



Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

CODE OF PRACTICE

Excavation



COSH
COMMISSION FOR OCCUPATIONAL SAFETY AND HEALTH



Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

CODE OF PRACTICE

Excavation



COSH

COMMISSION FOR OCCUPATIONAL SAFETY AND HEALTH

Disclaimer

The information contained in this publication is guidance material only. It is provided in good faith and believed to be reliable and accurate at the time of publication.

To ensure you understand and comply with your legal obligations, this information must be read in conjunction with the appropriate Acts and Regulations which are available from the Parliamentary Counsel's Office <https://www.legislation.wa.gov.au/>

The State disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages and costs you might incur as a result of the information being inaccurate or incomplete in any way, and for any reason.

In this disclaimer:

State means the State of Western Australia and includes every Minister, agent, agency, department, statutory body corporate and instrumentality thereof and each employee or agent of any of them.

Information includes information, data, representations, advice, statements and opinions, expressly or implied set out in this publication.

Loss includes loss, damage, liability, cost, expense, illness and injury (including death).

Reference

Commission for Occupational Safety and Health, Excavation: Code of practice, Department of Mines, Industry Regulation and Safety 89pp.

ISBN 978 1 920836 72 6 (web)

© State of Western Australia (Department of Mines, Industry Regulation and Safety) 2022

This publication is available on request in other formats for people with special needs.

Further details of resources safety publications can be obtained by contacting:

Safety Regulation Group – Regulatory Support
Department of Mines, Industry Regulation and Safety
303 Sevenoaks Street
CANNINGTON WA 6107

Telephone: 1300 307 877

NRS: 13 36 77

Email: Safety@dmirs.wa.gov.au

Foreword

This code of practice is issued by the Commission for Occupational Safety and Health (the Commission), under provisions of the *Occupational Safety and Health Act 1984* (the Act). The introduction of the Act enabled the establishment of the Commission. It comprises representatives of employers, unions and government, as well as experts, and has the function of developing the occupational safety and health legislation and supporting guidance material, and making recommendations to the Minister for Mines and Petroleum; Commerce and Industrial Relations for their implementation. To fulfil its functions, the Commission is empowered to establish advisory committees, hold public inquiries and publish and disseminate information.

The Commission's objective is to promote comprehensive and practical preventive strategies that improve the working environment of Western Australians. This code of practice has been developed through a tripartite consultative process and the views of employers and unions, along with those of government and experts have been considered.

Legislative framework for occupational safety and health

Occupational Safety and Health Act 1984

The Act provides for the promotion, coordination, administration and enforcement of occupational safety and health in Western Australia. It applies to all workplaces with the exception of mining and petroleum. With the objective of preventing occupational injuries and diseases, the Act places certain duties on employers, employees, self-employed people, manufacturers, designers, importers and suppliers. These broad duties are supported by further legislation, commonly referred to as regulations, together with non-statutory codes of practice and guidance notes.

Occupational Safety and Health Regulations 1996

The Occupational Safety and Health Regulations 1996 (the Regulations) set out specific requirements of the legislation. They prescribe minimum standards and have a general application, or define specific requirements related to a particular hazard or type of work. They may allow licensing or granting of approvals and certificates. If there is a regulation about a risk in the Regulations, it must be complied with.

Codes of practice published under the Act

A code of practice provides guidance on achieving the standards of occupational safety and health required under legislation. It applies to anyone who has a duty of care in the circumstances described in the code of practice. In most cases, following a code of practice would achieve compliance with the duties in the legislation in relation to the subject matter of the code of practice. However, like regulations, codes of practice deal with particular issues and do not cover all hazards or risks that may arise. Duty holders need to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code of practice in determining what is reasonably practicable in the circumstances to which the code of practice relates. However, compliance with the legislation may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code of practice.

Scope

This code of practice applies to all workplaces in Western Australia covered by the Act where excavation occurs, and to all persons with the potential for exposure to hazards resulting from excavation in those workplaces, including:

- all areas where equipment is used to excavate
- all areas where processes associated with excavation are undertaken.

The document provides practical guidance to prevent occupational injury and disease in all workplaces where excavation and associated earthworks are performed.

Excavation work may range from shallow trenching and simple foundation excavation to large and complex excavations for buildings and structures and deep sewers where the risk of serious injury is very significant.

Who should use this code of practice?

This code of practice should be used by all persons involved in any aspect of work related to excavation, including designers, manufacturers, suppliers, employers, contractors, self-employed persons, managers, supervisors, persons in control of workplaces, employees and safety and health representatives to assist them to comply with the Act and Regulations.

Definitions

Appendix 1 defines the terms used in this code of practice.

Using this code of practice

The code of practice includes references to both mandatory and non-mandatory actions.

The words 'must' or 'requires' indicate that legal requirements exist, which must be complied with. The word 'should' indicates a recommended course of action, while 'may' is used to indicate an optional course of action.

Foreword..	III
Introduction.....	2
1 General	3
1.1 Purpose.....	3
1.2 Scope.....	3
1.3 Exclusions.....	3
1.4 Australian Standards	3
1.5 Definitions.....	3
1.6 Safe systems of work: workplace policies and procedures	4
1.7 Other people at the workplace.....	4
1.8 Preplanning and coordination	4
1.9 Referenced documents.....	5
2 Training, supervision and hazard	6
2.1 General	6
2.2 Training and supervision	6
2.3 Safety and health	7
2.4 Hazard management	7
3 Competent person	9
4 Preplanning	11
4.1 General	11
4.2 Support systems and retaining structures	13
4.4 Benching	14
4.3 Battering	14
4.5 Dewatering systems.....	15
4.6 Barriers and warning signs	16
4.7 Provision for movement of persons in, around and across an excavation	18
4.8 Inspections.....	19
4.9 Direct supervision	19
4.10 Establishing an area for placement of excavated materials, plant and other loads..	20
4.11 Traffic management	20
4.12 Location of underground services and other structures.....	20
4.13 Sources of information for assessing ground conditions	24
4.14 Factors to consider to avoid cave-ins	25
5 Daily site inspections.....	28
6 Safe practices in and around excavations	38
6.1 General	38
6.2 Working around mobile plant.....	40

7	Public safety around excavations.....	41
7.1	General	41
7.2	During working hours	42
7.3	Outside working hours	42
7.4	Special precautions	42
8	Worker safety in and around excavations	43
8.1	Access	43
8.2	Emergency access and egress	43
8.3	Working alone	45
8.4	Working space	45
8.5	Safety helmets	45
8.6	Eye protection	45
8.7	Dust nuisance	45
8.8	Fumes and emissions	46
8.9	Adequate lighting	47
8.10	Protection from falls	47
8.11	Separation of traffic	47
8.12	Ramps and runways	48
8.13	Plant and gear	48
8.14	Excavation plant operating near overhead power lines	48
8.15	Scaffolding	51
8.16	Use of lasers	51
8.17	Drainage	51
8.18	Additional precautionary measures	51
9	Safe slopes.....	52
9.1	General	52
9.2	Placing the excavated material	54
9.3	Cohesive strength and earth pressure	55
10	Types of excavations.....	57
10.1	General	57
10.2	Mechanical excavation – open cut	57
10.3	Mechanical excavation in clay, or rock	58
10.4	Mechanical excavation – blasting	58
10.5	Excavators, trench diggers and backhoes	60
10.6	Bulldozers and scrapers	60
10.7	Vacuum excavation	61
10.8	Hand excavation in sand	61
10.9	Hand excavation in clay and limestone	61

11	Ground support systems.....	62
11.1	Excavations without shoring.....	62
11.2	Cutting the face of an excavation to a safe slope	63
11.3	Excavation support.....	63
11.4	Closed sheeting or shoring	64
11.5	Telescopic sets.....	66
11.6	Specifications for timber shoring of trenches.....	66
11.7	Stability of affected buildings or structures.....	68
11.8	Sacrificial sets.....	68
11.9	Soldier sets.....	68
11.10	Alternative soldier set: hydraulic support systems	69
11.11	Tunnelling	70
11.12	Shafts	71
11.13	Side lacing	71
11.14	Shields or boxes	72
12	Removal of shoring.....	76
12.1	General.....	76
12.2	Removal of steel trench boxes	79
13	Steel sheet piling	80
13.1	Uses of steel sheet piling.....	80
13.2	Driving steel sheet piling.....	81
13.3	Supporting steel sheet piling	81
14	Steel trench sheeting.....	83
14.1	Driving steel trench sheeting	84
Appendix 1	Definition of terms.....	85
Appendix 2	Referenced documents	87

Introduction

Excavation is regarded as one of the most hazardous construction operations.

Excavation failure occurs very quickly, giving a worker 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, burying and crushing any person in its path. This can result in potentially fatal injuries or suffocation.

This code of practice sets out industry-wide guidelines for establishing and maintaining a safe working environment wherever excavation, including trenching, is carried out.

The construction industry should be aware of its obligations to protect workers and members of the public under the Act, Regulations and codes of practice.

This code provides practical advice about the safe practices required in carrying out all forms of excavations, including trenching, in various soil types. Advice is given on the provision of protective systems to prevent cave-ins, to protect workers when cave-ins occur and to protect workers from material that could fall or roll from an excavated face or from the collapse of adjacent structures.

Protective systems include support systems (steel, aluminium and timber), battering, benching and shield systems.

The code is based on current knowledge and construction methods. However, it is not intended to exclude other techniques that can be shown to meet the requirements of providing a safe workplace.

The advice provided on safe slopes for various soil types in Section 9 and Figure 16 of this code should be used only as a guide. Examination of site conditions by a competent person is necessary to determine safe slopes for excavations.

Safe slopes depend on the height of the face, soil type and geological conditions, the moisture content of the soil and any surcharge loads.

Soil moisture content and geological conditions may change as excavation progresses, causing safe slopes to become hazardous.

1 General

1.1 Purpose

The *Occupational Safety and Health Act 1984* (the Act) contains general duties which describe the responsibilities of people who affect safety and health at work. These duties apply to the safe work practices to be followed in excavation, including trenching, to ensure, as far as is practicable, a safe working environment for those involved. The Act and Occupational Safety and Health Regulations 1996 (the Regulations) should be read in conjunction with this code of practice.

1.2 Scope

This code provides information to assist with the planning, preparation and conduct of work practices, including the installation or provision of protective systems to protect workers from earth collapse or ground movement while working in and around excavations. The code also includes information on support systems, battering and benching, and shield systems.

1.3 Exclusions

This code is not intended to cover excavations carried out on mine sites, which are covered by the *Mines Safety and Inspection Act 1994* and its Regulations.

1.4 Australian Standards

Australian Standards referenced in this code are listed at Appendix 2.

1.5 Definitions

The terms 'excavation', 'excavation work' and 'competent person' are used extensively in this code of practice.

- 'Excavation' means a hole in the earth, or a face of earth, formed after rock, sand, soil or other material is removed (such as a trench, ditch, shaft, well, tunnel, pier hole, cutting or caisson or a hole drilled in the earth).
- 'Excavation work' means work to make, fill or partly fill an excavation.
- 'Competent person' is defined in regulation 1.3 of the Regulations as follows:
 - 'competent person', in relation to the doing of anything, means a person who has acquired through training, qualification or experience, or a combination of those things, the knowledge and skills required to do that thing competently.

Section 3 of this code provides advice on the knowledge and skills required of a competent person for various types of excavation work.

Appendix 1 defines the terms used in this code of practice.

1.6 Safe systems of work: workplace policies and procedures

Policies and procedures should be developed and implemented for each workplace where excavation work is to be carried out to ensure safe systems of work. These should include:

- hazard identification and risk assessment and control processes
- monitoring performance and reviewing control measures
- mechanisms for consulting with workers
- induction and training programs
- an agreed system for reporting and recording information on identified hazards or other relevant safety and health information
- safe work methods (e.g. job or task procedures)
- ongoing inspection and maintenance programs
- emergency rescue procedures
- review of safety management policies and procedures.

1.7 Other people at the workplace

The Act sets out duties for other parties involved at the workplace.

Employers or self-employed people must take reasonable care to ensure their own safety and health at work, and the safety and health of others affected by their work [Section 20–21 of the Act].

Employment or engagement of contractors and their employees – the person (called the principal) must ensure the safety and health of anyone they engage (called the contractor) to do the work. The principal is considered to be the employer of a contractor and any people employed or engaged by the contractor to carry out the work. Therefore, the principal has an employers' duty of care to contractors and their employees for matters over which the principal has control [Section 23D of the Act].

Designers, manufacturers, importers and suppliers of plant must ensure through testing and examination, so far as is practicable, that the design and construction of the plant is such that anyone installing, maintaining or using the plant in excavation work is not exposed to hazards. Adequate information regarding any dangers associated with the plant, its specifications, conditions of use and its proper maintenance must be provided when the plant is supplied or as requested [Section 23 of the Act].

1.8 Preplanning and coordination

Preplanning and coordination between those involved in excavation activities is essential to ensure the safety of all those involved and members of the public.

Before any excavation work commences, the exact location of certain underground services needs to be established in accordance with regulation 3.21. These services are electrical power cables, gas pipes, sewer pipes and water pipes.

The exact location of other underground services, such as telephone and telecommunications cables, drainage pipes and soakwells, fuel lines and storage tanks, should also be established.

Site plans and drawings from public utilities and relevant local government authorities may be useful, but could be outdated and inaccurate.

Consideration should be given to the possibility of encountering toxic atmospheres during excavation operations, especially if gas pipes or fuel lines cross, or are close to, the excavation line. Where toxic atmospheres are encountered, testing must be carried out to establish the nature of the atmosphere so that the correct personal protective equipment (PPE) can be provided. Hazardous substances may be present in excavated material where the work is carried out in existing or old industrial areas and landfill sites. The Commission code of practice, *Personal protective clothing and equipment* should be referred to for further information on the need for personal protective equipment, such as respiratory protection.

Before any excavation work commences, the existence, or otherwise, of overhead power lines in the vicinity of the excavation should be established. Consideration should be given to safe methods of operation of excavation and lifting equipment around overhead power lines. Section 8.14 of this code provides information on the safe operation of plant near overhead power lines.

All plant and equipment to be used must be properly maintained in accordance with the provisions of the Act and Regulations and plant operators must be appropriately trained and certificated, if necessary.

Sufficient industrial grade portable ladders complying with the requirements of AS/NZS 1892 need to be on hand to enable workers to gain access to, or egress from, the excavation. Workers should not be permitted to climb up or down components of shoring systems since this may weaken the shoring and trigger a collapse.

Unless a competent person determines otherwise, workers should not be allowed to enter a trench excavation unless it has been safely sloped, benched, shored or the workers are protected by a trench shield.

Workers and members of the public must be protected from falling into excavations by the use of appropriate barriers and warning signs.

Provision should be made for the regular inspection of the excavation by a competent person in accordance with the relevant sections of this code. 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, or if a previous excavation has disturbed virgin ground. The soil condition and state of any battering and benching of excavation faces and any shoring needs to be frequently checked for signs of earth fretting, slipping, slumping or swelling.

1.9 Referenced documents

Documents referenced in this code are listed in Appendix 2.

2 Training, supervision and hazard management

2.1 General

A principal objective of the Act is to promote safe working environments and to prevent harm to workers. To do this, it imposes duties of care on employers, employees and others, and requires employers and workers to cooperate in ensuring that workplaces and work practices are safe and without risks to health.

One of the employer's primary duties under the Act is to provide:

'such information, instruction, and training to, and supervision of, the employees as is necessary to enable them to perform their work in such a manner that they are not exposed to hazards'.

Employers owe this same duty of care to independent contractors and the contractor's employees working at the workplace. The Commission guidance note, *General duty of care in Western Australian workplaces* provides detailed information on the duty of care.

In fulfilling this obligation, there should be a structured system of education and training to enable both employers and workers to:

- identify and manage the risks involved in excavation
- keep up-to-date with the current state of knowledge within the industry on means of eliminating hazards and controlling risks to safety and health.

2.2 Training and supervision

Workers, including supervisors, must work safely. They should be trained and instructed in safe systems of work and safe work practices in order to maintain a working environment that ensures, so far as is practicable, they are not exposed to hazards.

Employers should ensure a competent person maintains supervision of workers when excavation work is being carried out.

The required capabilities of a competent person will vary depending on the nature of the excavation work being carried out, and are discussed in Section 3 of this code.

Training programs should emphasise occupational safety and health and should provide opportunities for individuals to develop new knowledge and skills. Such training should be in addition to, and not replace, the requirement for site-specific induction.

Training and instruction programs should include:

- induction on this code, including training in safe methods of excavation work
- identification of hazards and risks associated with the use of excavation plant and equipment
- the selection, fitting, care, use and storage of protective clothing and equipment
- first aid training to the minimum requirements of the Commission code of practice, *First aid facilities and services*.

2.3 Safety and health

Employers should consult with workers in the development of procedures applying to hazard identification, assessment of risk and methods used to control the risk.

Employers need to take all practicable steps to:

- provide and maintain a safe working environment
- provide and maintain facilities for the safety and health of workers
- ensure that workers are protected from hazards in the course of their work
- provide procedures to deal with emergencies that may arise while workers are at work
- consult and cooperate with safety and health representatives, if any, and other workers at the workplace regarding safety and health at that workplace.

Before commencing work on a project, workers need to be informed by their employer of:

- hazards they may be exposed to while at work
- hazards they may create while at work that could harm other people
- how to minimise the likelihood of hazards becoming a source of harm to themselves and others
- the location and correct use of safety equipment
- emergency procedures.

Employers should inform workers of the results of any safety and health monitoring carried out in the workplace.

Workers are responsible for their own safety and health while at work and should take reasonable care to ensure that their actions do not harm or place others at risk. One of their obligations is to cooperate with their employer on safety and health matters and not to interfere with or misuse anything provided by their employer to protect safety and health.

Employers, so far as is practicable, are also responsible for the safety and health of people who are not employees. Employers need to take all practicable steps to ensure that the work of the employer or workers does not harm any other person while at work, including members of the public or visitors to the workplace.

2.4 Hazard management

Workers need to have an effective method in place to identify hazards and to determine whether there are significant hazards that require further action. A hazard is an existing, new, or potential situation or event that could result in injury or harm to health.

Excavation is recognised within the construction industry as one of the most hazardous operations, with risk always present.

Workers must not be required to work in an excavation 1.5 metres or more deep that is not protected by shoring.

Excavated slopes considered to be safe may quickly become hazardous due to changes in weather or geological conditions.

Workers should not be permitted to work under raised loads and must be protected from loads or objects falling from excavation equipment or other equipment.

To ensure appropriate hazard management, an identification of the hazards and an assessment of the risks from these hazards should be carried out in conjunction with safety and health representatives. If there are no safety and health representatives, other workers should be involved in developing the hazard identification, assessment and management process.

A job safety analysis that lists the hazards and suggests safety procedures should be prepared. The minimum requirements for this job safety analysis (JSA) include:

- a JSA that is specific to the current project and task
- an identification of the hazards
- an assessment of the risks from the hazards identified
- control measures required to eliminate or minimise the risks from the hazards
- identification of the person responsible for implementing and monitoring the control measures.

Where possible, the hazard should be eliminated, or the risk reduced, by changing or modifying the proposed work method or construction method, or by use of alternative equipment.

Where the hazard cannot be eliminated, control measures should be implemented to isolate the hazard and to minimise risk to workers. In these circumstances, measures, such as barricading areas of danger, provision of specific safety training and work instructions, use of protective equipment and posting of warning signs, should be implemented. Such measures should be discussed with workers and evaluated to ensure that they are effective and do not create additional hazards.

The accepted means of planning to prevent injury is to identify hazards and then assess and control the risk. At the control stage, there is a preferred order of hazard control measures that should be applied.

3 Competent person

Employers should ensure a competent person maintains supervision of workers when excavation work is being carried out.

A competent person is defined in the Regulations as:

'one who has acquired through training, qualification or experience, or a combination of those things, the knowledge and skills required to do that thing competently'.

A competent person should be capable of identifying existing and predictable hazards or dangerous and unsafe working conditions in and around excavations, and be authorised to take prompt corrective action to eliminate them. A competent person should have knowledge of, and experience in, the installation and use of protective systems and their causes of failure, and the ability to detect conditions in excavations that could result in cave-ins.

The term competent person is used extensively throughout this code and the necessary capabilities of the competent person in each particular instance will vary depending on the complexity of the excavation work being carried out.

The scope of excavation work, by definition, varies from straightforward and simple excavations, such as shallow trenching, to extremely complex and deep excavations in unstable ground where engineer-designed support systems are needed.

The knowledge and skills required of a competent person will increase as the complexity of the excavation work increases. Size is not the only determinant of knowledge and skills needed. Many small size excavation works will be complex because of the soil conditions and stability considerations.

Many simple and straightforward excavations will only require experience while work that is more complex may require training and qualifications as well. It is the complexity of the excavation that determines the need for training, qualification or experience, or a combination of those, to carry out regular inspections.

