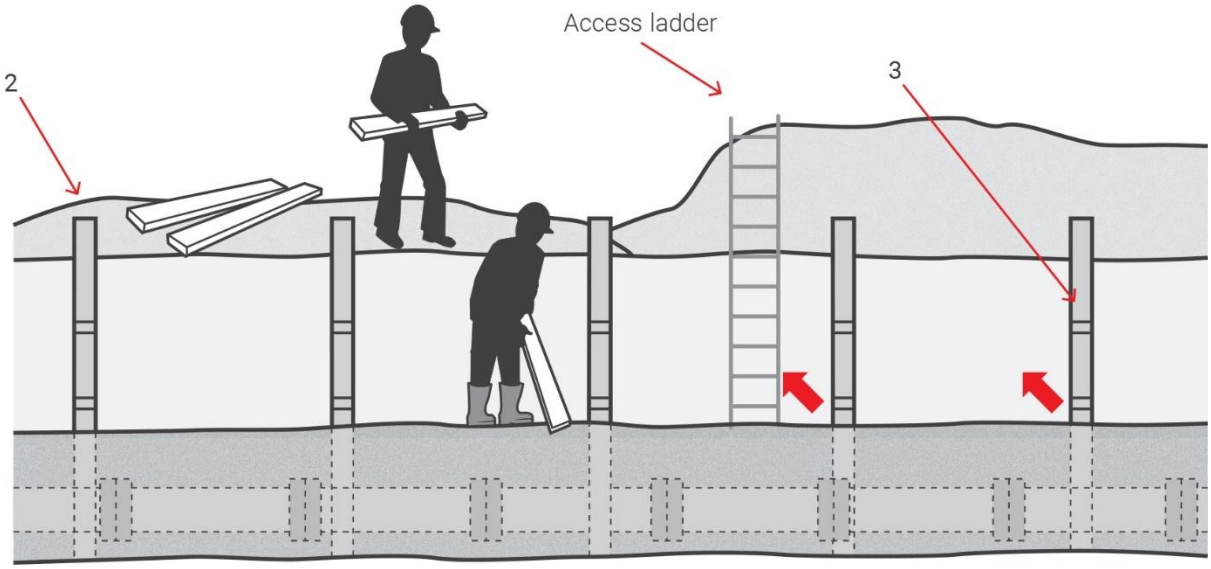
Method 1

Without entering the excavation, workers push the excavated material back into 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 bottom toms. When they leave the trench, it is backfilled to the next level of 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 a backhoe and chains or lifting lug. Backfilling is then completed. This is the preferred method



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

1. *Backfill reaches the level of the bottom*
2. *Soldiers are pulled out last after the removal of the bottom 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.*



The soldiers should be left in place until all the toms have been removed for added side support during the removal process while workers are in the trench.