Because of the technical issues involved in many situations covered in this code, a competent person will need either to be an appropriately experienced engineer, or to act on advice from an engineer on a specific aspect of the excavation. This may include situations excavations that are:

- deeper than six metres
- adjacent to ponded water
- in soils with slip planes or variable ground conditions
- involving complex dewatering
- where it is necessary to evaluate the pressure on trench walls from surcharge loads; for example, excavated material, machinery or adjacent structures, so as to determine appropriate ground support systems.

In many other situations, considerable experience in excavation work, including shoring of excavated faces, and a sound knowledge of the technical principles involved in excavation work, will be necessary.

All competent persons should have a sound knowledge of:

- how to identify and locate underground services
- the hazard identification and risk management process for excavation work
- safe work practices for excavation work
- how to identify soil types and other factors that affect the safety of an excavation
- occupational safety and health legislation and relevant Australian Standards.

4 Preplanning

Assessing means of reducing excavation risk

Regulation 3.108 states:

A person who, at a workplace where excavation work is to be done, is an employer, the main contractor or a self-employed person must consider, as part of the assessment process referred to in regulation 3.1, whether any identified risk of injury or harm to persons doing the work, persons in an excavated area or persons otherwise in the vicinity of the work may be reduced by any of the following means:

- (a) temporary support systems;
- (b) battering;
- (ba) benching;
- (c) other forms of retaining structures whether of a temporary or permanent nature; and
- (d) dewatering systems,

for use or application during and after the work.

4.1 General

Preplanning and coordination between those involved in excavation operations and activities is essential to ensure the safety of workers and protect members of the public.

Safety in and around excavations should be considered as part of job planning from the commencement of a project. Identification of hazards should be part of the planning, design and estimating process.

Particular hazards should be identified by those people involved in excavation projects before excavation commences and during the life of the project as site conditions change. Hazard identification should be an ongoing process. Identifying hazards at an early stage should enable methods of operation and protective systems to be chosen which will reduce risk as far as practicable throughout all stages of the project.

A systematic approach to documenting hazards for large or complex excavations during the planning phase of a project is necessary to enable information to be effectively utilised during the construction phase. This should include identifying any in ground services in the area being excavated due to the potential for engulfment from water or gas.

Before excavation commences, all available information should be collected about the exact location and details of the excavation, and disposal areas for excavated material, so that suitable methods of working can be planned and the most appropriate plant for the job can be obtained.

Workers should be instructed on current industry best practices for stabilising and shoring up the walls of an excavation to prevent collapses and maintain the integrity prior to commencing or entering an excavation.

From a consideration of the nature of the material to be excavated and the method of its disposal, the type of excavation, the length of haul, and the amount of compaction needed, it is possible to select the most suitable items for:

- excavating plant (when quantities are large, it may be productive to use different types of plant for the various materials to be excavated)
- stockpiling on site (a site may need to be found for temporary stockpiling of materials)
- transporting the excavated material (the length of haul, the nature of the haul route, the conditions of tipping, or spreading, and the type of excavator used are factors to consider)
- placing the material (the methods and plant used for transporting and compacting the material should be evaluated)
- dewatering equipment, if required, and the system to be used.

Collapses or cave-ins occur in excavation work for a number of reasons and are seldom due to one factor only. A collapse or cave-in is the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a support system or trench shield, and its sudden sliding or falling into the excavation in sufficient quantity to entrap, bury or otherwise injure and immobilise a person.

Cave-ins often occur because of inadequate investigation being carried out before work commences, and the failure to use methods and install protective systems shown to be necessary by an analysis of the soil structure of the face. Poor workmanship, the use of defective materials, poor maintenance and the failure to adequately provide for temporary loads above the face and loads from nearby structures are other causes of collapse, as well as inadequate subsoil drainage and weather changes that alter the ground water level and condition of the soil.

Collapse of an excavation may endanger life and property.

Regulation 3.108 requires that consideration be given, as part of the risk assessment process, to whether any identified risk of injury or harm to persons doing excavation work, or in the excavation or in the vicinity of the work, may be reduced by:

- temporary support systems
- battering
- benching
- other retaining structures
- dewatering systems.

This provision applies to persons carrying out the excavation work and persons carrying out other activities in the excavation, such as pipe laying, surveying, concreting, etc. It also applies to members of the public in the vicinity of the work.

The risk assessment process should also consider the establishment and maintenance of safe access and egress to the excavation and workplace, along with a secure structure to prevent unauthorised access, particularly after hours.

No item of plant, excavated material or other load must be placed near an excavated area where there is risk that the sides of the excavation may collapse or the plant, material or other load may fall into the excavation.

Therefore, materials and equipment should be kept at least 600 mm from the edge of an excavation and where possible, this should be a minimum of two metres (see Figure 1). These area from the edge of the excavation is known as the 'zone of influence', which refers to the volume of soil around the excavation which may be affected by an external load.

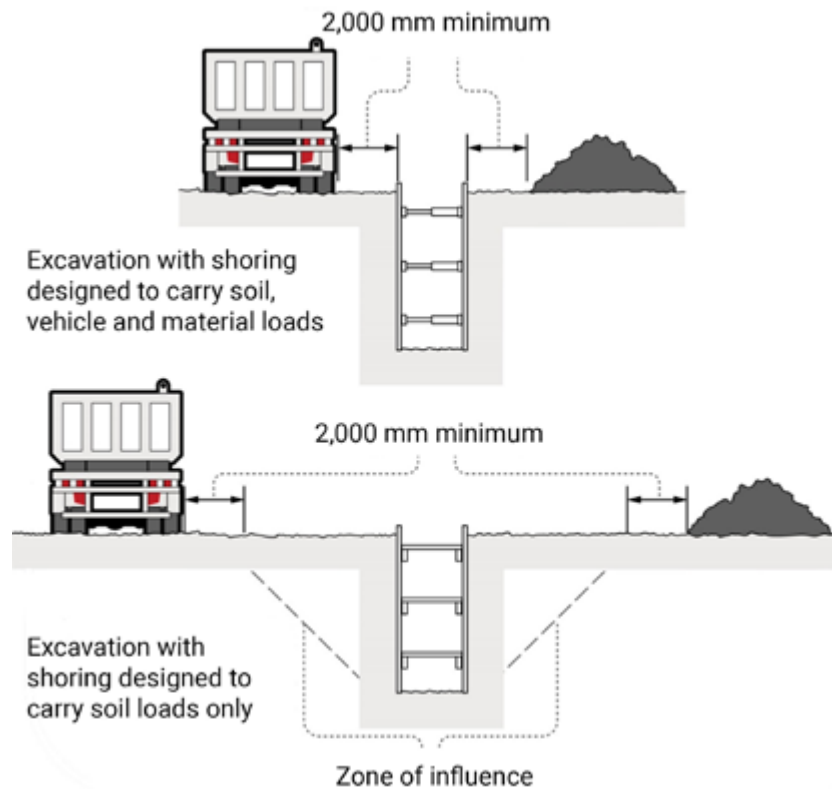


Figure 1 Excavated material and loads near excavations

As such, the location of laydown or storage areas should be considered during the preplanning phase.

The means of reducing the risk of injury or harm mentioned above are explained in Sections 4.2 to 4.5 of this code.

4.2 Support systems and retaining structures

Support systems and retaining structures include shoring systems to support the sides of an excavation, shield systems to protect against cave-in and structures such as underpinning, and shoring or bracing to provide support to an adjacent structure or underground installation.

Shoring is the provision of support for excavation faces to prevent movement of soil. Shoring or shielding is used when the location of an excavation or the depth of cut makes battering or benching impracticable.

The two basic types of shoring are hydraulically operated metal shoring and timber shoring. However, shoring commonly consists of hydraulic jacks and steel struts, walls and sheeting, although aluminium or timber components are sometimes used.

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. Materials such as wood, fibreglass or aluminium behave very differently to steel and require different design considerations, often making it more efficient to use adjustable metal jacks or struts.

Shields or trench boxes differ from shoring in that they do not support the trench face. They are intended primarily to protect workers from cave-ins. The space between the trench box and the sides of the excavation are backfilled to prevent lateral movement of the box.

Trench shields are generally used in open areas where drainage is satisfactory. However, they may also be used in combination with sloping and benching. Further information on support systems and retaining structures is contained in Section 11 of this code.

4.3 Battering

Battering, often referred to as sloping, is a way of preventing cave-ins by cutting the face back to a safe incline (see Figure 2). Advice from a competent person is always needed to assess safe slopes since the angle of incline required to prevent collapse varies with the soil type, the height of the face, the moisture content of the soil and any surcharge loads acting on the face.



Figure 2. Battering.

It is not necessary to batter the face of excavations which a competent person determines are in stable rock, or has assessed there is no risk of a potential cave-in.

Battering the sides of an excavation to provide safe working conditions is often only economical for shallow excavations in open ground with minimal obstructions. For deeper excavations and trenches, shoring or the use of shields can usually provide a quicker and more economical option by reducing the quantity of excavation, placement, backfill, and issues involved with land restoration in built up areas.

Workers need to be protected from loose rock or soil falling or rolling from a sloping face. Hand scaling of loose material from the face may be necessary, and in some instances, protective barriers may be necessary on the face to contain falling material.

Workers also need to be protected from excavated or other materials or equipment that could fall or roll into the excavation.

Information on safe slopes is provided in Section 9.

4.4 Benching

Benching is a method of preventing collapses or cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, with vertical surfaces between levels (see Figure 3).

As for battering, the type of soil determines the horizontal to vertical ratio of the benched side. Benching is suitable only for cohesive type soils.

Generally, the bottom vertical height of a trench excavation should not exceed 1.2 metres for the bench. Subsequent benches should also be 1.2 metres vertical height. In all benching operations, the overall slope of the excavated sides should not exceed the safe slopes mentioned in Section 9.1.



Figure 3 Benching

4.5 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
- swamp, dam, lake or river.

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.

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

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.

Drainage is achieved by jetting wellpoints or 'spears' into the ground to the desired depth, and pumping out the water at a rate exceeding the inflow from the surrounding water table.

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. Wellpoints are usually spaced about one metre apart.

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.

In wider trenches, or where water volumes are large or the water table is high, a line of wellpoints may be required on both sides of the excavation. Groundwater can be lowered about six metres by this method. If greater depths of excavation are required, a second stage installation can be installed at a lower level after the excavation has proceeded as far as the dewatering will permit.

Other systems for lowering ground water levels beyond six metres are available and expert advice should be sought to obtain the most suitable arrangement.

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 contractor 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 by simply withdrawing it.

The flow from each wellpoint will depend on the nature of the soil, porosity, etc. and the depth of the water table. The spacing of the wellpoints and the capacity of the pump should be designed to accommodate the volume of water.

Water control may also involve the prevention of flooding from surface run off. This may occur after heavy rain, or from overflowing stormwater drains because of the intensity of the rainfall or from under-design or lack of maintenance.

Consideration should also be given to the possibility of flooding from swamps, dams, reservoirs, lakes or rivers where the proximity of the excavation to these bodies of water and the terrain may allow overflow to enter the excavation.

Excavations in close proximity to bodies of water may also be at risk of collapse and flooding if the depth of excavation is lower than the water level. Where excavations are to be made adjacent to ponded water, advice should be sought from engineers experienced in this work.

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

Excavations that are subject to run off from heavy rains will also require inspection by a competent person at appropriate intervals.

4.6 Barriers and warning signs

Where person at risk due to excavation

Regulation 3.109(1) states:

- (1) *If, at a workplace where excavation work is to be done, any person is at risk of injury because of the excavation work then a person who, at the workplace, is an employer, the main contractor or a self-employed person must ensure that –*
 - (a) *suitable barriers are erected between the person at risk and the likely cause of the danger; and*
 - (b) *suitable signs that warn of the risk are erected at the place where the excavation work is to be done.*

Regulation 3.109(1) provides for suitable barriers to be erected between the person at risk and the likely cause of danger. Note that no mention is made of the height of the barrier, the type of the barrier or the distance of the barrier from the edge of the excavation.

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.

A hoarding is defined in the Regulations as “a substantial and fully sheeted fence or screen”, while a barricade is defined as a “temporary fence consisting of rigid vertical and horizontal members”.

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.

A suitable barrier placed well back from the excavation edge will provide protection for members of the public and some workers. However, workers inside the barrier near the edge will need some other form of barrier, such as edge protection or shoring of the sides of the excavation.

Many excavations in the metropolitan area, and other areas, are of considerable depth. For example, sewer trenches may exceed a depth of five 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.

Regulation 3.109(1) also provides for suitable signs that warn of the risk to 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. Signs should comply with the requirements of AS 1319.

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.

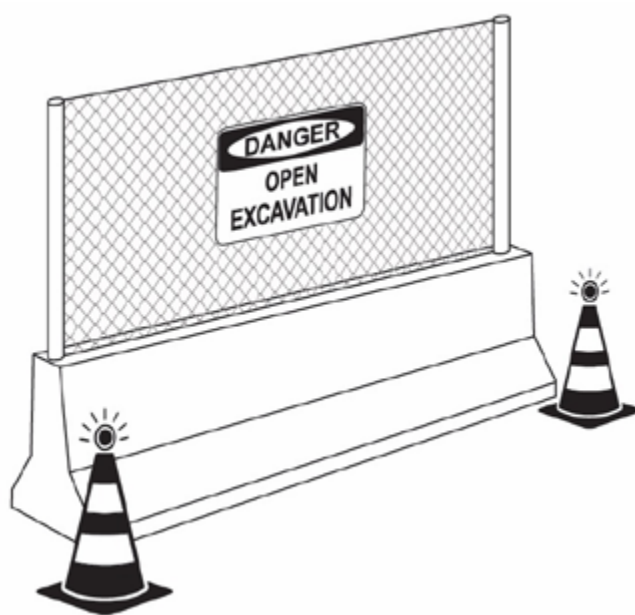


Figure 4 Barrier with hoarding

Barriers and warning signs in relation to public safety are covered in Section 7 of this code.

4.7 Provision for movement of persons in, around and across an excavation

Safe movement around and across excavation

Regulation 3.109(2) states:

- (2) *If, at a workplace, there is an excavated area in, around, or across the top of, which persons can move or plant can be moved then a person who, at the workplace, is an employer, the main contractor, a self-employed person or a person having control of the workplace must ensure, as far as is practicable, that –*
- (a) *persons can move safely in, around, and across the top of, the area; and*
 - (b) *plant can be moved safely in, around, and across the top of, the area. To enable safe access and egress to and from excavations, ladders, ramps or other safe means of entry or exit should be provided.*

For trench excavations exceeding a depth of one metre, ladders, ramps or other forms of access or egress should be provided at intervals of not more than 30 metres to limit the travel distance of a worker to 15 metres from the nearest means of exit (see Section 8.1).

Portable ladders must be in accordance with the relevant parts of AS/NZS 1892, properly secured and extend at least 900 mm above the surface of the excavation or intermediate landing. Metal ladders should be used with caution near overhead power lines or when electrical equipment is being used or electricity services are nearby.

Workers should not use the components of a shoring system as a means of entering or leaving an excavation. Toms and other components may have shifted and workers could easily injure themselves falling back into the excavation or, worse still, trigger a collapse onto themselves.

It is good practice to ensure that persons working in trenches are assisted by another person in the nearby vicinity in case of accidents. Working alone is discussed in Section 6.1.

Surface crossings of trenches should be avoided if possible. Where persons are required to cross trenches, properly designed walkways or bridges should be provided with guardrails and kickboards. Figure 21 in Section 11.4 of this code provides details of the requirements for simple access across the bearers of a closely sheeted trench.

Where there is a risk that persons could fall three metres or more from an edge or face, edge protection consisting of a fall injury prevention system (fall arrest harness and lanyard attached to an anchorage point) or alternatively guardrails consisting of a top rail, mid rail and toe board must be provided in accordance with regulation 3.55. The mid rail may be omitted if a mesh panel is provided with the toe board. Further information on the prevention of falls is provided in Section 8.10 and in the Commission code of practice, *Prevention of falls from height at workplaces*.

Provision for movement of plant in, around and across an excavation is discussed further in Sections 6.2, 7.2, 7.3, 8.13 and 8.14.

4.8 Inspections

Inspections of the excavation should be made daily before the start of work and as needed throughout each shift. A competent person should carry out inspections.

Inspections should look for indications of any situation that could result in cave-ins, failure of protective systems and any hazardous substances or toxic atmospheres being encountered.

Inspections should be carried out:

- daily and before work commences
- when tension cracks, sloughing, undercutting, water seepage, bulging or other similar events occur or when disturbed soil is encountered. These events are described in Section 5 and shown in Figures 6 to 13
- when the size, location or placement of the spoil heap changes
- when any indication of movement in an adjacent structure is noticed
- after every rainstorm and any earthquake or seismic event.

Where inspections reveal hazardous situations, workers must be removed from the excavation until precautions have been taken to ensure their safety.

Inspections should be documented when hazardous situations are identified.

4.9 Direct supervision

Employers should ensure a competent person maintains supervision of workers when excavation work is being undertaken. Section 3 details the requirements of a competent person for the purpose of this code of practice.

Direct supervision means continuous and close supervision necessary for particular activities and work processes. There are likely to be many activities in excavation work requiring this level of supervision. The need for direct supervision of particular activities will depend on the size and complexity of the excavation and the nature of the soil encountered.

The commencement of shoring or shielding operations and their subsequent removal are activities where the risk of injury to workers is particularly high and requires direct supervision.

Direct supervision should always be provided to operations involving exposure of underground services, such as electric power, gas, water or sewer lines. The risk of injury from electricity, fire, explosion, engulfment or becoming overwhelmed by a contaminant is high during these activities.

Direct supervision of trenching carried out for soil investigation purposes is always necessary when entry is made into unshored deep trenches to examine soil profiles.

The need for supervision of workers to ensure they are not exposed to hazards is a fundamental requirement of the Act, which states at section 19(1)(b):

'an employer shall provide such information, instruction, and training to, and supervision of, the employees as is necessary to enable them to perform their work in such a manner that they are not exposed to hazards'.

4.10 Establishing an area for placement of excavated materials, plant and other loads

No loads near excavation work

Regulation 3.110 states:

A person who, at a workplace where excavation work is done, is an employer, the main contractor or a self-employed person must ensure that no item of plant, no excavated material and no other load is placed near the excavated area in a position where there is risk that –

- (a) *the sides of the excavated area may collapse; or*
- (b) *the plant, material or other load may fall into the excavated area.*

Prior to excavation commencing, consideration should be given to the need for a dedicated area to be set aside for stockpiling excavated material and to accommodate idle plant and equipment and other materials until they are required on site. This area should be clearly signposted to alert workers to its location.

Without a temporary stockpile area, the excavated material and plant is usually placed above the face of the excavation. Unless these temporary loads have been provided for, collapse of the face may occur.

See Sections 5 and 9.2 for further information regarding placement of excavated material near the edge of a trench or other excavation.

4.11 Traffic management

Prior to commencement of excavation affecting roads or traffic movement, a documented traffic management plan should be prepared that includes, where necessary, traffic controller, barricades and any road closures. This traffic management plan should be available on site at all times when work is carried out.

Information contained in the Main Roads Western Australia code of practice, *Traffic management for works on roads* should be utilised in preparing the traffic management plan.

4.12 Location of underground services and other structures

Regulation 3.21 requires the location of certain underground services to be established before work commences where there is any risk that the excavation work may interfere with these services.

These services are electricity, gas, water and sewerage.

In addition, an assessment should be made of the likelihood of other underground hazards being present before any excavation work commences. These hazards could include telephone and fibre optic telecommunication cables, drainage pipes and soakwells, fuel lines and underground storage tanks. The exact location of these potential hazards should also be determined if they are in close proximity and may have a bearing on the safety of the excavation. The precise location of sewerage services where cut-ins are required on a sewer main in a trench should be established at the preplanning stage. This will avoid the need to remove any part of the support system for cut-in purposes.

Tunnelling into unsupported ground should never be undertaken.

Underground services are widespread and should be assumed to be present until proven otherwise. Trench excavations in street reserves will almost certainly encounter underground services within the trench or in the face of the excavation parallel to the line of excavation.

Many injuries occur when underground services are struck, penetrated or damaged during excavating. Electric shock or electrocution may result from striking electricity cables with excavation equipment. However, not all accidents happen immediately. Some happen much later due to the effects of corrosion on a damaged or weakened service line. Pipe leaks or bursts, gas flames or explosion can cause personal injury and disrupt vital community services.

When planning an excavation, a complete search for the location of underground services should be undertaken before work commences. At this stage, many risks associated with working near existing underground services can be minimised.

Once the records are obtained, they should be kept in the work area and be accessible to all workers.

Although records of underground services should be made when installed, many changes to the land surface may have occurred since the services were installed, for example road widening and regrading. It is important to check the location of services when working from old records. This may be carried out by visual inspection of valve pits and covers, use of pipe and cable locating instruments and careful spot excavation under direct supervision.

It should be noted that some services have no metallic content and therefore cannot be located by electromagnetic cable and pipe locators. Ground penetrating radar can be used to determine the approximate location of non-conductive underground infrastructure.

All digging to locate an underground service should be carefully carried out by hand approaching the service from the side. Mechanical excavating equipment should never be used to locate services.

Exposed service pipes should not be used as hand or foot holds or supports of any kind. Care needs to be taken to avoid any damage to protective coatings or cathodic protection.

In addition to the risk of personal injury caused by directly striking underground cables and mains, previously dug trenches have a weakening effect on the face of an excavation if they are in close proximity.

Information on the location of underground services may be obtained by contacting the Dial Before You Dig WA organisation. All public utilities and most service providers are members of the organisation. Operational guidelines are available from the website.

Dial Before You Dig WA operates as a coordinated underground facilities referral service providing a single point of contact for enquirers who wish to identify the facilities installed underground at the site of a proposed excavation in most public areas in Western Australia.

While providing a valuable source of information for the location of underground services in road reserves and other public areas, the information provided may not always be complete. In addition, it cannot provide information on the location of privately owned underground facilities on private property.

'As built' or 'as constructed' drawings may be available to show the location of underground services on private property. However, these are often unreliable or lost, so exploratory hand digging will be necessary to locate or confirm the location of services.

A contingency plan to be adopted in case of an emergency arising from damage to an underground service should be kept at the excavation site and communicated to workers. It should provide, as a minimum, emergency telephone numbers, containment procedures and procedures to ensure the safety of workers.

All work that is carried out within any urban, rural or regional road reserve in Western Australia needs to comply with the requirements of the *Utilities Providers Code of Practice for Western Australia* issued by the Utility Providers Services Committee.

The Code specifies procedures that should be carried out prior to commencing work, during work and requirements for reinstatement and restoration. Underground services are often backfilled with selected material to protect the coating of the service pipe. Generally, the backfill is fine grained to eliminate the risk of stone damage to plastic services. Any special backfill that is disturbed needs to be reinstated to its original standard.

The Code is also a source of information for contacting utility providers and sets out information on the allocation of space and alignments for utility providers within road reserves and rail reserves.

The *Utility Providers Code of Practice for Western Australia* has adopted the code of practice by Main Roads Western Australia, *Traffic Management for works on roads* to be used for all traffic control and safety purposes.

The main hazards that may arise from working near underground services are outlined in this section.

Electricity cables

It is not possible to give a description of all types of underground electricity cables, so any services not identifiable in the underground power alignment should be treated as electric cables. Specialist knowledge may be needed to make a positive identification.

Injury may occur or a loss of electricity supply may result if hand tools or machinery damages a cable sheath or conductor insulation. The explosive effects of arcing current, any associated fire or flames, or electric shock can cause serious or fatal injury.

All work near underground cables needs to be carried out in accordance with the requirements of the distribution authority (Western Power or other distribution authority).

Work should not commence until services identified as electric cables are de-energised and required precautions are taken.

Workers should not handle any cable or move any cable until the distribution authority has issued permission.

All electrical hazards and physical hazards associated with working near an electricity cable should be identified and the risks assessed. Formal safe working procedures need to be developed by the employer in association with the safety and health representative, if any.

The risk of contact with overhead power lines is covered in Section 8.14.

Gas pipes

Damage to gas pipes can cause gas to escape, which may lead to fires or explosions. Gas escape can occur immediately if the damage is severe or some time later if damage has occurred to the protective coating of the pipe. If damage occurs, contact the distribution authority who will undertake repairs. Damage that is not reinstated while the excavation is open can be extremely difficult and costly to repair at a later date.

Gas pipes are usually yellow coloured or have a yellow stripe. Gas mains and services belonging to the gas distribution authorities and are usually buried at depths from 300 mm to one metre.

Depending on the location and ground conditions, the mains are usually made from polyethylene, UPVC or steel and, in older suburbs, cast iron. Where the mains are plastic or steel and operate at high-pressure, they have a marker tape above them, 150 mm below ground level.

The pressure in gas mains can range from 1.25 kPa to 1900 kPa and should be treated with extreme caution. If a high-pressure main is fractured, gas will escape with an explosive force and probably catch fire, destroying anything in the vicinity.

If excavation work exposes gas pipes, the exposed pipes should be adequately supported. Distribution authorities have requirements for excavations near their infrastructure and must always be consulted prior to excavation work commencing.

Trenches should be adequately ventilated where gas pipes are exposed. In areas where LPG is reticulated, such as Albany, it may be necessary to use air movers to ensure leaking LPG does not accumulate in the bottom of trenches (see Section 8.8).

Gas installations on consumers' premises are constructed from copper, plastic or steel. The depth of cover is usually 300 mm to 750 mm. This type of installation can be isolated at the meter if a leak occurs downstream from the meter.

The minimum clearance between any gas pipe and other services is 150 mm, although 300 mm is preferred.

Fuel lines

These may contain liquid petroleum, oil or various types of gas. Damage can cause similar outcomes to gas pipe damage mentioned above. It is important to identify the product within the fuel line to enable appropriate safety measures to be undertaken.

Water, sewer and drainage pipes

Damage to water pipes can cause local flooding of an excavation which may undermine shoring and other supports causing collapse. This can have a disastrous effect on any other services in or nearby to the excavation. High-pressure pipelines, when damaged, can propel debris and other material at enormous force and cause severe injuries.

Broken sewer pipes can cause contamination of the ground and atmosphere and render an excavation unusable for some time. Many sewer pipes are under high-pressure.

Stormwater drains, when damaged, can flood excavations and may also contain contaminants and harmful gases.

Any results from monitoring carried out to detect toxic atmospheres or contaminants should be communicated to workers.

Telecommunication cables

Although the possibility of personal injury from a damaged telecommunication cable is small, the possibility of creating a hazardous situation due to interruption of communication during an emergency is very real.

Some telecommunication services contain fibre optic cables, which carry light signals generated by lasers. While the risk from a broken fibre optic cable is low, exposure to the laser beam may be harmful to the eyes and skin if in close proximity.

Telecommunication cables are usually coloured white or have a white stripe.

4.13 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. Safe slopes and support systems are covered in Sections 9.1 and 11.

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.

4.14 Factors to consider to avoid cave-ins

Shoring in excavation work etc.

Regulation 3.111 states:

(1) If, at a workplace –

- (a) any excavation work or earthwork is to be done and there is a risk that the matter forming, or adjacent to, the excavated area or the earthwork may fall or dislodge; or*
- (b) a person is required to work in an excavated area or other opening in the ground that is at least 1.5 metres deep,*

then a person who, at the workplace is an employer, the main contractor or a self-employed person must ensure that while a person is working in or near the work, area or opening, the work, area or opening is shored in a manner which will prevent it from collapsing or moving.

(2) A person does not commit an offence under subregulation (1) if, proof of which is on the person, the sides of the work, area or opening have been assessed by a competent person to be self-supporting by virtue of the angle of the slope of the sides or the stability of the matter comprising the sides.

Regulation 3.111 requires that every person working in or near an excavation needs to be protected from earth collapse or movement by an adequate protective system that has the capacity to resist, without failure, all loads that could be expected to be applied to the system. In addition, regulation 3.111 requires that if a person is required to work in an excavation 1.5 metres or more deep, then the person be protected by shoring.

The only exception to these requirements is where a competent person has determined that the excavation is made entirely in stable rock and an examination by the competent person shows no indication of a cave-in. The requirements of a competent person for the purposes of this code are set out in Section 3.

Protective systems were discussed in Sections 4.2 to 4.4 and include sloping and benching, support and shoring, and shield systems.

In assessing the risks to persons working in or near an excavation or earthwork, consideration needs to be given to the type of work being carried out. If a worker is on their knees laying pipes in a trench or working in a bent position, a trench less than 1.5 metres deep may present considerable risk. Changing soil and geological conditions, together with rain and seepage, can cause a safe slope to slump or flatten out.

In fulfilling the requirements of regulation 3.111, workers must be protected from risks at any depth.

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
 - 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.

Water control: Water control may involve the relatively simple removal of small amounts of water at the bottom of an excavation by electrically driven sludge pumps or it may involve the use of dewatering systems to control large quantities of water in situations where an excavation is below the level of the ground water table. Water control and dewatering systems were discussed in Section 4.5.

- 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: Enquiries should be made to the appropriate authority in regard to the location of services prior to excavation. Underground services and other structures were discussed in Section 4.12.

Previously dug excavations have a weakening effect on a trench wall if they are in close proximity to the trench 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.

- Point sources of instability that may require additional local support:
Closed sheeting should be used in unstable ground, possibly reverting to soldier sets when the excavation has progressed to more stable ground.
- 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, three metres deep and one metre wide, will create a heap weighing approximately six tonnes per linear metre of excavation. This needs 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
 - dams.

In case of static loads nearby, additional supports may need to be installed.

- 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.

5 Daily site inspections

In the course of daily routine inspections, it is important to watch for unsafe situations, which are common during excavating and backfilling. Surveillance of trench walls and support systems should be carried out frequently.

Other natural or artificial hazards, such as chemicals or hazardous substances like naturally occurring asbestos, may be present in the ground and pose a threat to health. Consideration should be given to having soil testing carried out or analysed by an independent hygienist as part of the inspection process.

All workers should immediately report to their employer any situation at the workplace that may constitute a hazard to any person if the worker cannot correct it. Workers at sites where an excavation is taking place, as well as others having reason to visit such sites, should be made aware of hazards likely to cause injury to themselves or others.

Adequate protection needs to be provided to safeguard workers from loose rock or soil that could fall or roll down the face of an excavation. Protection may be carried out by scaling to remove loose material or by the installation of protective barriers on the face to stop and contain falling material.

Workers should also be protected from excavated material, other materials or plant and equipment falling or rolling into the excavation.

Materials, plant and equipment should be kept or placed at least 600 mm from the edge of the excavation. The face of dumped excavated material should be kept at a safe slope and retaining devices or toe boards may be necessary to retain this 600 mm minimum clearance and prevent spoil from 'running' or sliding back into the excavation. See later paragraph 'Loads too close to edge of trench' on page 38, Figure 5, and Section 4.10.

Spoil should be placed so that it channels rainwater and other runoff water away from the excavation. When a trench is being excavated beside an old service line, spoil should be placed on the side opposite the old service line to prevent excessive loading on previously weakened ground.

When it is necessary to place spoil close to a trench due to nearby fences, buildings, trees, etc., the weight of the spoil pile may overload the sides of a trench, requiring the supporting system to be strengthened at these locations.

If it is necessary to place surcharge loads from stored material, plant or equipment near the edge of a sloped excavation face, the slope of the face may need to be flattened below the maximum allowable slope. A competent person should determine safe slopes, especially where surcharge loads are present.

An adequate system of safety should always be in place to protect workers from cave-ins or the risk to safety and health arising from one or more of the following:

- the fall or dislodgement of earth or rock
- the placement of excavated materials, plant or other loads
- the instability of any adjoining structure caused by the excavation
- the existence of a previous excavation
- the presence of underground services or structures
- the instability of the excavation due to persons or plant working adjacent to the excavation
- the presence or in-rush of water or other liquid.

Systems of safety were discussed in Sections 4.2 to 4.4 and include:

- **Battering** – protects workers from cave-ins by excavating the sides of an excavation at an incline, with the angle of incline varying with the soil type, the height of the face, the moisture content of the soil and the application of surcharge loads.
- **Benching** – similar to a sloping system but with horizontal levels and vertical slopes to give an overall benched slope.
- **Support systems** – generally refer to a structure used to support the sides of an excavation or to the underpinning or bracing of an adjacent structure or underground installation. Support systems are either shoring systems or shield systems.
- **Shoring systems** – steel or aluminium hydraulic or mechanical shoring system or a timber system to support the sides of an excavation and prevent cave-ins by the use of sheeting.
- **Shield systems** – structures, usually manufactured from steel, which is able to withstand the forces imposed on it by a cave-in and protect workers who work within the structure. Shields can be permanent structures or designed to be portable and be moved along as work progresses. Shields used in trenches are referred to as trench shields or trench boxes.

Workers in an unsupported trench

Workers can enter an unsupported excavation only if the exposed face is of good standing quality under all anticipated weather and working conditions, and where there is no imminent danger from collapse to persons within the excavation.

Figure 5 shows a worker in serious and imminent danger unless a competent person has assessed the vertical sides of the trench to be stable.

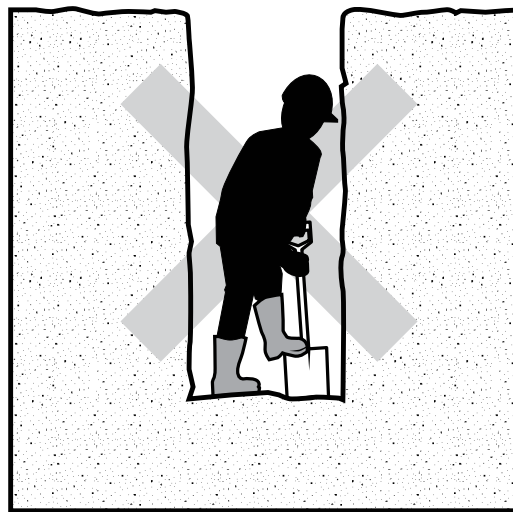


Figure 5 Worker in unsupported trench. Sides of trench need to be assessed by a competent person to be self-supporting.

Loads too close to edge of trench

Excavated material, pipes, tools or timber placed too close to the edge of an excavation are hazards likely to injure workers in the excavation if they are accidentally knocked or fall into the excavation.

Excavated material close to the edge of an excavation adds load to the excavated face. The probability of collapse without warning is increased (see Figure 6).

Generally, excavated material should not be placed closer to the edge of a supported trench than one-third of the trench depth.

For unsupported trenches, this distance will depend on the depth of excavation, moisture content and cohesive strength of the material and profile of the excavation. Generally, excavated material should be placed outside a 45-degree slope line passing through the bottom of the excavation and in no case closer than 600 mm from the edge of the excavation.

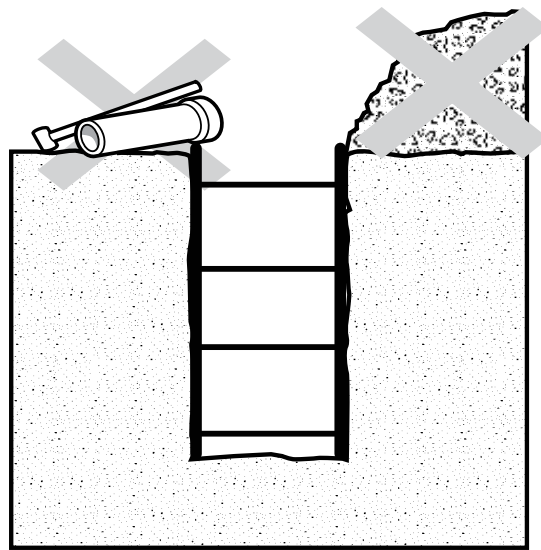


Figure 6 Excavated material, pipes and tools too close to the edge of trench

Cracks near and parallel to the edge of a trench

Cracks indicate that the ground support system has shifted or the support may be inadequate or incorrectly placed. Collapse may occur suddenly (see Figure 7).

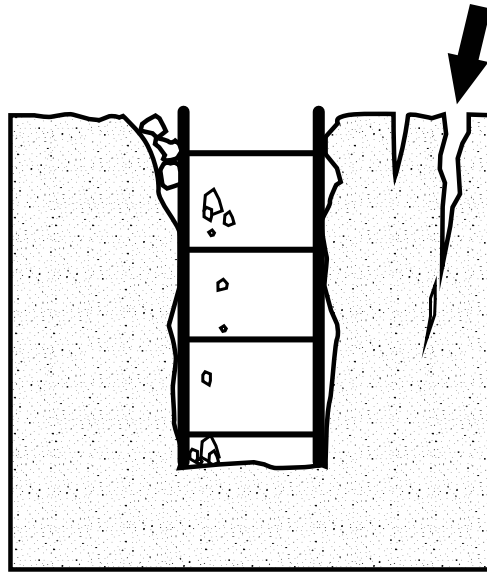


Figure 7 Cracks near and parallel to the edge of the trench

Subsidence alongside a trench

This event means there has been soil movement below the surface that increases the pressure against the supports, and therefore the possibility of a collapse. Soil movement may be caused by seepage behind the support (see Figure 8).

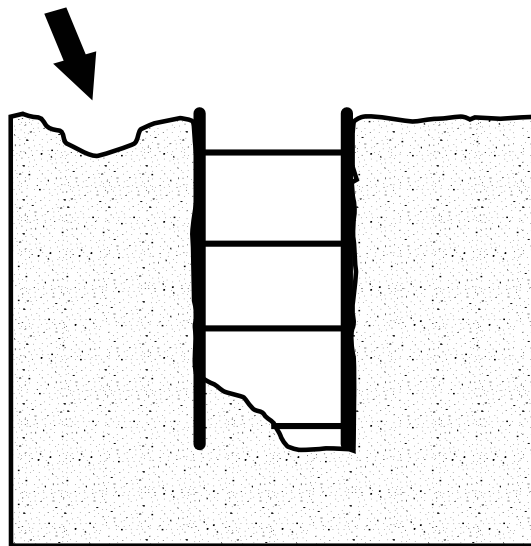


Figure 8 Subsidence alongside the trench

Water swelling or uplift of the trench bottom

This occurrence indicates soil movement, probably due to wet, unstable soil at the toe of the support system (see Figure 9).

The danger is that if supports are undermined, they may kick-in and cause a sudden collapse. An adequate trench support system is vital for safety in this situation.

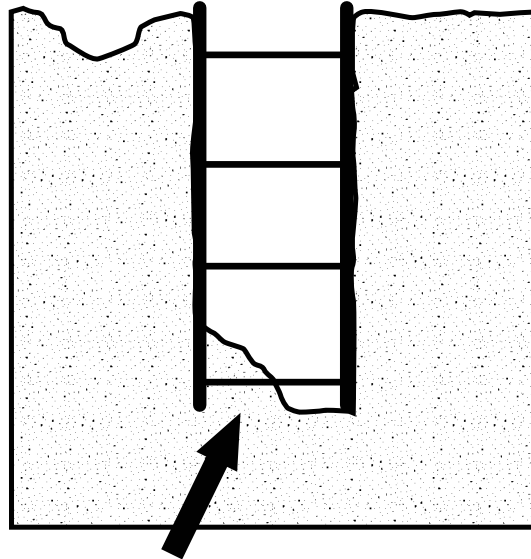


Figure 9 Water swelling or uplift of the trench bottom.

Surface soil falling into a trench

Trench support should project a minimum of 200 mm above ground level.

In Figure 10, workers in the trench are in danger from falling material that may cause eye or body injury.

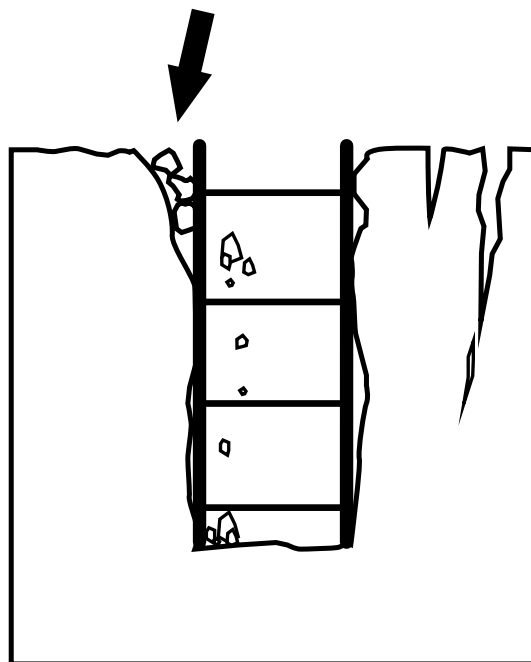


Figure 10 Surface soil falling into the trench.

Workers climbing on trench supports

This is a dangerous practice as the worker may slip or fall, or a tom or waling may be moved causing the support system to be weakened or collapse onto the worker (see Figure 11).

Ladders or other means of access should be provided and used for entry to and exit from the trench. See Section 8.1 for further information.

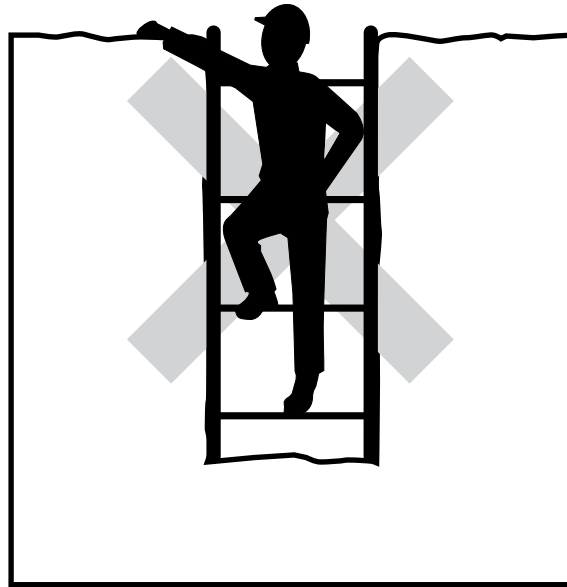


Figure 11 Worker climbing on trench supports.