Figure 33 *Removing soldier set ground supports – Method 1.*

Method 2

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

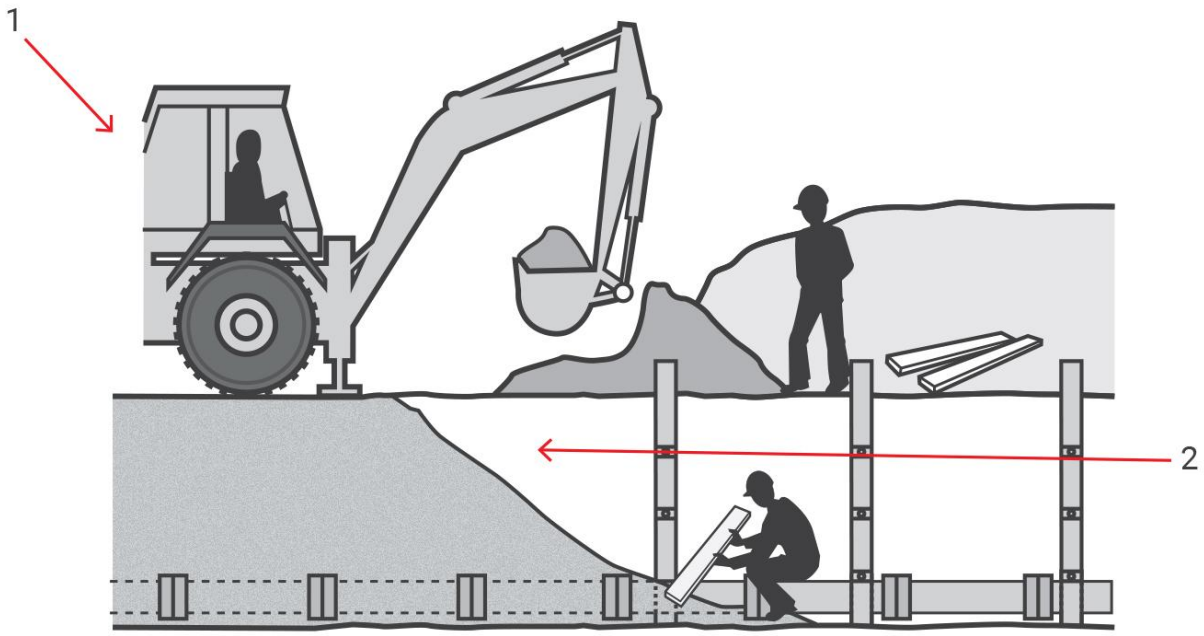
Backfill is placed in the trench until it begins to run over the bottom tom. A worker then approaches and removes this bottom tom. After the worker has left the trench or has gone behind a complete soldier set, more backfill is added until it reaches the next tom in the set being dismantled; this tom 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 than Method 1 because the area in front of the set being dismantled has uncompacted soil to stabilise its walls, and these walls must frequently withstand the additional weight of the excavator backfilling the trench.

Method 2 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 (see Figure 34).

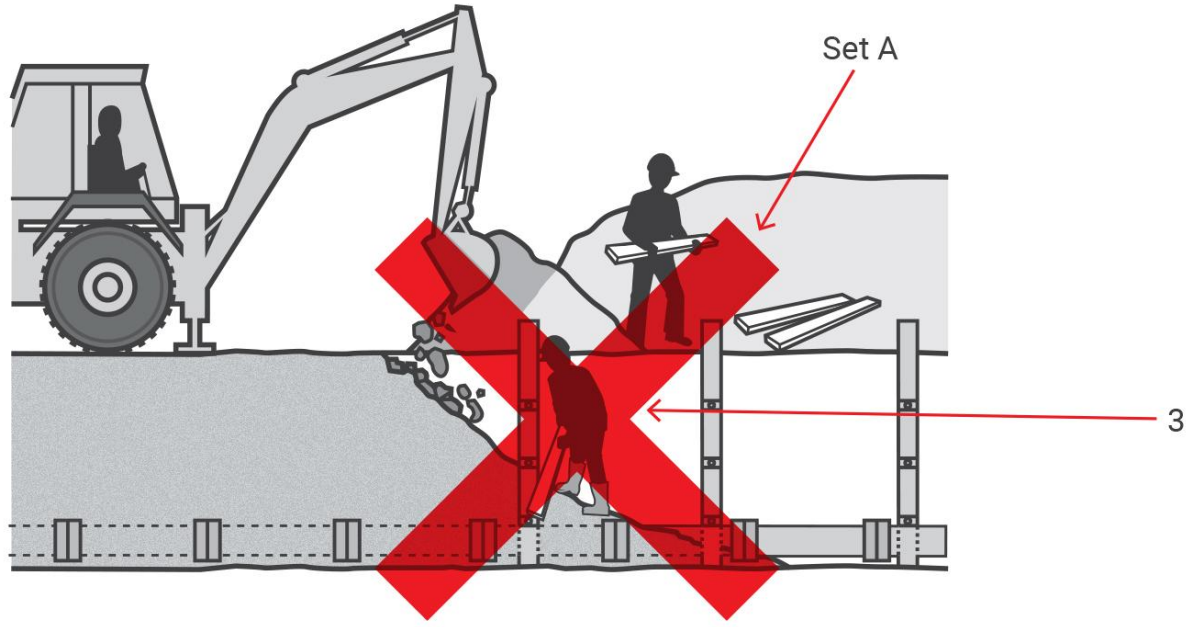
It may sometimes be better to abandon the support material if its removal is dangerous.

The whole purpose of shoring excavation is defeated if workers expose themselves to hazards while either installing or removing the shoring.



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

1. *A small mobile front-end loader/backhoe should be used for backfilling. Heavy excavators should be avoided as they place excess load on the trench walls and cause excessive vibration.*
2. *Partially supported ground.*



The set should only be removed after the trench has been backfilled as the soldier provides side support near the set being dismantled.

3. *The worker is in a dangerous situation. Workers should not be in front of Set A while the mobile plant is backfilling.*

Figure 34 *Removing soldier set ground supports – Method 2.*

7.2. Steel trench boxes

Steel trench boxes should only be removed from the ground by lifting at lifting points designated by the manufacturer. They should never be lifted from spreader bars or struts, which may be damaged in the process, as they are designed to resist axial loading only.

The possibility of damage to spreader bars increases with the width of the bar.

Dedicated chain slings should be used to extract steel boxes from the ground. The crane or other lifting plant together with the slings, shackles, hooks and other lifting components needs to be of sufficient capacity to lift the weight of the box and the associated ground frictional forces safely.

Heavy-duty steel boxes are usually removed from the ground one side after the other by partially backfilling the box before partially raising it and then compacting the soil before repeating the process until the steel box has been walked side to side out of the trench.

A heavy-duty box weighing several tonnes will require a crane or excavator large capacity to remove it from the ground.

Light duty boxes which are not hinged like heavy duty boxes should be lifted end to end in a seesaw action, and not side to side.

The manufacturer's instructions should be followed in removal of steel trench boxes and the operation supervised by a competent person.

Appendix A Glossary

Term	Definition
Active soil limit line	The area where the soil characteristics (particle size and moisture content) go from being active to inactive, i.e. stable.
Angle of repose	The steepest angle at which a sloping surface formed of loose material is stable. It is measured as the angle of the ground *under* the loose material and the slope of the loose material and will typically be less than 45 degrees.
Barrier	A physical structure which blocks or impedes something.
Barricade	An object or structure that creates a barrier obstacle to control, block passage or force the flow of traffic in the desired direction.
Backfill	Material used for refilling excavations.
Battering	To form the face, side or wall of an excavation to an angle, usually less than the natural angle of repose, to prevent earth slippage.
Bench	A horizontal step cut into the face, side or wall of an excavation to provide horizontal bearing and sliding resistance.
Benching	The horizontal stepping of the face, side, or wall of an excavation.
Closed sheeting	A continuous frame with vertical or horizontal sheathing planks placed side by side to form a continuous retaining wall supported by other members of a support system used to hold up the face of an excavation.
Competent person	In relation to carrying out clearance inspections of asbestos removal areas under WHS Regulation 473—a person who has acquired through training or experience the knowledge and skills of relevant asbestos removal industry practice and holds: • a certification in relation to the specified VET course for asbestos assessor work, or • a tertiary qualification in occupational health and safety, occupational hygiene, science, building, construction or environmental health. For all other purposes—a person who has acquired through training, qualification or experience, the knowledge and skills to carry out the task.
Construction project	A project that involves construction work where 5 or more persons are, or are likely to be, working at the same time at a construction site.

Term	Definition
Construction work	Any work carried out in connection with the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, maintenance, refurbishment, demolition, decommissioning or dismantling of a structure.
Earthmoving machinery	Operator-controlled mobile plant used to excavate, load, transport, compact or spread earth, overburden, rubble, spoil, aggregate or similar material, but does not include a tractor or industrial lift truck.
Excavation	A trench, tunnel or shaft, but does not include: • a mine • a bore to which a relevant water law applies, or • a trench for use as a place of interment.
Excavation work	Work to: • make an excavation, or • fill or partly fill an excavation.
Face	An exposed sloping or vertical surface resulting from the excavation of material.
Fall arrest system	Plant or material designed to arrest a fall, for example an industrial safety net, a catch platform, a safety harness system (other than a system that relies entirely on a restraint technique system).
Fall prevention device	Material or equipment—or a combination of both—typically designed to prevent a fall for temporary work at heights, that once erected or installed does not require any ongoing adjustment, alteration or operation by any person to ensure the device's integrity. For example secure fencing, temporary work platforms, guardrails and covers.
Geotechnical engineer	An engineer whose qualifications are acceptable for membership of the Institution of Engineers Australia and who has qualifications and experience in soil stability and mechanics and excavation work.
Hazard	A situation or thing that has the potential to harm a person. Hazards at work may include noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, bullying and violence at the workplace.
Hoist	An appliance intended for raising or lowering a load or people, and includes an EWP, a mast climbing work platform, personnel and materials hoist, scaffolding hoist and serial hoist but does not include a lift or building maintenance equipment.
May	'May' indicates an optional course of action.
Must	'Must' indicates a legal requirement exists that must be complied with.