Machines moving too close to edge of trench

The machine may damage the support system resulting in collapse of the trench. Where close working is unavoidable because of space limitation, the support system must be designed to cope with the extra loading due to the weight of the machine (see Figure 12).

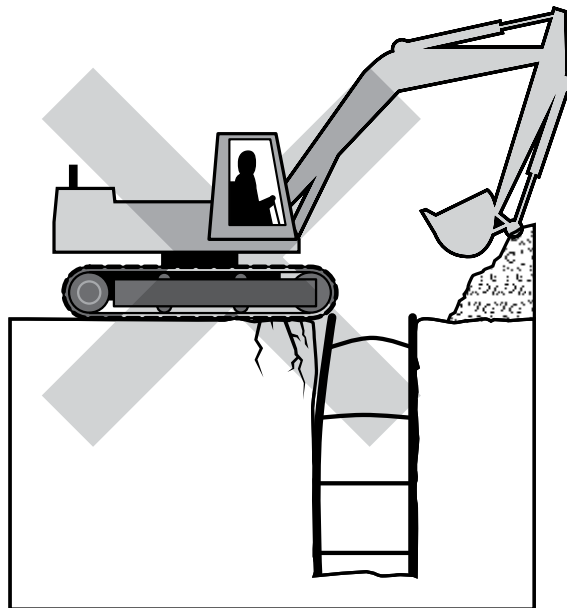


Figure 12 Machines moving too close to edge of trench.

Trench in or near previously dug ground

This situation requires special attention since collapse or cave-in is very likely. Where another service pipe is parallel to the trench, the previously dug soil may be waterlogged and that side of the new trench is more likely to collapse. Unfortunately, the previous excavation may not be apparent.

Where pipes are alongside or crossing a trench, there is also a danger if a pipe failure occurs. Good trench support is essential and temporary support for the pipe is necessary. A ladder adjacent to the hazard should be provided to allow quick escape in case of an emergency. This should be in addition to the usual entry and exit ladders. Figure 13 shows some possible situations.

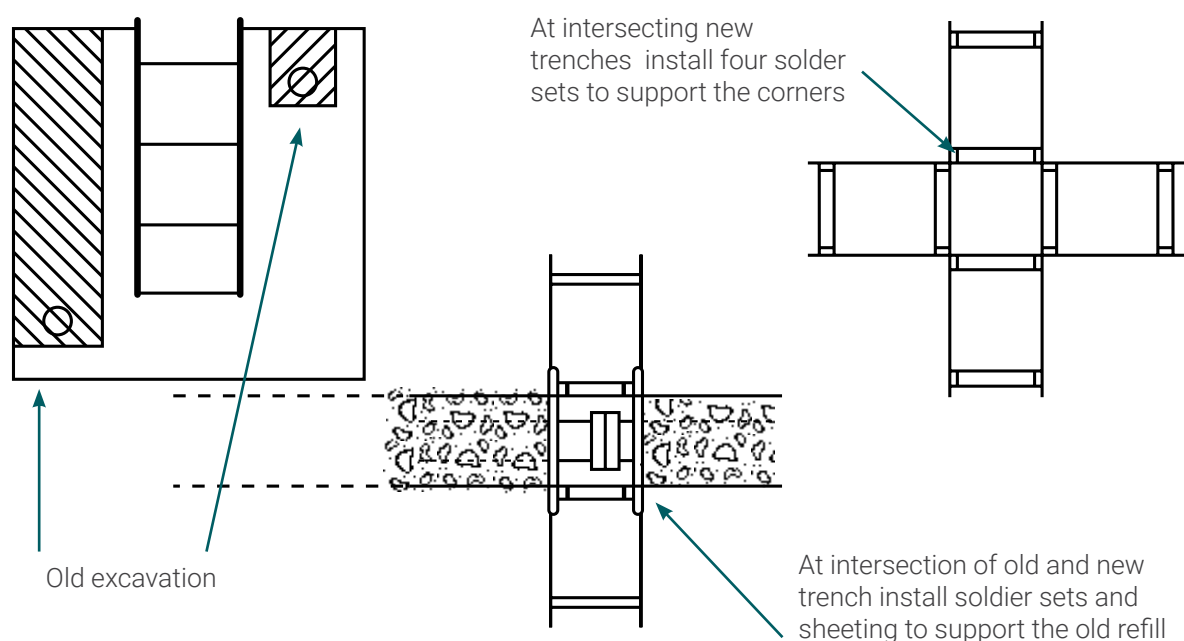


Figure 13 Trench in or near previously dug ground.

Made-up ground or backfill ground

Made-up ground or backfill ground increases the risk of collapse or cave-in and requires special attention. It may not be obvious that the excavation or trench is in made-up ground or backfill material. This type of ground is usually less compact than virgin ground and the sides of these excavations may be very unstable. Sides of excavations can quickly become waterlogged and collapse. Close attention to trench support is essential. Figure 14 shows a common occurrence.

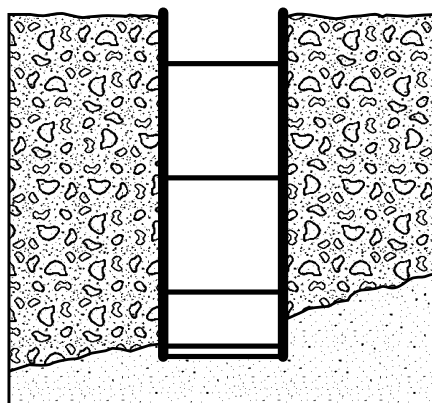


Figure 14 Made-up or backfill ground.

Nearby machines causing vibrations

Nearby machinery that can cause vibrations, include rock breakers and stationary plant, such as compressors or pile drivers. Vibrations may also be due to adjacent railway traffic, road vehicles or mobile compactors further along the trench or at adjacent road works.

The support system used needs to be adequate to cope with the extra load these vibrations may cause.

Undercut trench sides

Excavating machines sometimes undercut the sides of a trench, making trench supports necessary, even for otherwise stable material.

Surface water entering a trench

The presence of water will cause loss of strength in clay, silt and gravelly soils. This may cause collapse of an unsupported trench without warning.

All surface drainage should be directed away from a trench during construction.

Worker in trench outside the support system

Work should be performed from within the safety of a trench support system both when installing and removing supports (see Figure 15).

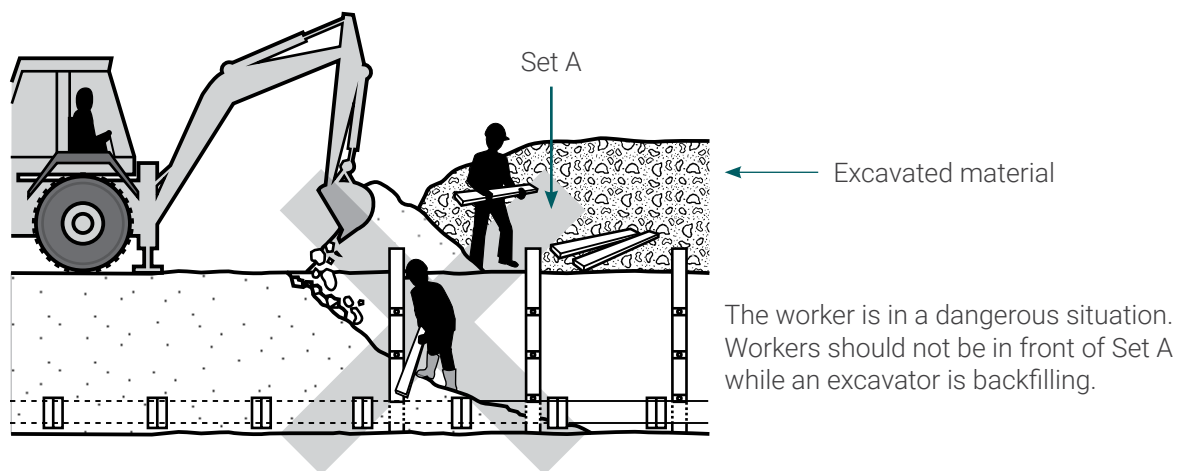


Figure 15. Worker in trench outside the support system.

Nails or spikes sticking out of timbers

Nails and spikes can cause injury and infection. Unnecessary or unused nails or spikes should be removed from any trench timbers that may be used.

As timbers are removed, they should have nails taken out and be checked for any damage. Timbers should be stacked clear of installed supports to safeguard the workers working below.

Damaged timber should not be reused.

Gas pipes near a trench

Temporary support should be provided for a gas pipe if it is in close proximity to the excavation. Some gases are heavier than air, and even minor leaks will cause gas to collect as an unseen hazard in the bottom of a trench. The situation where gas pipes are in close proximity to an excavation should be reported to the relevant distribution authority. See Section 4.12 for further information regarding gas pipes.

Loads supported by walings

Walings are provided in a trench support system to hold back the sides and resist horizontal pressure exerted by the material of the trench walls.

When walings are also used to support a platform that will carry workers or material, extra structural members are essential to prevent the walings slipping down the sheeting. The hazard is that the toms may be dislodged, leading to collapse of the support system.

Wedges in sacrificial sets

Wedges should not be used to force sheeting against a trench face if timber sets are installed in situations that require them to be left in place after backfilling.

Wedges can be easily knocked during backfilling and this may cause excessive movement of the timber supports.

Machines operating close to workers in a trench

Machinery must not be permitted to swing loads over a worker as shown in Figure 16. This is a particularly dangerous practice.

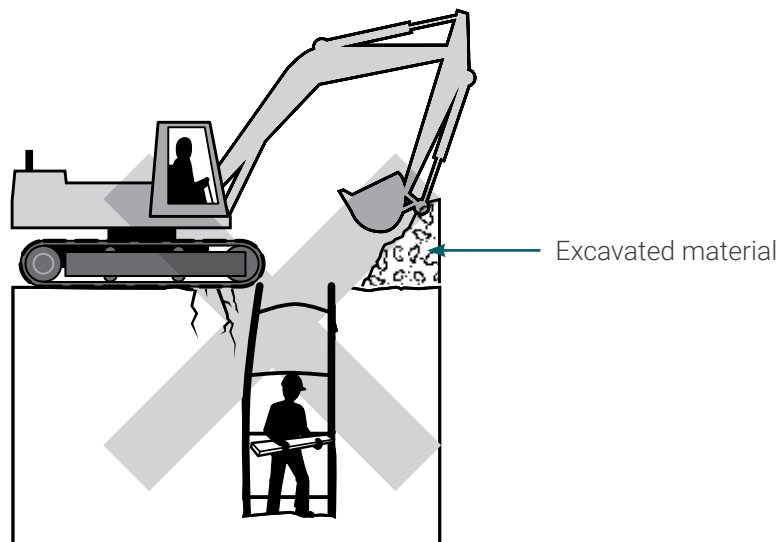


Figure 16 Machine operating close to worker in a trench.

Removal of ground support systems

No part of a ground support system should be removed until the trench is ready for final backfill and compaction.

Other hazards, natural or artificial

Daily site inspections should watch for the following unsafe situations, which are commonly encountered in or near excavations:

- telephone and power poles
- trees
- intersecting old excavations
- bends and corners in trench excavations
- manholes and other shafts
- leaking gas, water, sewerage or drainage services
- the threat to health from past dumping of chemicals and hazardous substances, such as asbestos
- toxic atmospheres in trench excavations (see Section 8.8).

6 Safe practices in and around excavations

6.1 General

It has been stated previously in this code that excavation is one of the more dangerous of construction operations.

People working in an excavation include those undertaking excavation work and anyone carrying out other activities in the excavation, such as pipe laying, surveying, concreting etc.

Certain excavation work not to be done in isolation

Regulation 3.112 states:

- (1) *If a person is required to work in an excavated area or in another opening in the ground, either of which is at least 1.5 metres deep, then a person who, at the workplace, is an employer, the main contractor or a self-employed person must ensure that the first-mentioned person does not do any work without at least one other person being present in the immediate vicinity of the area where the work is being done.*
- (2) *A person does not commit an offence under subregulation (1) if, proof of which is on the person, the sides of the excavated area or opening have been assessed by a competent person to be self-supporting by virtue of the angle of the slope of the sides or the stability of the matter comprising the sides. In accordance with regulation 3.112, another person must be in the immediate vicinity when excavation work is being carried out to a depth of 1.5 metres or more unless the sides of the excavation are stable or cut back to a safe slope as assessed by a competent person, or the sides are adequately supported to prevent a cave-in.*

However, it is good practice to ensure that persons working in trenches supported by shoring systems or shield systems are assisted by another person in the immediate vicinity in case of an accident no matter the depth of the excavation.

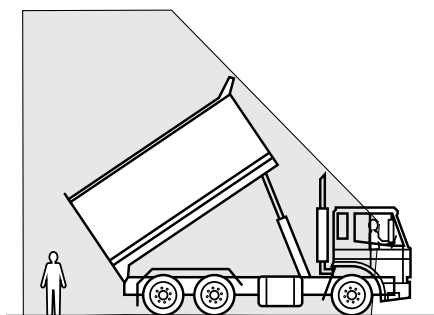
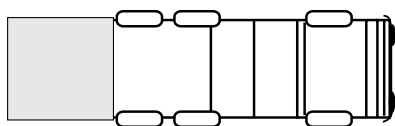
Where the excavation work is at a remote location, effective means of communication, such as a telephone or two-way radio, should be available to maintain regular contact and to call for assistance in the case of an emergency. However, having access to mobile communication does not remove the requirement for another person to be in the vicinity of the excavation if at a depth of 1.5 metres or more as per the regulation 3.112.

Maintaining good housekeeping in and around an excavation area helps it to be a safer place for workers and the public.

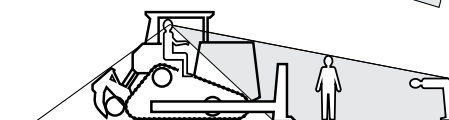
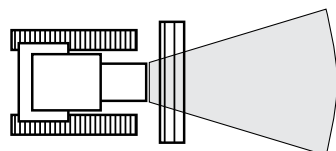
Rain and frost are common weather hazards affecting work in excavations. Wet conditions on some soils may require cessation of work. When work recommences, all drainage channels should be cleared and surfaces should be maintained in a non-skid condition.

Excavations need to be provided with barriers and warning signs to prevent workers and others, especially children, from accidentally falling into holes or down a slope (see Section 4.6). Security needs to be maintained during lunch and tea breaks.

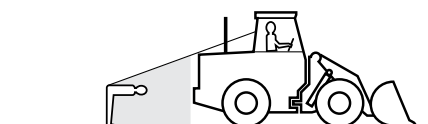
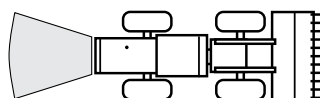
Warning devices, such as signage, lights and protective barriers, need to be effective at all times, including outside of working hours and at night.



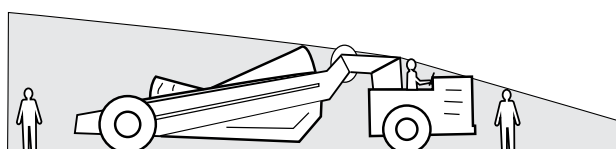
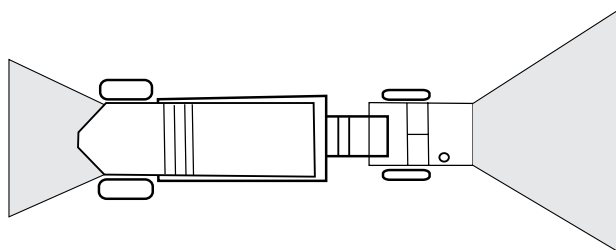
Tip truck



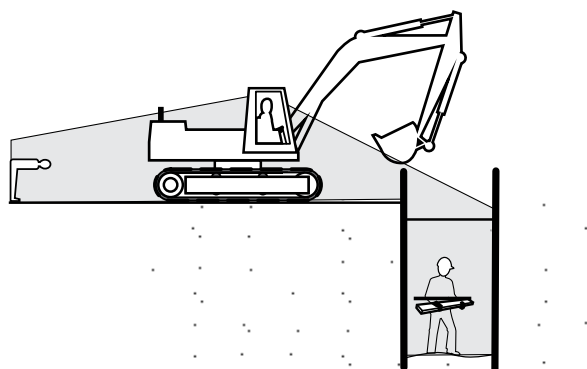
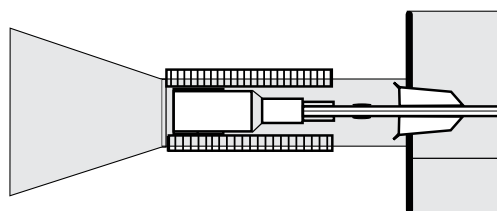
Dozer



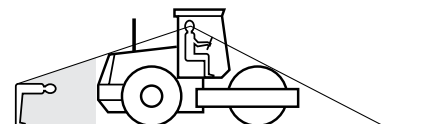
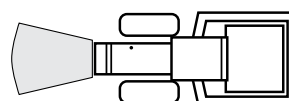
Rubber tyred loader



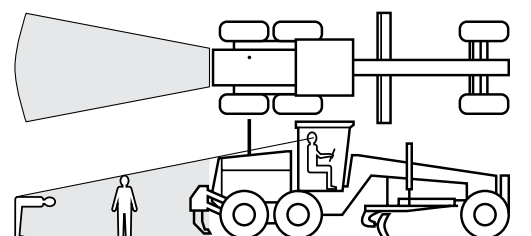
Rubber tyred scraper



Excavator



Vibrating roller



Grader

Figure 17 Dangerous shadows. Blind spots where operators may not see ground personnel.

6.2 Working around mobile plant

One of the most important matters to be considered around excavation sites is the danger inherent in working near mobile plant and vehicles.

Vehicles and mobile plant moving, reversing, loading and unloading in and around workplaces are activities frequently linked with workplace injuries and fatalities.

Traffic and pedestrian movement should be planned and controlled so that pedestrians and plant can operate safely at the site at the same time. Where practicable, traffic and pedestrians should be kept apart and work in separate areas. The movement of site visitors should be limited with barriers and signage. See Section 8.11 for further information.

Operators of mobile plant often have severely restricted visibility of ground workers or nearby pedestrians, particularly those close to the plant. See Figure 17, which shows the blind spots for operators of typical excavation equipment.

An effective system of communication based on two-way acknowledgement between mobile plant operators and ground personnel should be established before work commences and relevant personnel trained in the procedures involved.

The system should stop ground personnel approaching mobile plant until the operator has agreed to their request. Similarly, the system should stop operators from moving plant closer than a set distance from ground personnel until the operator has been advised by ground personnel that they are aware of the proposed movement.

Mobile plant operators and ground workers should be made familiar with the blind spots of particular items of plant being used. Induction training programs should emphasise the dangers of personnel working in close proximity to mobile plant, and adequate supervision should be provided.

Mobile plant operators and ground workers should be provided with and required to wear reflective or high-visibility clothing in accordance with the requirements of AS/NZS 4501.

Mobile plant operating near ground personnel should be equipped with a reversing alarm and a revolving light.

Regulation 3.6 requires that workplaces are arranged so that persons are able to move safely within the workplace and that passages enabling persons to move within the workplace are kept free of obstruction.

Regulation 3.22 requires that the movement and speed of vehicles and plant be managed in a way to minimise the risk of injury to pedestrians and operators.

7 Public safety around excavations

7.1 General

Excavation work presents particular hazards to members of the public unless protective measures are taken.

The safety of the public must be considered where excavation work is carried out.

Regulation 3.109 of the Regulations requires that where any person is at risk because of excavation work, suitable barriers are erected between the persons at risk and the likely cause of danger.

The type of barrier will depend on the level of risk and may consist of a hoarding, barricade or simple barrier and reflective tape.

A hoarding is defined in the Regulations as a substantial and fully sheeted fence or screen, while a barricade is defined as a temporary fence consisting of rigid vertical and horizontal members. The decision as to whether a hoarding or a barricade is necessary will depend on the location and nature of the excavation work being carried out.

In many instances, because of the nature and/or location of the work, the risk of injury or harm to members of the public will be negligible and neither barricading nor hoarding will be needed. In these situations, simple barriers and reflective plastic tape or mesh around excavations will be sufficient.

However, where members of the public are likely to be in the vicinity of excavation works and the risk of injury or harm is real, a decision has to be made whether a barricade or hoarding is required for protection. In these situations, a hazard identification, risk assessment and control exercise should be carried out to determine the level of risk and the control measure to be implemented.