Term	Definition
Officer	An officer under the WHS Act includes: • an officer under section 9 of the *Corporations Act 2001* (Cth) • an officer of the Crown or a public corporation within the meaning of section 4A of the WHS Act. A partner in a partnership or an elected member of a local authority is not an officer while acting in that capacity.
Overburden	The surface soil that must be moved away.
Operator protective device	A roll-over protective structure (ROPS), falling object protective structure (FOPS), operator restraining device or seat belt.
Person conducting a business or undertaking (PCBU)	PCBU is an umbrella concept which intends to capture all types of working arrangements or relationships. A PCBU includes a: • company • unincorporated body or association, and • sole trader or self-employed person. Individuals who are in a partnership that is conducting a business will individually and collectively be a PCBU. A volunteer association (defined under the WHS Act, see below) or elected members of a local authority will not be a PCBU.
Powered mobile plant	Plant provided with some form of self-propulsion ordinarily under the direct control of an operator.
Risk	The possibility harm (death, injury or illness) might occur when exposed to a hazard.
Safe slope	The steepest slope at which an excavated face is stable against slips and slides, having regard to the qualities of the material in the face, the height of the face, the load above the face and the moisture conditions for the time being existing.
Shaft	A vertical or inclined way or opening from the surface downwards or from any underground working, the dimensions of which (apart from the perimeter) are less than its depth.
Sheet piling	Vertical, close-spaced, or 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 structural members from within the excavation as the work proceeds.
Shoring	The use of timber, steel or other structural material to support an excavation to prevent collapse so construction can proceed.
Should	'Should' indicates a recommended course of action.

Term	Definition
Soldier	Vertical upright steel or timber element used for supporting a trench wall.
Strut	Structural member (usually horizontal) in compression resisting thrust or pressure from the face or faces of an excavation.
Tom	Structural member used to hold soldiers against a trench wall or to press walers apart in a close sheeted trench.
Trench	A horizontal or inclined way or opening: • the length of which is greater than its width and greater than or equal to its depth • that commences starts at and extends below the surface of the ground, and • that is open to the surface along its length.
Trench box	A structure with four vertical side plates permanently braced apart by bracing designed to resist the pressure from the walls of a trench and capable of being moved as a unit.
Trench shield	A steel or metal structure with two vertical side plates permanently braced apart by cross frames or struts designed to resist the pressure from the walls of a trench and capable of being moved as a unit.
Tunnel	An underground passage or opening that is approximately horizontal and starts at the surface of the ground or an excavation.
Volunteer association	A group of volunteers working together for one or more community purposes where none of the volunteers, whether alone or jointly with any other volunteers, employs any person to carry out work for the volunteer association.
Waler	A steel or timber element used for supporting a trench wall.
Water scouring	An erosion process resulting from flowing water.
WHS service provider	A person who conducts a business or undertaking that provides WHS services: • to a person who conducts a business or undertaking; and • that are to be used, or could reasonably be expected to be used, at, or in relation to, a workplace at which work is carried out for the other business or undertaking.