Regulation 3.109 also requires that suitable signs that warn of the risk are erected. These should be placed at appropriate locations around the perimeter of the excavation. All signs need to comply with the requirements of AS 1319. Where excavation works may cause a distraction to passing traffic, barrier screens, also known as anti-gawking or anti-debris screens can be erected. These can help to reduce visibility into the work area while also offering protection to workers from flying debris that may come from the roadway. Open weave mesh screens can also be used to provide protection to workers in high wind or coastal areas.

Barriers and warning signs were discussed under Section 4.6 in relation to preplanning.

7.2 During working hours

The following precautions should be taken during working hours:

- display warning signs at the work site and erect appropriate barriers around the excavation
- set up warning signs on approach roads to the excavation, particularly where the work is not readily visible from a distance, and provide a temporary bypass for vehicular traffic if necessary. It may also be necessary to arrange for a traffic controller to warn and control traffic. Where excavation work is carried out on gazetted roads, all signage, traffic control and safety measures should comply with the code of practice by Main Roads Western Australia, Traffic management for works on roads. The need for a traffic management control plan to be prepared prior to work commencing was discussed in Section 4.11
- establish access, with direction signs for pedestrians, around or over an excavation
- consider whether temporary barriers, such as heaps of earth, are needed to prevent accidental vehicle entry to a hazardous location
- do not leave any hazard unguarded during work breaks.

7.3 Outside working hours

The following precautions should be taken outside working hours:

- erect appropriate barriers around the excavation
- provide warning lights
- set up reflective signs to give advance warning to vehicular traffic
- where practicable, arrange construction so that excavation work across driveways and roadways is backfilled before the end of a working day. If this is not practicable, provide access with safety guardrails across the excavation.

7.4 Special precautions

Where excavation work breaks through security fences around features, such as electricity switchyards, railway protection, swimming pools, etc., temporary fencing needs to be provided to maintain security to the original standard existing prior to excavation work being carried out.

Special precautions will also be necessary at excavation work adjacent to schools and shopping centres and other facilities where members of the public gather. For example, 1.8 metre high link mesh fencing will generally be required to provide sufficient public protection.

8 Worker safety in and around excavations

Everyone involved in excavation work should be aware of their responsibilities under the Act.

Employers must, so far as is practicable, provide and maintain workplaces in which workers are not exposed to hazards, and this is especially important given that excavation is one of the most hazardous of construction activities due to the risks involved.

The following matters should receive careful attention to minimise the risks to workers.

8.1 Access

Careful planning is necessary to give safe access and egress for workers and plant under normal working conditions. Full provision for the safety and rescue of workers in the case of an accident should not be overlooked and this includes the free movement of stretchers.

Access to surfaces more than one metre above or below ground level should be by fixed means using either a ladder, stairway or ramp.

In trenches, access ladders or other means of access should be provided at intervals of not more than 30 metres where people are working and near junctions or angles in the trench line. Ladders must be secured and extend a minimum of 900 mm above the landing. Metal ladders should be used with caution where electricity or overhead power lines are present. Workers should not use shoring to climb into or out of an excavation.

Portable timber or metal ladders must comply with AS/NZS 1892.

Normal access routes used within an excavation should, wherever practicable, permit workers to pass without bumping into obstructions. Walking in an excavation should occur on a secure footing without risk of being hit by falling debris.

In the situation where an excavation or trench is heavily shored and headroom is limited, access to and from work should be along well-defined routes that can be protected more readily and the use of other routes should not be permitted.

Secure footing is essential for safe access. Loose stones and large rock projections should be removed, and in some cases, it may be necessary to provide a timbered walkway to ensure safe walking. Accumulations of mud should be prevented and sloping walkways should be cleated or otherwise made slip proof.

8.2 Emergency access and egress

Under the Act and Regulations, the employer, main contractor, self-employed person or person having control of the workplace has:

- obligations regarding emergency evacuations, which include ensuring that there is an evacuation procedure in place to protect anyone on site in the event of an emergency
- a 'general duty of care' obligation to ensure that preparations have taken place for potential emergencies that might occur, which include identifying potential hazards that might arise and in the case of excavations may include engulfment from water or gas, outbreak of fire or entrapment in the event of a wall collapse.

Emergency procedures should be developed in consultation with workers and safety and health representatives, where applicable.

The main objectives in emergency evacuation planning are to ensure that:

- everyone knows what to do in the event of an emergency
- preparations for potential and unexpected incidents at the workplace have taken place.

A selection of key people should be appointed to manage emergency procedures, such as emergency response personnel, site wardens or first aiders. Roles and responsibilities should be clearly defined and a clear line of reporting established.

Specialised training may be required for those responsible for managing emergency evacuation procedures. Some emergencies will only take a short time to become a significant incident. Depending upon the location and geographical factors of the site, emergency service response times could be affected, especially if remote or around rough terrain. Therefore, it may be necessary for some workers to be trained in the use of specialised logistical support and devices, such as winches, stretchers, breathing apparatus or first aid.

Workers should be trained in set emergency evacuation procedures with regular drill practice undertaken. Any shortfalls identified during training or practice should be addressed.

A risk management process should be used to ensure that any changes at the workplace have been taken into account and will not impact emergency response procedures.

In the event of an emergency, only rescue traffic should be permitted in the area and this may include vehicles from an on-site response team or an emergency services agency, such as DFES, and all access ways cleared immediately.

Workers and mobile plant operators should always park their vehicles clear of access routes or haul roads to leave adequate clearance for emergency traffic. Rescue teams will then be able to use routes normally used by plant. Rescue traffic may also include stretchers, and these should be considered and provided for when planning details of access.

Wherever possible, some alternative access should be provided for emergency use. Open excavations should have a spare ladder provided at the top of the excavation, which should be left in a place known to all workers and reserved solely for emergency use. It should be painted red or yellow to emphasise its emergency role.

Emergency access and egress also implies safe egress from the face of an advancing excavation. At the face, while supporting members are being placed, protection cannot be as good as where the supporting work is completed. This zone of reduced protection should be kept short by keeping the support as close as practicable to the face being excavated.

Workers should be provided with a clear run to safety should there be a fall of earth. This requires the floor of the excavation to be kept as clear as possible of loose spoil, tools, timber, etc. Full walking headroom should be provided where practicable in a trench near the working face, and constant attention is needed by all workers and supervisors to keep the floor clear of hazards. The provision of sufficient headroom for safety near the face will often prove difficult and therefore should receive special attention.

Emergency rescue equipment is required when a hazardous atmosphere exists or can reasonably be expected to exist. Respirators must be of the type suitable for the exposure, and workers need to be trained in their use and a respirator program initiated. See Section 8.8 for further information.

8.3 Working alone

See Section 6.1 for the requirements of regulation 3.112, as a person must not carry out certain excavation work if they are alone.

8.4 Working space

Workers should be kept sufficiently far apart when working to avoid injury from the use of picks or other tools. This applies particularly to work in trenches and small excavations.

8.5 Safety helmets

Regulation 3.36 requires persons in and around trenches and other excavation sites to wear safety helmets if there is a risk of the person being struck on the head by falling objects. The helmet must comply with AS/NZS 1801.

It is important for people in and around excavations and trenches to wear safety helmets. Not wearing a safety helmet is a dangerous practice.

8.6 Eye protection

Suitable eye protection must be worn when there is a risk of eye injury. Flying grit and chips of rock are two common sources of danger to eyes in excavation work. Safety glasses must comply with the requirements of AS/NZS 1337.

8.7 Dust nuisance

Dust must be controlled during excavation and earth-moving works as exposure can cause serious damage to health. Regularly breathing dusts can cause lung diseases, such as asthma or chronic obstructive pulmonary disease.

Excavation dust can also contain silica. Due to the mechanical processes of excavation, some silica dust particles can be so small that they are not visible. These are referred to as respirable particles.

Respirable silica dust particles are small enough to breathe in and can penetrate deep into the lungs causing permanent damage that can lead to serious illness or death. Silica dust is also linked to the development of autoimmune disorders and chronic renal (kidney) disease.

Factors to consider when assessing the risk of exposure to dust include consideration of the location of the excavation work and excavation methods used, such as the type of digging equipment, environmental conditions and the material in the work area. Dust levels will not necessarily be low when working outside and longer durations of exposure to dust increase the risks to health.

Methods of dust control during excavation work include:

- **Water suppression** – water assists to dampen dust clouds, but enough water needs to be supplied at the right level to control the dust for the entire time the work is being conducted. In dry conditions, frequent watering may need to be applied to haul roads and work areas to reduce the level of nuisance dust. Oiling or sealant may be suitable for some work areas. Ensure that any runoff water does not affect the excavation site. Runoff water can be controlled with a silt fence, shallow trench or other barrier, which will help to reduce soil erosion and limit water ingress into the excavation. Keeping natural vegetation and topsoil around an excavation can also help to control water runoff and limit soil erosion.

- **Isolation** – if using earthmoving plant, a fully enclosed operator cabin can effectively control exposure to dust and respirable silica when fitted with properly designed and maintained high-efficiency particulate arrestance (HEPA) air filtration.
- **Respiratory protective equipment (RPE)** – RPE does not prevent or control dust from becoming airborne and it should not be used as a primary form of control, but rather in combination with higher order controls like water suppression. The correct respirator for the job should be selected in accordance with AS/NZS 1715.
- **Induction, information, training and supervision** – the employer, main contractor, self-employed person or person having control of the workplace must provide induction, and training about dust hazards including silica hazards and must supervise safe controls. Information provided should cover:
 - health risks from inhaling dust and respirable crystalline silica (RCS)
 - control measures used to minimise the risk to safety and health
 - correct use of the methods used to minimise exposure
 - correct use and care of respiratory protection
 - potential need for and details of any health surveillance processes.

The training given has to take into account the level of risk posed by the dust/respirable silica exposure. A record should be kept of who was trained, who conducted the training, when it was given, and the topics covered.

8.8 Fumes and emissions

Workers should not be permitted to work in hazardous or toxic atmospheres.

Toxic or explosive gases may be encountered when work is carried out in excavations, including trenches, shafts and drives.

Portable petrol or diesel driven machines produce fumes that may be hazardous in an excavation and should not be used within enclosed areas, such as trench support systems and well liners.

Excavations are a natural sump for any gas heavier than air. Various types of gas, such as methane and sulphur dioxide, can seep through the ground, while leakage may occur from nearby underground services such as gas or sewer pipes or underground fuel storage. Carbon dioxide may accumulate from nearby internal combustion engines and toxic atmospheres may be created where excavation occurs in contaminated sites, such as landfill areas.

Where there is any risk of air contamination, tests using detection equipment must be carried out prior to work commencing, and at regular intervals throughout the course of the work.

Where testing reveals an oxygen deficient or toxic atmosphere, attempts should be made to reduce the risk by means, such as ventilation or exhaust systems. Where this is not practicable, respiratory protective equipment must be selected in accordance with AS/NZS 1715 and comply with the requirements of AS/NZS 1716. The Commission code of practice, *Personal protective clothing and equipment* provides further information on respiratory protection.

8.9 Adequate lighting

Trenches and open excavations, including shafts and drives, where daylight is insufficient, must be provided with adequate lighting. A suggested minimum is lighting of 40 lx for walkways or access and 160 lx for general work areas, or equivalent arrangement.

Glare should be eliminated. When contrasted with a deficiency of light, glare considerably increases the risk of falls from slipping or tripping.

8.10 Protection from falls

Where there is a risk of a person falling from an access way, a handrail, and sometimes an intermediate rail or a toe board, should be provided to enable persons to pass more easily and to prevent falls.

Regulation 3.55 specifies that where there is a risk that persons could fall three metres or more from an edge, edge protection consisting of a fall injury prevention system (fall-arrest harness and lanyard attached to an anchorage point) or alternatively guardrails comprising a top rail, mid rail and toe board, or top rail, toe board and meshing, must be provided.

Edge protection may often be required on access ways and at the edge of steep cuttings, such as excavations for deep sewerage lines, large structures, pump stations and quarries, where other barriers provide insufficient protection.

Ladder runs (take-off to landing) should be not more than six metres, and intermediate landings should be provided to break up any longer runs. At any landing, the ladder below should be offset from the ladder above so that it is not possible for a person or object to fall past the landing. Landing platforms should be fitted with guardrails and toe boards.

Ladders should be placed so that the foot of the ladder is approximately 30 cm out for each 90-120 cm vertical distance. A ladder should extend at least 900 mm above the landing it serves, unless alternative handholds are provided. It is particularly important that the rise to the lowest rung is uniform with the rung spacing. All ladders must be secured against slipping.

All work must be carried out in accordance with the Regulations, with regulations 3.48 to 3.57 specifically relate to prevention of falls. The Commission code of practice, *Prevention of falls from height at workplaces* contains useful guidance on complying with the regulations.

8.11 Separation of traffic

Wherever practicable, the traffic route used for excavated material should be separated from that used by workers. In a small shaft or drive where it is not possible to provide separate routes for the two kinds of traffic, the movement of workers should cease while excavated material or plant is being moved and vice versa.

Where mechanical haulage is used in small drives, manholes or refuges should be excavated into the side of the drive to provide shelter from passing traffic. Such refuges should be of a reasonable size and appropriately spaced on the same side of the drive.

Workers operating near traffic should be provided with and be required to wear warning vests or other suitable garments marked with or made of reflective or high-visibility materials.

In shafts shallow enough for workers on top to see and talk to workers below, no difficulty should arise, but in shafts of intermediate depth, in which the workers climb up and down ladders, there is need for an effective signalling system and there may be a requirement for automatic locking of winding gear while workers are moving.

See Section 6.2 for factors to be considered when working around mobile plant.

8.12 Ramps and runways

Ramps or runways used for running plant into and out of an excavation need to be constructed of appropriate strength, width and grade for the plant being used. Ramps intended for use by track vehicles only should be marked as such and no other vehicles allowed to use them.

Ramps or runways should normally have a clear width of at least 3.7 metres for non-passing traffic and at least 6.7 metres when providing for passing traffic and be fitted with substantial wheel guards where there is any risk of vehicles slipping sideways into the excavation. A substantial earth windrow may be sufficient in some cases. Frequent careful examination and maintenance is needed to keep ramps in a safe and serviceable condition.

Ramps used for foot traffic within the job should preferably be not steeper than one vertical in six horizontal unless cleats are used and in no case steeper than one in four. To climb a steeper grade than this, flights of steps alternating with landings should be used.

Provision for movement of persons in, around and across an excavation was discussed in Section 4.7.

8.13 Plant and gear

Excavation work cannot be carried out safely unless plant and equipment is in good condition. It is the responsibility of the employer to provide plant such that, so far as is practicable, workers are not exposed to hazards. Suppliers must, as far as practicable, ensure that the design and construction of plant does not expose workers to hazards.

Regulation 4.37 specifies the responsibilities of employers and contractors in caring for plant in use at a workplace. Plant must be:

- tested, inspected, repaired and maintained in accordance with the original equipment manufacturer recommended procedures
- used only for the purpose it was originally designed
- equipped with guards over dangerous parts
- withdrawn from service if it represents a risk to safety or health.

8.14 Excavation plant operating near overhead power lines

Cranes and excavation equipment, particularly backhoes, trench diggers, excavators and draglines, need to be operated with extreme care in the vicinity of overhead power lines. Trench excavation for service utilities often runs parallel to overhead power lines meaning the hazard is usually present.

Contractors should plan ahead as far as possible to maximise safety. Electricity distribution authorities can isolate most overhead power lines when sufficient notice is given, and every attempt should be made to achieve isolation.

Where overhead power lines are isolated, the electricity distribution authority's access permit should be kept in the plant operator's possession during operations.

Where there is no access permit, all power lines should be treated as being live and without written confirmation of the line voltage from the distribution authority, the highest line voltage should be assumed and a six metre 'danger zone' used.

Regulation 3.64 of the Regulations specifies a 'danger zone' around overhead power lines of different voltages, which must not be entered by workers, plant or material. This 'danger zone' is within:

- (a) 0.5 metres for insulated overhead line or aerial bundled conductor line not more than 1000 volts
- (b) 1.0 metres for uninsulated overhead line not more than 1000 volts
- (c) 3.0 metres for overhead line exceeding 1000 volts but not more than 33000 volts
- (d) 6.0 metres for overhead line exceeding 33000 volts.

WorkSafe's *Guidelines for work in the vicinity of overhead power lines* provides guidance on the operation of cranes and the use of other plant and equipment in the vicinity of overhead power lines. The guidelines promote a 'no go' distance beyond the 'danger zone' which should not be entered by the lifting hook of a crane or the boom of an excavator or backhoe. This 'no go' distance is the horizontal distance from the centre line of the lift to the perimeter of any load.

Figure 18 shows required clearances for excavation plant and lifting equipment from overhead power lines in accordance with WorkSafe's guidelines.

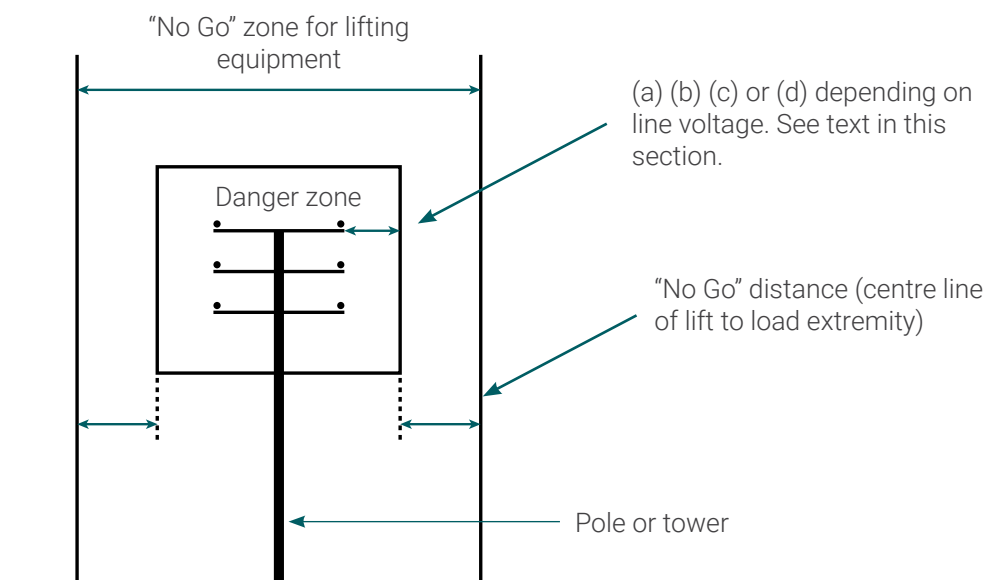


Figure 18 Clearance for excavation plant and lifting equipment from overhead power lines

If, for any reason, it is necessary for a person or any plant or material to enter the 'danger zone', the prior authorisation of the distribution authority must be obtained before entry is made.

In instances where it is necessary to operate lifting equipment within the 'no go' zone (but still outside the 'danger zone'), a dedicated spotter should be used. In these circumstances, the following measures should be implemented:

- increase the visibility of the power lines by the use of 'tiger tail' wrapping around the lines
- use engineering controls on lifting equipment:
 - mechanically slow down or limit the normal operating cycle of the plant to increase the available reaction time for assessing distances
 - limit the height/rotational movement of boom type plant with mechanical stops to prevent the boom being in proximity to overhead power lines
 - fit plant with programmable zone limiting devices
 - use electrically insulated plant and equipment
- keep workers away from the area with clear instruction to stand clear of the plant and load at all times

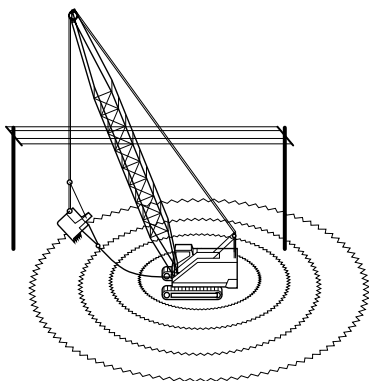
- install warning notices in a prominent position in the operators cabin to alert operators to check for the presence of power lines
- ensure the plant operator is using suitable personal protective equipment, such as, rubber soled boots, electrically tested insulating gloves, safety helmet, rubber insulating mat or equipotential earth mat. Clothing should be dry, especially in humid or wet conditions
- dry taglines (tail ropes) made of natural fibre, such as hemp, sisal or other non-conductive material, should be used to control the load. Due to their conductive properties, synthetic ropes should not be used. The tagline needs to be prevented from approaching or being blown into contact with any power line
- mobile equipment should be provided with a steel earthing chain. The chain should be bolted or welded to the carrier chassis and be of sufficient length to allow at least one metre of chain to be in contact with the ground. Earthing chain should not be used when the equipment is operating near the rails of an electric train system.

When operating or travelling in an unfamiliar area, the operator should always check for the presence of overhead power lines.

Proximity warning devices, insulating boom guards and similar devices all have limitations and should not be relied upon to give protection against electric shock.

In the event that mobile plant does contact live power lines, or arcing occurs, the operator should observe the following precautions:

- remain inside the cab
- warn all other personnel to keep away from the item of plant and not to touch any part of the plant, rigging, tail ropes or load
- try, unaided, and without anyone approaching the machine, to move it until clear of the power line
- if the machine cannot be moved away, remain inside the cab. If possible, get someone to inform the electricity distribution authority at once. Take no action until the distribution authority confirm that the conditions are safe
- if it is essential to leave the cabin because electrical contact or arcing has caused a fire or other life-threatening emergency, jump clear as far away from the machine as possible. Do not touch the machine and the ground at the same time
- when moving away from the machine, shuffle or hop slowly across the affected area. Large steps should be avoided as one foot could be in a higher voltage area and the other in a lower voltage area. Under some circumstances, the voltage difference between the two areas could kill (see Figure 19).
- ensure someone remains near the machine at a safe distance, to warn others of the danger of approaching.



High voltage contact will result in electrical current flowing down the bottom and through the machine to the ground. The ground will then be energised with a high voltage near the machine and lower voltage further away.

Figure 19 High voltage contact

Following any contact with live power lines or arcing, a competent person should inspect the machine for possible damage caused by the contact or arcing before further use. Wire rope should be replaced if it touches the power lines, as the arc will usually weld, melt or badly pit the rope.

In the case of wheeled machinery, it is important that this inspection consider the possible degradation of rubber tyres caused by high temperatures.

All tyres suspected of being subjected to heat from any source should be replaced.

8.15 Scaffolding

Scaffolding may be required for certain special excavation work when access to high faces is needed.

Scaffolding must be erected and dismantled in accordance with the requirements of regulations 3.66 to 3.81 and the relevant parts of AS/NZS 1576 and AS/NZS 4576.

8.16 Use of lasers

The use of lasers or laser products must be in accordance with the requirements of regulation 4.49. This regulation requires that:

- lasers and laser products must be classified and labelled in accordance with AS/NZS 2211 *Safety of laser products*
- the use of lasers and laser products must be in accordance with AS 2397 *Safe use of lasers in the building and construction industry*
- Class 3B or Class 4 lasers or laser products must not be used on construction sites (including excavation sites) because of the high risk they present.

8.17 Drainage

In all excavations, the safety of faces depends largely on the effectiveness of steps taken to control surface and ground water. Where practicable, surface water should be collected in drains and discharged clear of the working area. All sub-soil drains found should be effectively diverted and the water led away from the site.

During construction, checks should be made for inflow from seepage and springs. When found, such inflows should be collected into a sump and pumped clear of the excavation. Such seepage may cause faces to slump, and localised shoring may be needed. Springs coming through the floor of an excavation may cause dangerous unstable conditions leading to cave-in.

See Section 4.5 for further information on water control.

8.18 Additional precautionary measures

In all cases, if there is any uncertainty about the minimum amount of safe trenching support, it is better to play safe and:

- batter the excavation
- over-design the supports
- obtain engineering advice.

It is desirable to build extra safety margins into a support system rather than to under-design the supports and increase the risk of accidents.

9 Safe slopes

9.1 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.

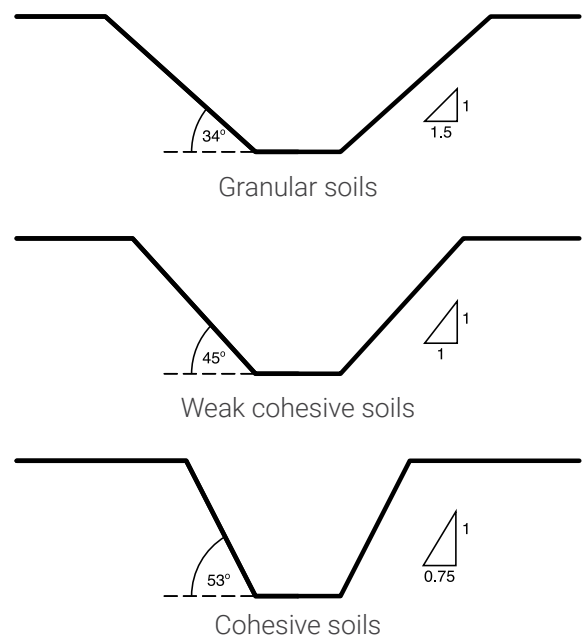
In considering the stability of an excavated slope, it is important to note that, as a rule of thumb, the magnitude of horizontal forces is a function of the square of the total depth of the face. Therefore, at a depth of two metres, horizontal forces are four times the magnitude of such forces in a one-metre deep cut, nine times in a three-metre deep cut, 16 times in a four-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 (see Section 3) should determine safe slopes for excavations. For excavations deeper than six 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 six 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 (e.g. Bassendean sand), and loamy sand with very little cohesive properties.
- Weak cohesive soils, such as angular well graded sand (e.g. Karrakatta sand 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 six 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).



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 sand' or 'Spearwood sand'), silt, silty loam, sandy loam.	1:1	45°
Cohesive soils: clay, silty clay, sandy clay.	0.75:1	53°

Figure 20 Slopes which may be safe for various soil types. 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 three 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 three metres, faces should be stabilised with horizontal benching, which will also prevent material from the top of the slopes falling down 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 by the use of 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.

9.2 Placing the excavated material

During excavation, excavated material should be placed outside a 45-degree slope line passing through the bottom of the excavation and in no case closer than 600 mm from the edge of the excavation. This distance will enable safe access along the sides of a trench. If a trench runs across sloping ground, excavated material should normally be placed on the uphill side of the excavation. This will usually enable easier backfilling and prevent loss of stability of excavation machinery which can occur if excavated material is placed on the downhill side. Care needs to be taken to ensure material placed on the uphill side does not increase the risk of flooding by ponding or holding back runoff water.

When a trench is being excavated adjacent to an old service line, excavated material should be placed on the side opposite the old line, to prevent excessive loading on previously weakened ground.

When it is necessary to place excavated material close to a trench due to restrictions, such as fences, buildings, trees, etc., toe boards in the form of close sheeting could be used. It must be remembered that the weight of excavated material may overload the sides of a trench. The supporting system should, therefore, be strengthened at these locations.

If excavated material is very close to a trench, it may roll into the excavation. To prevent this, toe boards should protrude at least 300 mm above the toe of the excavated material.

9.3 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 considered 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.

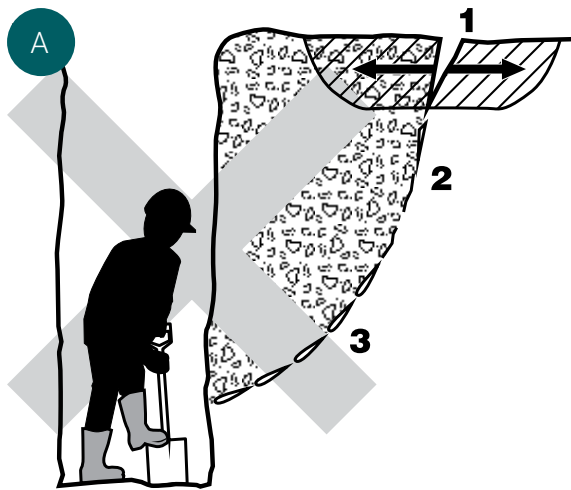
Non-cohesive faces may be very treacherous. With just the right amount of moisture, they look, for a short time, safe and solid. Very little loss of water by evaporation will make the soil crumble, as would an increase in the water content from rain or other causes.

Figure 21 shows an example of ground failure where a worker is pinned and crushed by the soil. Trench collapses of this nature may cause fatal injuries.

Trench cave-ins occur very quickly giving a worker virtually no time to escape, especially if the collapse is extensive.

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.

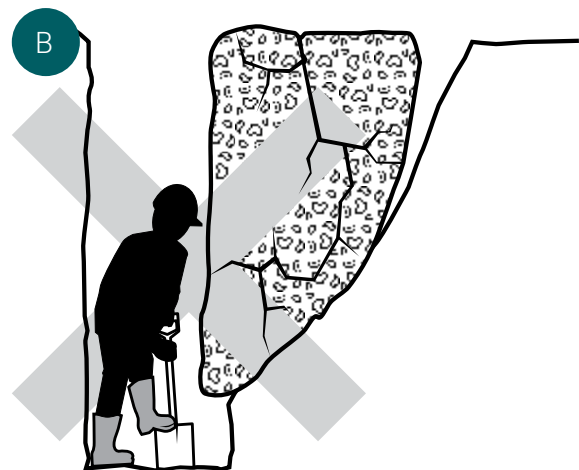
Engineering advice on the need and application of ground support systems should be sought, except in the situation of shallow trenches.



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

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

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



Shear plane failure along the seepage (slippage) plane.



Worker trapped and crushed against the trench wall by the quick collapse.



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 two metres deep is about three tonnes; more than enough to crush a worker's chest.

Figure 21 Trench collapse and associated ground forces.

10 Types of excavations

10.1 General

The safety system chosen will depend on the nature of the excavation being undertaken. Careful consideration needs to be given to safety issues when planning the work where the excavation involves other than shallow trenching and small quantities of material.

A common cause of injury involves workers being struck by excavating machinery including where machinery is driven into, or falls into, an excavation due to operator error or inadequate barriers. Barricades should be installed where necessary to prevent vehicles and equipment from accidentally falling into an excavation.

Excavated soil should be graded away from an excavation to assist in vehicle control.

See also Section 6.2 and Figure 17 showing the blind spots of operators of typical excavation equipment and the need for an effective system of two-way communication between operators and ground personnel.

A check should be carried out to ensure all drivers and operators have appropriate licences and any certificates of competency required under the Regulations.

The Regulations do not specify what support system is required for the range of excavation work that may be carried out. For complex excavation work, such as excavation for deep sewers, an engineer experienced in this type of work should approve the ground support system in writing.

10.2 Mechanical excavation – open cut

Bulldozers, excavators, scrapers and other types of earthmoving equipment are commonly used for open cut excavation.

For all excavations, operators need to know:

- the line
- the final depth of the excavation
- the approximate width of the excavation at the top
- the location of any underground services or other hazards.

The excavation line and any underground services or hazards should be marked. A trench should be marked along the centreline of the proposed excavation.

Safe disposal of excavated material involves consideration of:

- where any materials have been temporarily positioned on the ground
- the placement of manifolds and wellpoints and the location and positioning of discharge pipes associated with dewatering plant in the case of wet ground
- unusual obstacles and existing conditions, such as buildings, trees, power lines and sloping ground
- distance that excavated material is to be placed away from the excavation
- the need to ensure access and egress are not prevented.

As the excavation increases in depth, the sides should be battered to prevent collapse. The bulk of this work is done by machine, but in deep excavations, trimming by hand is often required. This is accomplished by shovelling or pushing the material with a long handled tool or shovel to the bottom of the excavation where it is picked up by the excavation equipment.

Care needs to be taken to avoid over excavation. Frequent 'boning' or levelling is necessary to check the depth of cut. Hand trimming of the excavation is often required.

10.3 Mechanical excavation in clay, or rock

Mechanical excavation of this type of material requires either backhoes, trench diggers or bulldozers with back mounted rippers. The latter is used to rip up surfaces and is used extensively where there is enough room for bulldozers to operate.

Whichever method is used, the operator must be given the exact depth and width of cut.

Where backhoes are used, buckets with steel teeth are fitted to assist with the breaking up of the materials to be excavated.

Clay is often difficult to excavate by open cut. When clay is not fully saturated, or if pile driving is carried out at the bottom of the excavation, the banks should be braced by tomking between laths placed vertically no more than one metre apart against the banks. If possible, the works program should be organised so that excavation is avoided in clay areas during the winter or wet season.

In streets or in built up areas, the excavation may have to be fully or partly sheeted.

10.4 Mechanical excavation – blasting

Blasting operations are sometimes undertaken as an aid to excavation in rock. All explosives handled in the course of blasting operations must be under the direct supervision of a licensed shotfirer.

Under the Dangerous Goods Safety (Explosives) Regulations 2007, a blast plan and written blast records must be prepared before an explosive is used to blast rock or similar material. The shotfirer, the person for whom the shotfirer is working, the person who has control and management of the work that requires the use of the explosive and the person who has the control and management of the place where the explosive is to be used must prepare a blast plan or ensure that one is prepared.

The purpose of a blast plan is to:

- detail the objectives for the project or task identify risks, hazards and controls
- identify site-specific requirements
- introduce blasting as part of the overall task
- control the blast process from design to initiation, evaluation and misfire treatment
- implement a review process to ensure that the objectives are met
- assure the safety of the public, site personnel and surrounding properties.

It is a regulatory requirement that the blast plan be followed. Components of the blast plan may be submitted to one or more competent persons within the organisation responsible for authorising the blast.

Within seven days of the use of an explosive, the shotfiring licence holder must make a proper written record of the blast. Copies of the blast plan and proper written record of an explosive are to be kept by those responsible for their preparation for a period of two years after the use of the explosive.

By maintaining written records of the use of explosives as part of the blast plan, details surrounding the conduct of the blast and post-blast analysis are documented. This will be important should there be a complaint or incident in relation to the blast.

Blasting within a townsite requires a permit from the local government authority and public risk insurance. Blasting should be on a very limited scale in built up areas and only take place after all nearby buildings have been thoroughly inspected, photographed if required and recorded. Adequate warning signs need to be displayed and all precautions against flying material taken by the use of pegged or weighted blasting mats or similar aids.

In open country, it is possible to make maximum use of explosives. With shallow trenches, the ground can often be broken up to its full depth in one operation. In deeper trenches, benching would have to be undertaken.

It is important that all drilling for blasting be carried out as quickly as possible and blasting be conducted soon after to avoid the possibility of extraneous matter entering drill holes. It is good practice to temporarily plug drill holes prior to charging. If extraneous material is allowed to enter drill holes, the amount of charge possible in each hole will be reduced, thereby diminishing the force of the explosion and fragmentation of the rock. The possibility of misfires will also be increased if delays occur. It is important to count the number of charged holes prior to blasting and identify any misfires which occur.

A mobile rotary percussion drilling rig is generally used for the above type of drilling operations. If drilling is to be carried out by hand drills, it is important that an adequate supply of compressed air and sufficient air drills and drill rods be supplied to minimise delays.

Although any drilling activity will involve risks of manual handling injury, the use of hand drills will create additional manual handling hazards, which should be considered during excavation operations. The use of hand drilling equipment will also involve risk of vibration injuries occurring, which needs to be assessed and controlled.

Long periods of repeated exposure to the noise of drilling equipment may expose workers to excessive noise. Regulation 3.46 requires that workers must not be exposed to noise levels in excess of the exposure standard specified in regulation 3.45.

Regulation 3.47 requires that workers be provided with personal hearing protection, selected in accordance with the requirements of AS/NZS 1269.3, if it is not practicable to avoid them being exposed to noise above the exposure standard. The Commission code of practice, Managing noise at workplaces should be referred to for practical guidance on managing noise, which may be damaging to hearing.

Drilling activity may also generate significant quantities of dust requiring respiratory protective equipment to be provided to workers. Respiratory protective equipment must be selected in accordance with the requirements of AS/NZS 1715 and comply with the requirements of AS/NZS 1716. The Commission code of practice, Personal protective clothing and equipment provides further information on respiratory protection.

10.5 Excavators, trench diggers and backhoes

Selection of excavation equipment best suited to the task is made by considering the following factors:

- depth of excavation
- quantity and disposal area of excavated material. Large excavators are able to dump excavated material away from the excavation site.

Trench diggers and backhoes are used mainly in:

- sand to depths of approximately 1.5 m
- deeper in softer clay and limestone.

10.6 Bulldozers and scrapers

These items of plant are sometimes used in excavation operations, either for:

- the entire excavation
- removing the top of the excavation for subsequent excavation by an excavator or backhoe.

Self-propelled rubber-tyred scrapers enable very large quantities of excavated material to be hauled economically over long distances at relatively high speed. Because of the large potential output of modern scrapers, careful attention needs to be given to job layout and planning to achieve the optimum performance. Haul roads should be well constructed and maintained to enable drivers to operate the units with safety.

Scraper units will often require push loading by bulldozers in hard compact ground. Twin power scrapers having front and rear engines can often excavate without a pusher dozer in hard compact ground.

Elevating scrapers have the advantage of being able to self-load in a wide variety of soil types where conventional scrapers may require assistance in loading. By adjusting the speed of the loading elevator, they are able to self-load hard compacted clay and wet materials. A big advantage is they do not lose traction when loading.

It may be economical to use bulldozers and scrapers to complete an excavation where, for example, large diameter pipes have to be set and the bottom of a trench is at least 1.8 metres wide. Bulldozers may also be used to rip where hard rock is present.

Bulldozers can have hydraulically operated rippers at the back of the machine, which are capable of loosening the hardest of sedimentary rocks. This material may then be bulldozed away. This method frequently proves more economical than drilling and blasting the rock in all but the strongest rock.

Bulldozers are generally limited to working in open country where large areas are available for disposal of soil.

Excavating equipment, such as bulldozers, should not operate close to an overhang or a deep excavation as the weight may collapse the sides. Equipment should always approach embankments or trenches from across the line of a trench rather than parallel to it.

10.7 Vacuum excavation

Vacuum or suction excavators are items of plant that use a boom-mounted high-pressure suction hose to excavate small, precise holes. These machines are useful for locating or excavating underground utility services and reduce the risk to workers of contacting or cutting utility pipes, which can occur with other mechanical excavation methods.

A high-pressure air lance or water jet is used to loosen soil and other granular material, which is then removed by the vacuum hose and drawn into a hopper where it can be emptied back into the excavation later.

Vacuum excavators can extract and store a range of materials, such as stone, rubble, sand, mud and liquids. They can also be used to carry out the removal of low or high-risk contaminated soils, such as asbestos, or other hazardous materials or chemical substances.

10.8 Hand excavation in sand

Hand excavation in sand is usually a simple operation apart from the manual effort involved. In trenching, it should only be carried out in depths less than 1.5 metres unless the trench is shored to prevent collapse or the sides made self-supporting by virtue of their slope.

10.9 Hand excavation in clay and limestone

Excavation in this type of ground is carried out with the aid of powered tools, with spade heads being the most suitable tool in clay and a pick or pointed head in limestone. Hand picks and mattocks are often used in smaller operations.

11 Ground support systems

As discussed in Section 4, systems of safety include battering, benching, support systems, shoring systems and shield systems.

One of these systems of safety must be used to ensure safe excavation and prevent cave-ins, and selection is usually dependant on the depth of excavation. The particular system employed will also be influenced by many other factors, such as the location of the excavation and the nature of the soil.

The most basic system does not require any ground support system at all.

11.1 Excavations without shoring

Where it has been decided to carry out excavation work without shoring, the conditions met during construction need to be suitable. If conditions during construction are not as expected, or if conditions change during the course of the work, action needs to be taken immediately to safeguard workers, other persons and property, by changing the support system or, if necessary, by temporarily suspending work.

For a trench to be excavated without shoring, the sides should be cut back to a safe slope, such that the material in the sides is able to stand under all anticipated conditions of work and weather.

The stability of any excavated face depends on the strength of the soil in the face being greater at all times than the stresses it is subjected to.

The following situations all increase soil stresses in a face and may lead to possible failure under adverse weather conditions or vibration:

- deep cuts and steep slopes, by removal of the natural side support of the excavated material
- loads on the ground surface near the top of the face, such as excavated material, digging equipment or other construction plant and material
- shock and vibration, which could be caused by pile-driving, blasting, passing loads or vibration producing plant
- water pressure from ground water flow, which fills cracks in the soil, increases horizontal stresses and the possibility of undermining
- saturation of soil, which increases the weight and in some cases the volume of the soil.

Soil strength may be reduced by the following:

- excess water pressure in sandy soil which may cause boils or saturate the soil and increase its plasticity
- dryness of the soil, which causes reduction of cohesion in sandy soil and soils high in organic content, making it crumble readily
- prolonged stress, which may cause plastic deformity (squeezing or flowing)
- prolonged inactivity at an excavation site. Where this occurs, an evaluation of the soil should be undertaken before work recommences.

11.2 Cutting the face of an excavation to a safe slope

The safe slope for faces will depend on the depth of cut, the type and condition of material in the face and the length of time the face will be required to stand before backfilling. In a trench 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 for depths of up to 1.5 metres. However, consideration needs to be given to the type of work being carried out in a trench. If a worker is on his knees laying pipes or working in a bent or seated position, a trench less than 1.5 metres deep may present significant hazards and risks.

A safe slope may be judged by the careful examination of the size, shape, nature and bedding of the material in the face. A competent person is needed to make this judgement, which requires experience and knowledge of the local area. The capabilities of a competent person are set out in Section 3.