Term	Definition
WHS services	Services that relate to work health and safety. Exclusions from the definition include: • services provided under this Act by a WHS authority, a health and safety representative (or deputy) or a health and safety committee • services provided under a corresponding WHS law by a person or body corresponding to a WHS authority, a health and safety representative (or deputy) or a health and safety committee • emergency services provided by police officers, or other emergency services personnel, in situations where there is a serious risk to the health or safety of any individual • services that are subject to legal professional privilege or that would be subject to legal professional privilege but for that privilege having been waived.
WHS service provider	A person who conducts a business or undertaking that provides WHS services: • to a person who conducts another business or undertaking • that are to be used, or could reasonably be expected to be used, at, or in relation to, a workplace at which work is carried out for the other business or undertaking.
Work group	A group of workers established to facilitate the representation of workers by one or more health and safety representatives. A work group may be all workers at a workplace, but it may also be appropriate to split a workplace into multiple work groups where workers share similar work conditions or are exposed to similar risks and hazards. For example, all workers on night shift.
Worker	Any person who carries out work for a person conducting a business or undertaking, including work as an employee, contractor or subcontractor (or their employee), self-employed person, outworker, apprentice or trainee, work experience student, employee of a labour hire company placed with a 'host employer' or a volunteer.
Workplace	Any place where work is carried out for a business or undertaking and includes any place where a worker goes, or is likely to be, while at work. This may include offices, factories, shops, construction sites, vehicles, ships, aircraft or other mobile structures on land or water.
Work positioning system	Any plant or structure, other than a temporary work platform, that enables a person to be positioned and safely supported at a location for the duration of the relevant work being carried out.
Zone of influence	The volume of soil around the excavation affected by an external load, for example vehicles, plant, excavated material.

Appendix B Ground conditions

Sources of information for assessing ground conditions

Information is available from a wide range of sources. Natural features, such as rock outcrops, watercourses, creeks and swamps, should be inspected. Information on ground conditions may be available from nearby works, such as existing railway and road cuttings, and foundation works.

Results of any test bores are usually available from the appropriate authorities. When they are not available, unsupported test excavations using a backhoe should be dug in doubtful areas to observe ground conditions and enable suitable support systems to be designed.

When excavation commences, visual examination will provide qualitative information regarding the excavation site in general, the soil forming the sides of the excavation, and the soil taken as samples from the excavated material.

Samples of soil excavated and the cut faces of the excavation sides should be examined for particle size. Soil primarily composed of fine-grained material is likely to be cohesive, while soil that is primarily of coarse-grained sand or gravel is likely to be non-cohesive.

Excavated soil that remains in clumps will be cohesive, while soil that breaks up when excavated will be non-cohesive.

When moist, cohesive soil can be successfully rolled into threads without crumbling. Granular soils will not do this. The ability to form thin threads is a useful test to determine if a soil sample is cohesive or not.

Determination of whether the excavated faces are cohesive or non-cohesive will determine the safe slope if the excavation is to be battered and the need, or otherwise, for any support system and the type of support system.

Observe the faces of the opened excavation for:

- crack-like openings, such as tension cracks, which could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured, indicating moving ground and a potentially dangerous situation
- evidence of existing underground services or structures and disturbed soil requiring support
- layers of soil in the excavated face sloping towards the excavation indicating the need for support
- seeping water from the sides of the excavation indicating instability, or the level of the water table if above the bottom of the excavation.

Factors to consider to avoid cave-ins

Safe slopes

General

The face of an excavation may be cut back to a safe slope as an alternative to shoring. Sloping (battering) the face may be a safe and viable method if there is sufficient space at the site.

A slope is safe when the material is stable. That is, the slope does not flatten when left for a considerable period, there is no movement of material down the slope and the toe of the slope remains in the same place.

Different soils, when dumped in heaps, will assume a characteristic shape and settle naturally at different slopes. The angle which a sloping face of loose earth makes with the

horizontal is sometimes referred to as the angle of repose. However, it is poor practice to relate the safe slope of an excavation to the angle of repose, even though the safe slope may be similar in some types of soil to the angle of repose.

On some excavations, typically those of long-term duration, an analysis of soil samples will enable an engineer experienced in soil mechanics to calculate safe slopes. However, in trenching works of shorter duration, this is usually not practicable and excavated slopes should be sufficiently conservative to avoid the risk of collapse.

The safety of the slope can change if the local geology and condition of the soil changes. The presence of water has a substantial effect on the safe excavated slope of any material. If the material is wet by rain or seepage water, it may slump or flatten out.

The safe slope for a face will depend on the depth of cut, the type of soil, the moisture content and condition of the material in the face and the length of time the face will be required to stand. The location of any underground services near the excavation will also affect the safe slope. In a shallow trench for pipe laying, where the material is uniform and known to be stable and the trench will be back filled within a short time, vertical faces may be safe. However, the excavation of a vertical sided trench in which workers are required to work should be considered as dangerous and advice from a competent person should always be obtained.