All loose or hanging rock should be removed and frequent inspections are necessary as weather conditions can quickly loosen excavated faces.

Where an excavation exceeds three metres in depth, it should be horizontally benched to stabilise the slopes and to prevent material from the top of the slopes falling down to the working area. Benches should be at about three metre vertical intervals and should not be less than 1.2 metres wide. They should be sloped to reduce the possibility of water scouring.

For large excavations, face slopes and widths of benches should be determined by the size and type of excavating machinery used. On large works, detailed construction planning should be carried out and be approved by an engineer before work commences (see Section 9, Safe slopes).

11.3 Excavation support

Where faces cannot be cut to a safe slope for reasons of economy or otherwise, positive ground support or shielding needs to be used.

After deciding on the most appropriate support, it should be installed with the minimum possible delay. Structural members of the support system should be securely connected together to prevent sliding, falling or kicking out, which will enable cave-ins to occur.

Support systems need to be installed in a manner that protects workers from cave-ins, structural collapse or being struck by members of the support system.

There is a difference between a ground support system and a shield. A ground support system supports the sides of an excavation, preventing collapse and ensuring worker safety whereas a shield does not always support the ground, but protects workers inside the shield if the face of the excavation collapses.

All ground support systems, including shields and any timbering, should be regularly inspected, repaired and reinforced if necessary as excavation encounters changed ground or is subjected to extremes of weather.

A number of alternative ground support systems exist and are set out in the following sections.

11.4 Closed sheeting or shoring

This is a primary method of ground support in trench excavation where unstable ground conditions, such as in soft ground or ground liable to be wet during excavation including sand, silt or soft moist clay, are encountered and there is danger of the ground 'running' or collapsing. Closed sheeting or shoring is also used when the location of an excavation or the depth of cut makes battering or benching impractical.

The two basic types of shoring are hydraulically operated metal shoring and timber shoring. Figure 22 shows the components of closed timber sheeting for trench excavation. Walers and toms are installed as soon as practicable during the excavation process. Vertical closed sheeting is then inserted. When using this type of ground support, capping over the toms should extend to the full width of the trench, as these support the toms.

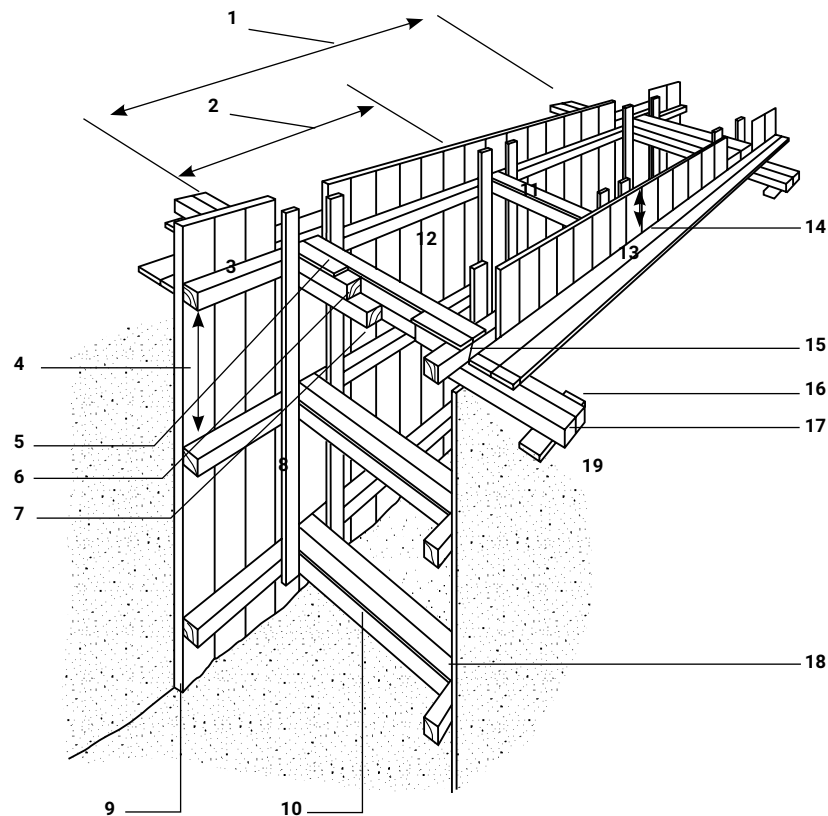
Bearers are used to support the set of toms and walers. To ensure that walers are correctly located, toms are secured to the walers.

It is common to use of shoring or sheeting using hydraulic jacks and steel struts, walers and sheeting although aluminium and sometimes timber components are also used. The use of metal shoring has largely replaced timber shoring because of its adaptability to various depths and trench widths and its ability to evenly distribute pressure along a trench line. Steel sets are usually quicker and simpler to install.

Timber used in ground support systems should, wherever possible, be hardwood. Hardwood timber will usually creak or groan when it is overloaded whereas softwood may fail suddenly without warning.

Excavation of material below the bottom of the ground support system is only permitted if the system is designed to resist the forces of the full depth of the excavation. However this over-excavation should not exceed 600 mm.

Specifications for timber shoring of trenches are shown at Section 11.6 of this code.



- | | |
|--|--|
| 1. Maximum distance between bearers, 3.5 m. | 13. Timber walkway with joints over bearers. |
| 2. Maximum distance between toms, 1.8 m. | 14. Minimum height. |
| 3. Waling minimum size, 100 mm x 100 mm. | 15. Waling joints over bearers. |
| 4. Maximum spacing between walers, 0.5 m. | 16. Pressure boards below bearers. |
| 5. Cap. | 17. Bearers from which all sets are suspended, or on which top set of walings and struts are placed; minimum size 100 mm x 100 mm. Where bearers are used to provide access over trench, minimum access width is 450 mm requiring five bearers. Access should not occur at tom points. Guard rails must be provided to both sides of access. |
| 6. Tom. | |
| 7. Bearer. | |
| 8. Lacing to support timber waling, minimum size, 75 mm x 25 mm. | 18. Capping over toms and bearers, 100mm x 25mm. |
| 9. Vertical sheeting driven securely into trench bottom. | 19. Two bearers accompanied by two capped toms should be used to ensure full support of waling joints. |
| 10. Twin toms, minimum size 100 mm x 100 mm. | |
| 11. Central capped tom. | |
| 12. Vertical timber sheeting, minimum size, 235 mm x 38 mm. | |

Figure 22 Closed sheeting – vertical timber trench support in loose or running ground, for trenches with a maximum depth of 5.0 metres

11.5 Telescopic sets

In trenching, when unstable ground, such as wet sand, is being excavated and the excavation exceeds five metres in depth, it may be necessary to excavate the trench in two stages – upper and lower.

A section of the upper stage should be excavated and supported first. The lower section should then be sheet piled, excavated and supported through the interior of the upper support system without damaging the upper system or creating a dangerous situation in the lower level. Considerable expertise is needed to do this properly; a person inexperienced in this double support system must obtain expert assistance.

This method of trench support requires great care to ensure the correct degree of support and safety. If a deep excavation collapses on a person, the result could be fatal. The method should only be used after consultation with contractors and authorities who have experience in close sheeted excavations. Figure 22 shows a cross sectional sketch of a telescopic set using timber components.

11.6 Specifications for timber shoring of trenches

Maximum depth of trench	Walings	Walings	Toms	Toms
(metres)	Minimum member size (millimetres)	Maximum vertical spacing (metres)	Minimum member size (millimetres)	Maximum horizontal spacing (metres)
3.0	125 x 125	1.5	125 x 125	1.8
	125 x 125	0.9	125 x 125	2.4
	100 x 100	0.8	100 x 100	1.8
	100 x 100	0.5	100 x 100	2.4
4.5	125 x 125	1.0	125 x 125	1.8
	125 x 125	0.6	125 x 125	2.4
	100 x 100	0.5	100 x 100	1.8
6.0	125 x 125	0.8	125 x 125	1.8
	125 x 125	0.45	125 x 125	2.4

Note:

1. For dry and moist sandy soil conditions only.
2. Timber sizes based on use of structural grade karri or hardwood timber of equal strength.
3. Minimum sheeting board size - 235 mm x 38 mm.
4. Tom sizes detailed assume a maximum trench width of three metres.
5. Tom sizes detailed assume only compression forces applied, no direct bending forces.
6. Only waling and tom details on the same line relate.
7. The waling spacing nominated for a particular depth trench is to apply for the entire depth.
8. If the above specifications cannot be achieved or karri cannot be used, an engineer will need to approve the amended specifications.

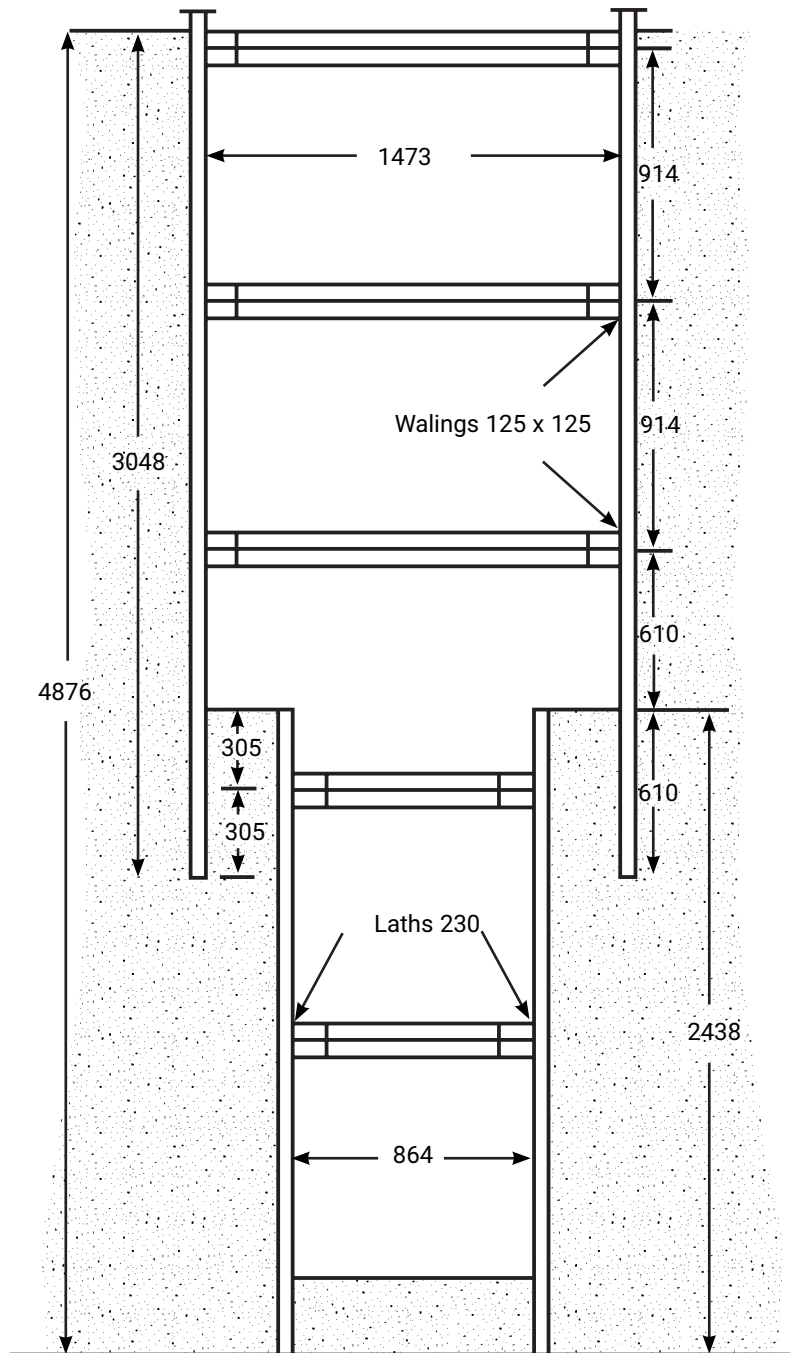


Figure 23 Telescopic set – all measurements in millimetres (not to scale).

11.7 Stability of affected buildings or structures

Stability of affected buildings, etc.

Regulation 3.113 states:

If any excavation work or earthwork to be done at a workplace is likely to adversely affect the stability of any building or structure or any road then a person who, at the workplace, is an employer, the main contractor or a self-employed person must ensure that the work is not commenced or continued unless the stability of the building or structure or the road is protected by sheet piling, shoring, bracing, guying or other appropriate means.

Where the stability of adjoining buildings, roads, walls, paths, pavements or other structures is endangered by excavation or earthwork operations, a support system, such as sheet piling, shoring, bracing, guying or other appropriate means, needs to be provided to ensure the stability and protection of the structure and the protection of workers. Sacrificial sets (see Section 11.8), may also be used. Stability and protective measures need to be in place before excavation work commences.

Unless the excavation is in stable rock, any excavation below the level of the base, or footing of any foundation or retaining wall that could affect the stability of the structure, needs to be secured by a suitable support system.

The effectiveness of the support system needs to be monitored as excavation work or earthwork continues to ensure stability of the building or structure.

11.8 Sacrificial sets

Sacrificial sets are designed to prevent the undermining of existing foundations, such as where a trench is positioned next to a building. If timber sets are used, they should, wherever possible, be made from jarrah as they stay in the ground indefinitely.

11.9 Soldier sets

The soldier set is a common 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 properties. Unlike closed sheeting sets, soldier sets retain the earth where there may be a fault in the embankment. Figure 20 shows use of timber soldier sets in a trench up to 3.5 metres deep.

When trenching is deeper than 3.5 metres, it will be necessary to use horizontal members (walers) to support the increased pressure on the soldier sets. This is particularly important when excavating alongside an existing service.

An extension of the use of soldier sets is to use plywood bearer sheets nailed or attached to the soldiers where fretting of the excavation face may occur.

11.10 Alternative soldier set: hydraulic support systems

Hydraulic support systems are mainly used to provide mobile ground support while other ground support, such as soldier sets are being installed.

These travelling support systems may become unreliable if not properly used and maintained. Frequent inspections of pressure hoses and rams are necessary to detect abrasion, fatigue or damage, such as bent or notched rams. Ground pressures should be considered prior to installation of these supports; it is dangerous to rely on a hydraulic support system that is under-designed in relation to the ground pressure. If this situation is likely, ground supports should be increased.

When two hydraulic ground support sets (A and B) are installed no more than 1.5 metres apart, the area between these sets can be considered to be supported; workers can enter this area to erect a soldier set (C) midway between sets A and B.

One of the travelling sets A may then be removed and placed on the other side of set B, no further than 1.5 metres away.

Three ground support sets are then operational in the trench in this order: soldier set C, travelling support set B, travelling support set A.

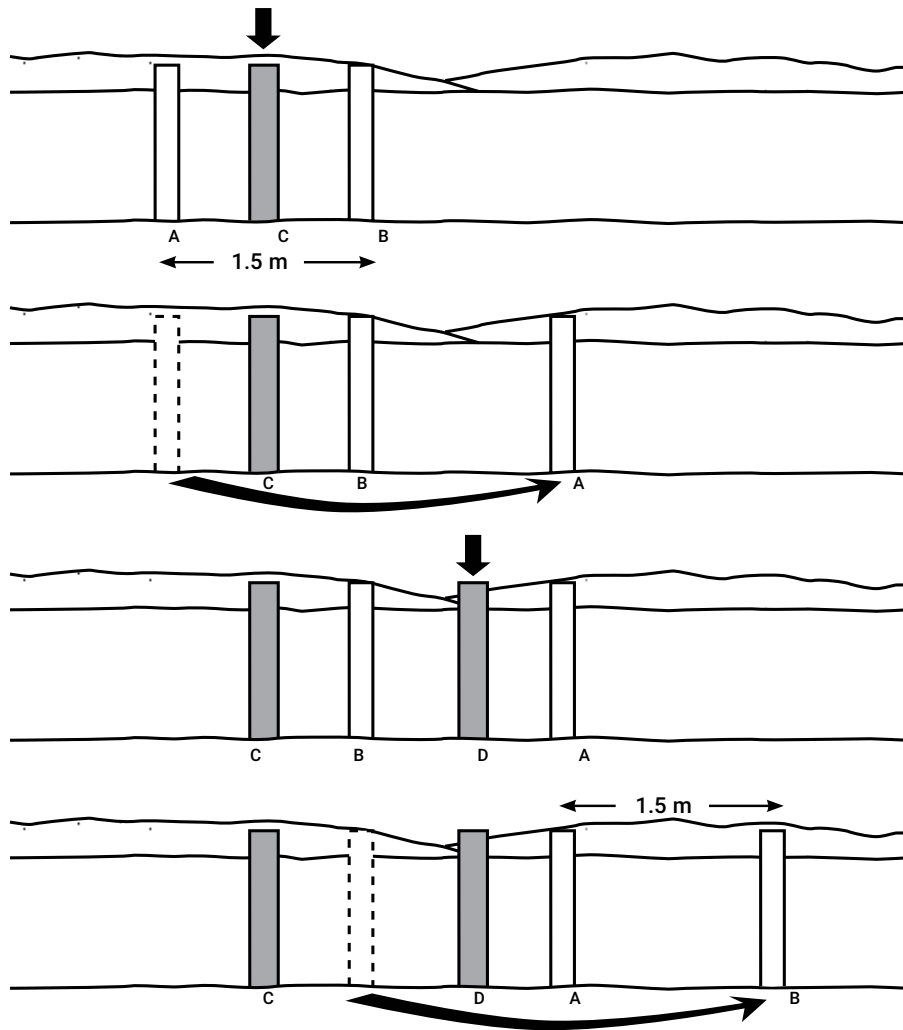
The ground between travelling sets B and A is supported and workers may enter this area of excavation to erect another soldier set (D) ensuring that the distance between sets C and D is no more than 1.5 metres.

There are now four ground support sets in this order: soldier set C, travelling support set B, soldier set D, and travelling support set A.

Travelling support set B may then be lifted out and placed on the other side of travelling support set A, whereupon another soldier set may be erected between A and B.

This leapfrogging of the two travelling support sets is continued down the length of the trench, leaving behind a soldier set each time a travelling support set moves.

When a trench has been fully supported by soldier sets, the travelling support sets should be dismantled to prevent damage. After they have been inspected, the hydraulic supports should be repaired, if necessary, and carefully stored away. Figure 24 illustrates how the hydraulic support system is used.



A, B = Hydraulic set

C, D = Soldier set

Figure 24 How the hydraulic support system works.

11.11 Tunnelling

Generally, tunnelling is effective when an excavation is required at depth greater than six or seven metres. Tunnelling is usually carried out using steel shields; however, all excavation for tunnelling must be supported. It is a specialised aspect of excavation work.

As an approximation, the use of steel tunnelling shields becomes more economical than the use of supported trenches at depths greater than six metres and about seven metres for a battered trench. This is only a rough approximation, and a final decision can only be made after careful investigation. Tunnelling requires engineering design and engineering supervision.

Steel shields and cylinders telescoped inside each other are frequently used to give a cover section greater than 2.4 metres under roads. Typically, recoverable steel shields are used to hold back the soil while excavation is taking place. If it is important that no settlement takes place over the cover section at future dates, steel cylinders which are left in the ground are used.

11.12 Shafts

A shaft is a vertical opening or inclined development usually opening into a mine for the purposes of raising or lowering people and equipment, or for the provision of ventilation, and in this situation is covered by regulations under the Mines Safety and Inspection Act 1994.

Comparatively shallow shafts sunk for investigating or constructing foundations for bridges, dewatering or providing openings to underground facilities should be guarded by a suitable guardrail and toe-board with gate rail for access. The sides of the shaft should be supported by steel frames or sets of timber. In special cases, support can be provided by installing precast concrete or steel caissons.

Shafts usually have special features and expert engineering advice needs to be obtained before installation. In some cases, special ventilation facilities may have to be provided.

11.13 Side lacing

Side lacing is used primarily to ensure worker safety in preventing banks from slipping by the placement of fill behind timber boards or steel plates. 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 side lacing is the only means of ensuring safety in a trench, workers should not:

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

The design of side lacing should be carried out by an engineer experienced in the work. The installation and removal of side lacing should be carried out by crane or backhoe using an experienced operator. Figure 25 shows side lacing in a sand trench.