In considering the stability of an excavated slope, it is important to note that, as a rule of thumb, the magnitude of horizontal forces is a function of the square of the total depth of the face. Therefore, at a depth of 2 metres, horizontal forces are four times the magnitude of such forces in a one-metre-deep cut, 9 times in a 3-metre-deep cut, 16 times in a 4-metre-deep cut and so on. These simple calculations indicate the very significant impact of the rate of increase of horizontal forces with increasing depth.

As mentioned previously, a safe slope depends on many factors and a competent person should determine safe slopes for excavations. For excavations deeper than 6 metres, safe slopes should be determined by an engineer.

In trench excavation over long distances, soil types can change dramatically and different weather conditions will alter the strength and stability of excavated faces, as will the length of time the excavation is open. A competent person should determine a safe slope as soil conditions change.

Where there are no adverse geological conditions present, such as slip planes, or high groundwater levels, the following guide to safe slopes in various soil conditions may apply:

- For most types of soil for excavations up to 6 metres depth, one-and-a-half horizontal distance to one vertical distance (equivalent to an angle of approximately 34 degrees from the horizontal). This slope may be safe, even for granular soils, such as crushed rock, gravel, non-angular poorly graded sand (for example, Bassendean sand), and loamy sand with very little cohesive properties.
- Weak cohesive soils, such as angular well graded sand (for example, Karrakatta or Spearwood sand), silt, silty loam and sandy loam may be safe at slopes of one horizontal to one vertical (45 degrees) for excavations up to 6 metres.
- Cohesive soils with a greater compressive strength, such as clay, silty clay and sandy clay, may be safe at steeper angles, three-quarters horizontal distance to one vertical distance (equivalent to an angle of approximately 53 degrees from the horizontal).

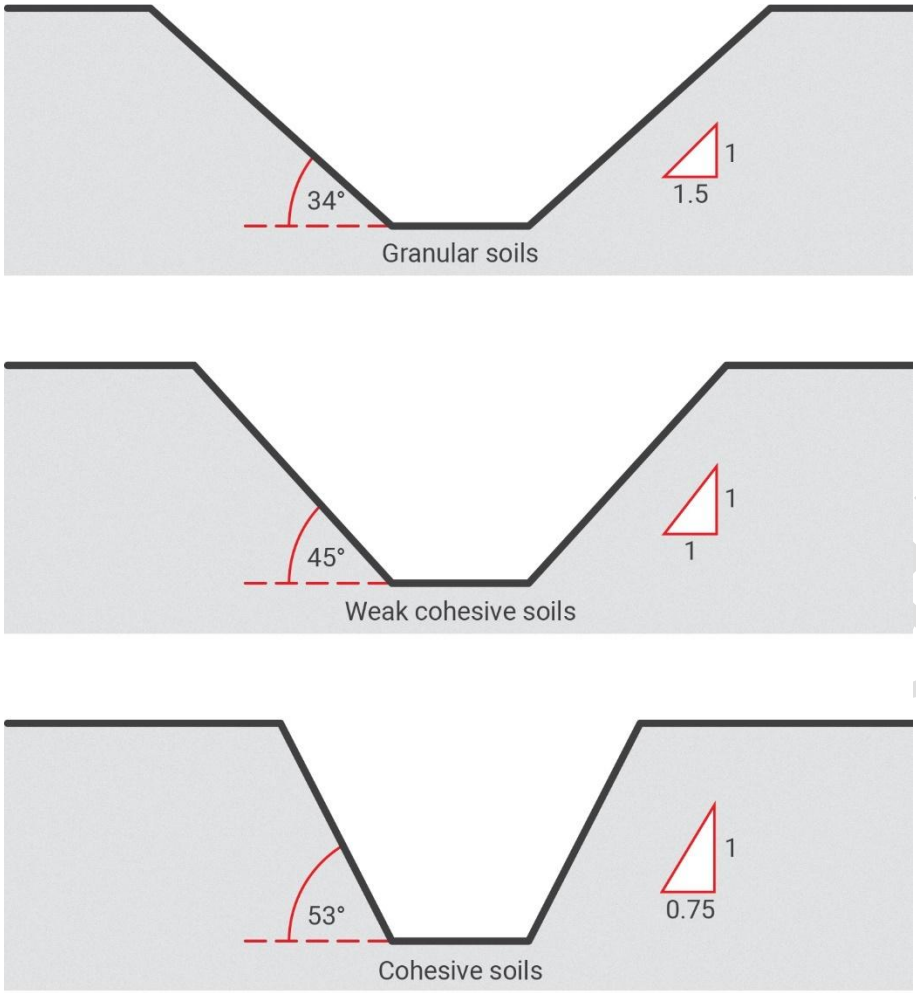


Figure 35 *Slopes which may be safe for various soil types.*

Soil type	Horizontal/depth ratio	Slope angle
Granular soils: crushed rock, gravel, non-angular poorly graded sand (such as Bassendean sand), loamy sand	1.5:1	34°
Weak cohesive soils: angular well graded sand (such as Karrakatta or Spearwood sand), silt, silty loam, sandy loam	1:1	45°
Cohesive soils: clay, silty clay, sandy clay	0.75:1	53°

These slopes may not be safe in all conditions.

Typical circumstances that may require a safer slope (or shoring and other precautions) include where:

- there are surcharge loads

- there are planes of weakness or soil layering
- the ground to be excavated is not level
- groundwater will be encountered
- there are vibration forces.

For the 3 types of soil mentioned above, there may be situations where these slopes will not be safe due to adverse geological conditions or the presence of groundwater. Saturation will considerably flatten these slopes. Conversely, there may be situations where steeper slopes are safe due to favourable geological conditions or the absence of groundwater. Where the excavation is deeper than 1.5 metres, steeper slopes should only be used on the basis of assessment and advice of an appropriately experienced engineer.

At depths greater than 3 metres, faces should be stabilised with horizontal benching, which will also prevent material from the top of the slopes falling to the working area. When horizontal benching is used, consideration should be given to the width of the bench where machinery is required to operate.

Support to the face of an excavation can sometimes be effectively provided using chemical stabilisation techniques which involve injection under pressure of chemical solutions which bind and solidify soil. This method of stabilisation is only possible in porous soils and is expensive. However, under certain circumstances where space limitations are a major consideration and it is not feasible to cut the face of an excavation back to a safe slope, chemical injection may be economical.

Cohesive strength and earth pressure

In their natural condition, soils have varying degrees of cohesive strength and frictional resistance. Examples of materials with virtually no cohesive strength are dry sand, saturated sand and gravels with minimum clay content.

Ground encountered in trench excavations can generally be categorised as one of three main kinds:

- hard, compact soil
- soil liable to crack or crumble
- loose or running material.

Of these materials, hard compact soil is the type that can cause the most trouble because the face often looks good, and this can lead to risks being taken; loose or running material is in most respects the safest, because the need for precautions is obvious from the start. Soil liable to crack or crumble is doubtful and should be consideration carefully before the treatment to be given is determined. Useful information can often be obtained by inquiring from local authority officers.

Where there is any doubt about the cohesiveness of a soil, a simple field test is to remove a handful of natural soil and mould it into a ball with both hands. Leave it standing and observe the shape and separation tendencies of the soil over a period of time.

Non-cohesive faces may be very treacherous. With just the right amount of moisture, they look, for a short time, safe and solid. Very little loss of water by evaporation will make the soil crumble, as would an increase in the water content from rain or other causes.

Evaluating pressure on a trench wall is a complex matter requiring consideration of a number of factors including soil type, moisture content, effect of the weight of the excavated material and adjacent machinery loadings, and should be undertaken only by engineers experienced in such matters.

Engineering advice on the need and application of ground support systems should be sought, except in the situation of shallow trenches.

Appendix C Additional information

Codes of practice

Construction work: Code of practice

How to manage work health and safety risks: Code of practice

How to manage and control asbestos in the workplace: Code of practice

How to safely remove asbestos: Code of practice

Managing risks of plant in the workplace: Code of practice

Safe design of structures: Code of practice

Work health and safety consultation, cooperation and coordination: Code of practice

Guidance notes

Occupational Safety and Health Management and Contaminated Sites Work: Guidance note

Interpretive guides

Duty of persons conducting business or undertakings that provide services relating to work health and safety: Interpretive Guide

The health and safety duty of an officer: Interpretive Guide

Information sheets

Safe work method statement for high risk construction work: Information sheet

Templates

SWMS template