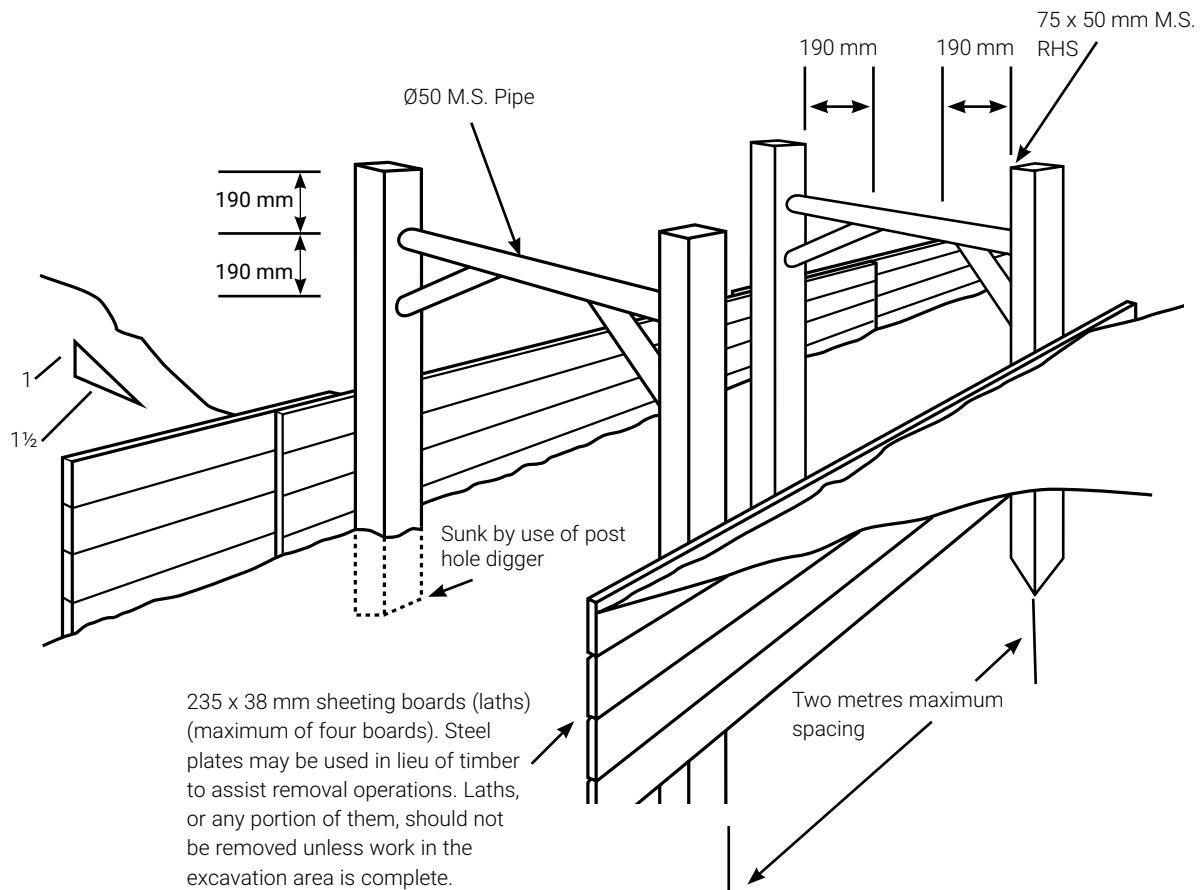


Figure 25 Trench supports in sand. Steel soldier sets, horizontal timber sheeting boards (side lacing). Maximum trench depth two metres.

11.14 Shields or boxes

A shield is a structure, usually manufactured from steel, which is able to withstand the forces imposed by a cave-in and protect workers within it. Shields can be permanently installed or portable and designed to move along as work progresses. They need to be designed by an engineer and can be pre-manufactured to job specific dimensions.

Shields used in trenches are often referred to as trench shields or trench boxes, and are designed and constructed to withstand the earth pressures of particular trench depths. They incorporate specific lifting points for installation and removal.

Many different system configurations presently in use are available for hire or purchase. Figure 26 shows a typical trench shield.

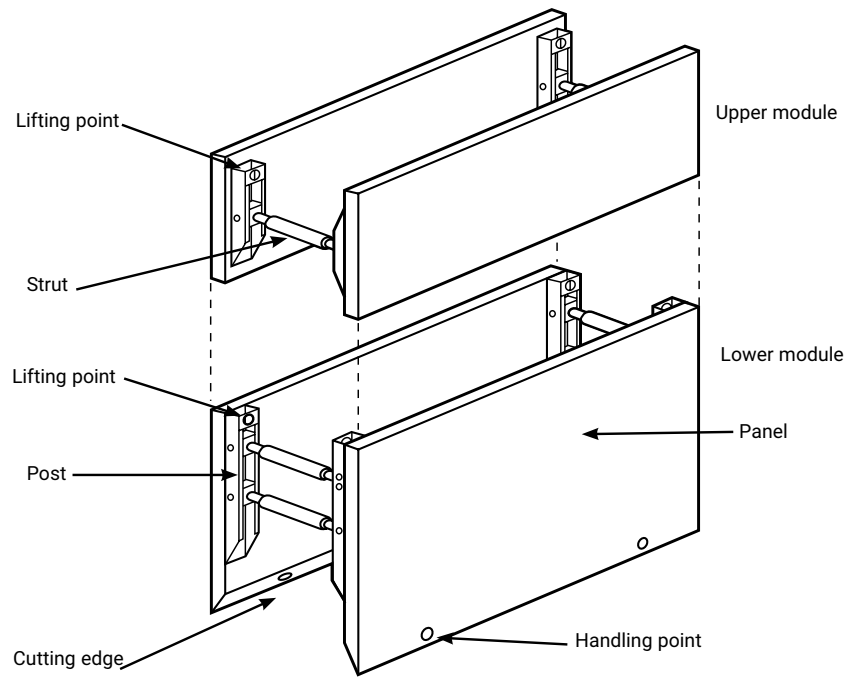


Figure 26 Typical trench shield.

Used correctly, steel trench boxes normally provide a safer means of trench shoring than other conventional means. If abused or misused, steel boxes may cause serious injury during their installation, use or removal.

Instructions for their use should be developed in consultation with the manufacturer and safety and health representatives, if any. Supervisors need to ensure that plant operators understand these instructions.

Trench boxes differ from other trench lining equipment in that they do not usually support the sides of the excavation. They protect workers within the shield from cave-ins, although the space between the shield and the sides of the excavation is backfilled to prevent lateral or other hazardous movement in the event of sudden lateral loads.

Steel boxes for trench work are of light or heavy-duty construction, depending on the depth of the trench. Light construction boxes, often referred to as backhoe boxes are normally used to a maximum depth of two metres while heavy-duty boxes 2.4 metres high can be used up to 4.8 metres in depth. The use of steel boxes to greater depths needs to be approved by an engineer.

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

Whenever trench boxes are telescoped to extend the depth of shoring, the ground forces acting on the box need to be checked to ensure the safe working load of the box is not exceeded. This check should be performed by an engineer. Trench boxes are mainly used in open areas where runs are long and relatively uninterrupted, and where access is available for craneage 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, but can be useful where other forms of support are difficult to install.

Installation of trench boxes

Installation procedures for steel trench boxes will depend on the soil conditions encountered in the trench. In all situations, the box should be located squarely in the trench and not inclined from the vertical. The box should not be wedged or jammed into the vertical position as this may cause difficult removal problems.

Boxes should only be lifted from specific lifting points designated by the manufacturer, not from struts or spreader bars.

For sandy conditions, the trench should be excavated to approximately one metre deep, the steel box placed within the trench and the excavation completed from within the box. As the excavation progresses, the box is pushed lower by pressure of the excavator bucket on the top rail of the box. The box should not be struck or hit by the excavator to lower it.

In clay conditions where the excavated sides of the trench are stable, it may be possible to excavate the trench to the desired depth and then install the steel box. After installation, the space between the box and the excavated sides should be backfilled.

Excavation of material below the bottom of the steel box is only permitted if the steel box is designed to resist the forces of the full depth of the excavation. However, this over-excavation should not exceed 600 mm.

Workers are only permitted inside a steel box in which mechanical excavation is being carried out, in accordance with documented procedures developed in consultation with the safety and health representative, if applicable. In all situations where excavators are operating within a steel trench box occupied by workers, the workers should wear high-visibility clothing and have acknowledged the presence of the excavator operator.

If dewatering is carried out, the bottom of the submersible pump should be kept above the bottom of the steel box. This reduces the flow of sand to the pump, and reduces the risk conditions around the steel box.

The installation, use and removal of steel trench boxes should be supervised by a competent person.

The removal of steel trench boxes is covered in Section 12.2.

Storage and transport of trench boxes

Heavy-duty steel trench boxes can weigh several tonnes and care needs to be taken to ensure equipment used to lift and transport the boxes in and around the site has sufficient capacity.

Trench boxes should be stored and transported in accordance with the manufacturer's instructions. In some situations, heavy-duty boxes may require disassembly for transport.

Boxes should be regularly inspected for damage. They should not be altered or modified without the approval of an engineer.

Persons who provide steel trench boxes and those who design and construct or modify them have significant responsibilities under the Act and Regulations.

The Act requires that employers provide and maintain plant and systems of work such that workers, so far as is practicable, are not exposed to hazards.

The Act also requires that suppliers of plant ensure that the design and construction is such that persons, so far as is practicable, who properly install, maintain or use the plant are not exposed to hazards.

The Regulations require that if the design of plant is altered:

- the alteration is assessed for risk of injury
- the alteration is carried out by a competent person
- the plant is inspected and tested by a competent person before being returned to service.

12 Removal of shoring

12.1 General

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, as shown in Figure 27.

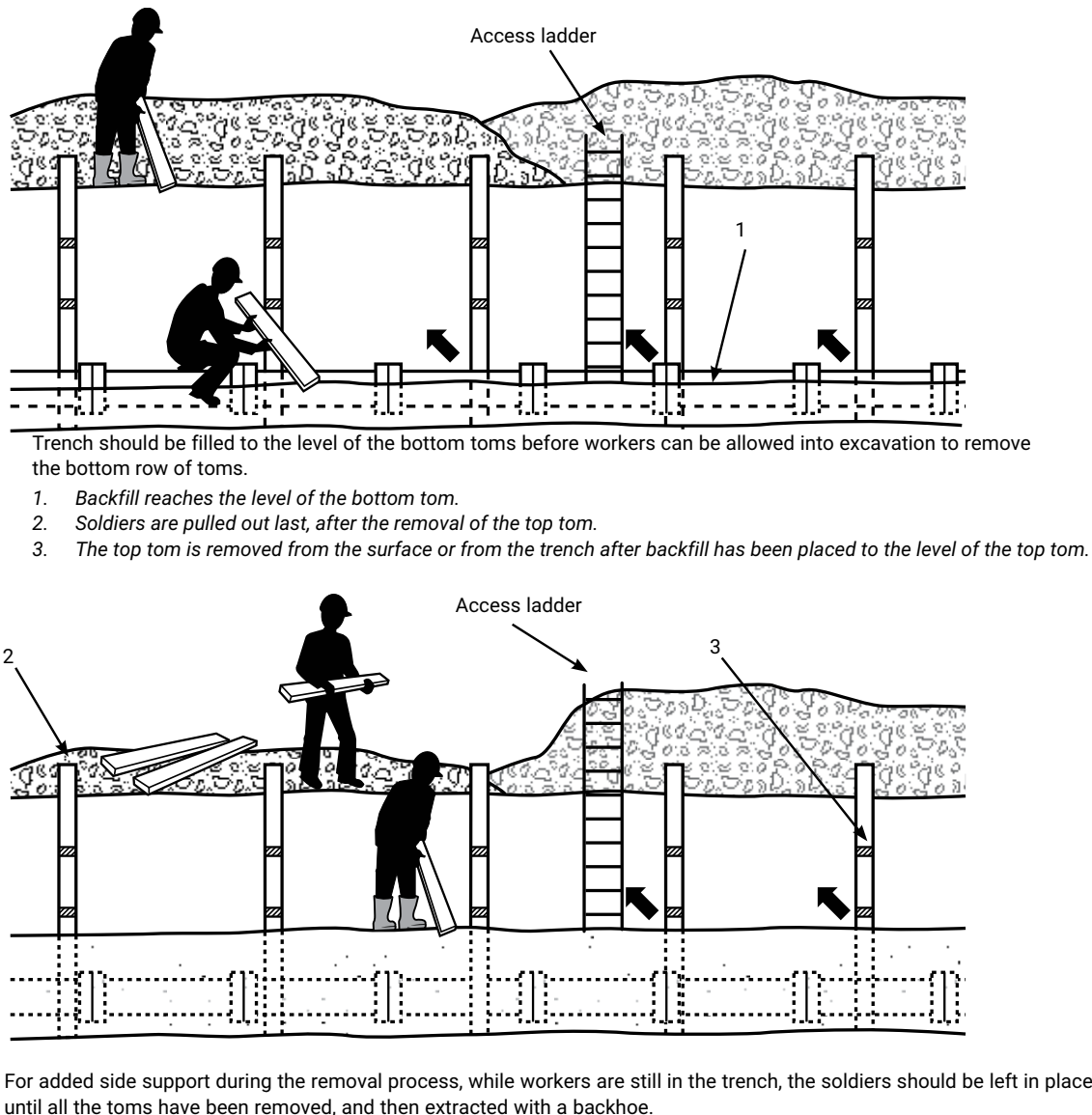


Figure 27 Removing soldier set ground supports – Method 1.

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.

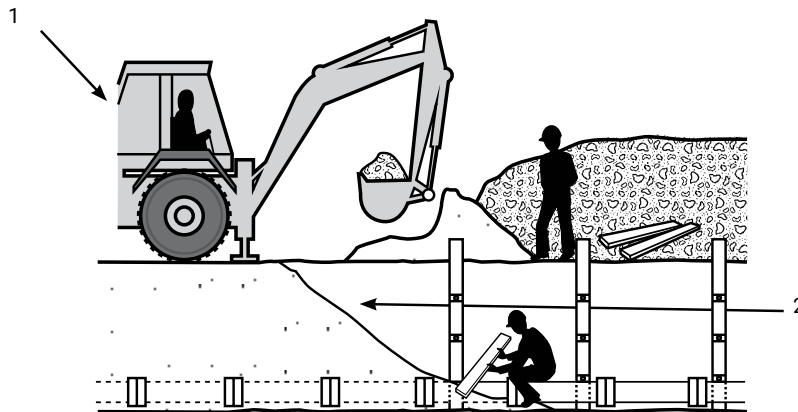
Backfill is placed in the trench until it begins to run over the bottom tom. A worker then approaches and removes this bottom tom. After the worker has left the trench or has gone behind a complete soldier set, more backfill is added until it reaches the next tom in the set being dismantled; this tom 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 to bottom. This means that the area of partially unsupported ground around a worker in the trench is increased after the bottom to bottom has been removed (see Figure 28).

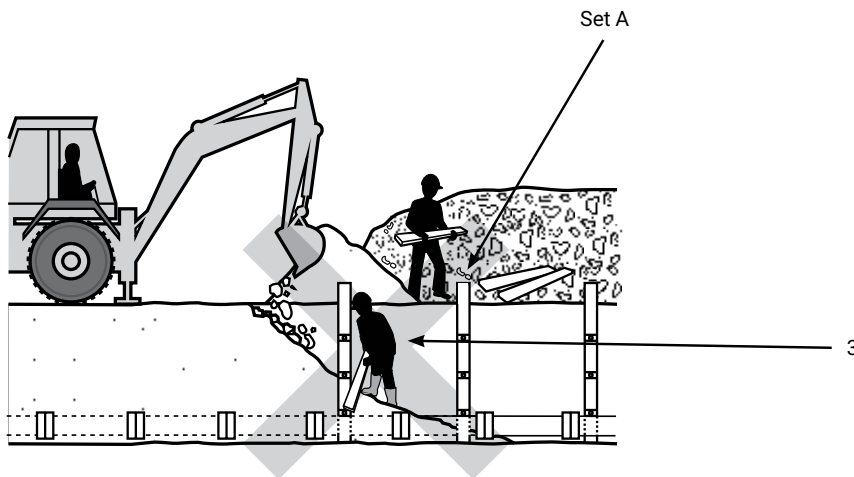
It may sometimes be better to abandon the support material if its removal is dangerous.

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 to bottom before the to bottom is removed.

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



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

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

Figure 28 Removing soldier set ground supports – Method 2.

12.2 Removal of 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 of at least 16 tonne maximum 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.

A crane or excavator of at least 12 tonne maximum capacity is required to remove light duty boxes from the ground.

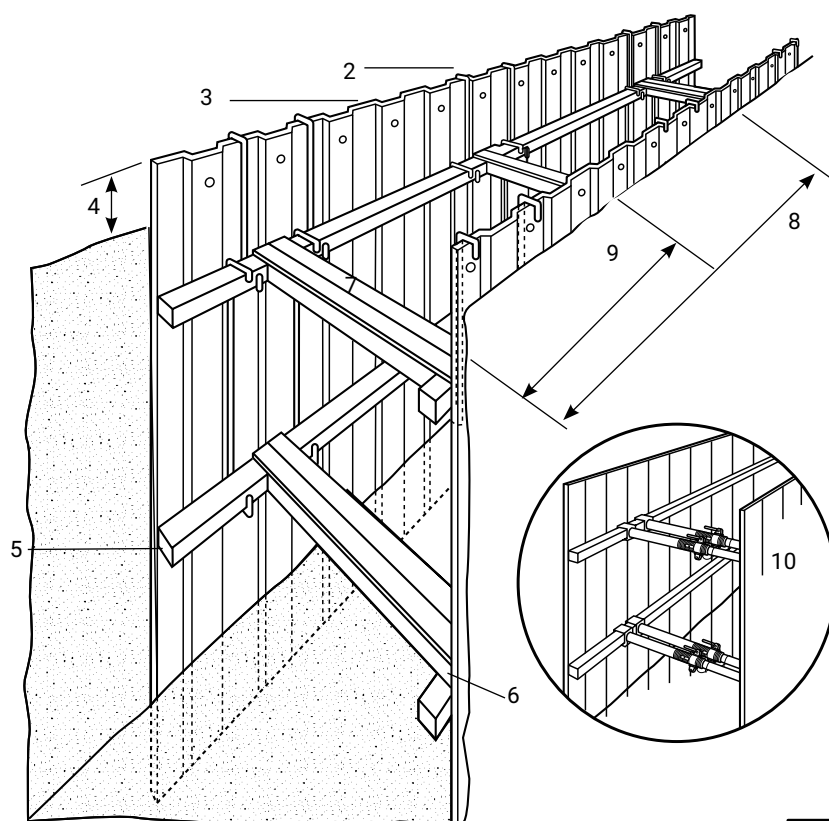
The manufacturer's instructions should be followed in removal of steel trench boxes and the operation supervised by a competent person.

13 Steel sheet piling

13.1 Uses of steel sheet piling

Steel sheet piling is generally used on major excavations, such as large building foundations, or where large embankments are to be held back. It is also used where an excavation is in close proximity to adjoining buildings.

The use of steel sheet piling is a similar method of trench support to closed sheeting, but does not require as much expertise and time. However, skill is necessary to install walers and toms that support the steel sheet piling safely (see Figure 29).



1. Centre capped single tom.
2. Hanging bar: minimum diameter, 15mm mild steel bar.
3. Sheet piling.
4. Minimum height of sheet piling above surface: 300mm.
5. Waling: minimum size, 3500mm x 100mm x 100mm.
6. Twin toms: minimum size 100mm x 100mm.
7. Twin capping: minimum size 100mm x 25mm.
8. Maximum distance between twin toms: 3500mm.
9. Maximum distance between toms: 1750mm.
10. Twin steel jacks should be used where extra strength is required due to heavy loading.

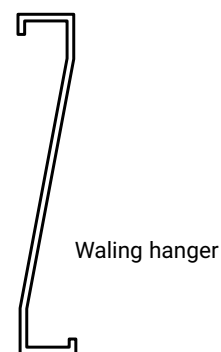


Figure 29 Sheet piling in unstable ground. Sheet piling may be used when ground is so unstable that side wall collapse would be likely immediately after excavation, for example, in loose and running sand. In such cases, sheet piling needs to be carried out before excavating.

Steel sheet piling is formed from plates that are pickled and oiled before rolling, which makes the sheets clean and free from rust or mill scale. If it is considered necessary to add to the effective life of the sheeting by providing a protective coating, the sheets can be coated with a tar base paint after the oil has been removed.

There are several types of steel sheet piling which can be obtained, all usually having similar applications.

13.2 Driving steel sheet piling

Correct driving procedure and the provision of temporary falsework will ensure the sheeting is driven as rapidly and economically as possible. This is particularly important if interlocking types are driven to form a permanent retaining wall, occupying a conspicuous place in the finished work.

The interlocking sections may show a tendency to lean over in the direction of driving. This tendency is common to all types of sheet piling and can usually be overcome by interlocking the sheets in panels before driving them.

13.3 Supporting steel sheet piling

There are two methods of supporting steel sheet piling, internal propping and ground anchors.

Internal propping

Generally, the work area protected by sheet piling is restricted and the total area is in use. Removal of props supporting the sheet piling can be difficult in these situations, particularly if the excavation is wet, which often occurs in the foundation excavation of large buildings.

Ground anchors

A ground anchor is a tie back to the soil behind the face requiring support. It can be said a ground anchor is a cast in situ pile resisting tension forces only (see Figure 30).

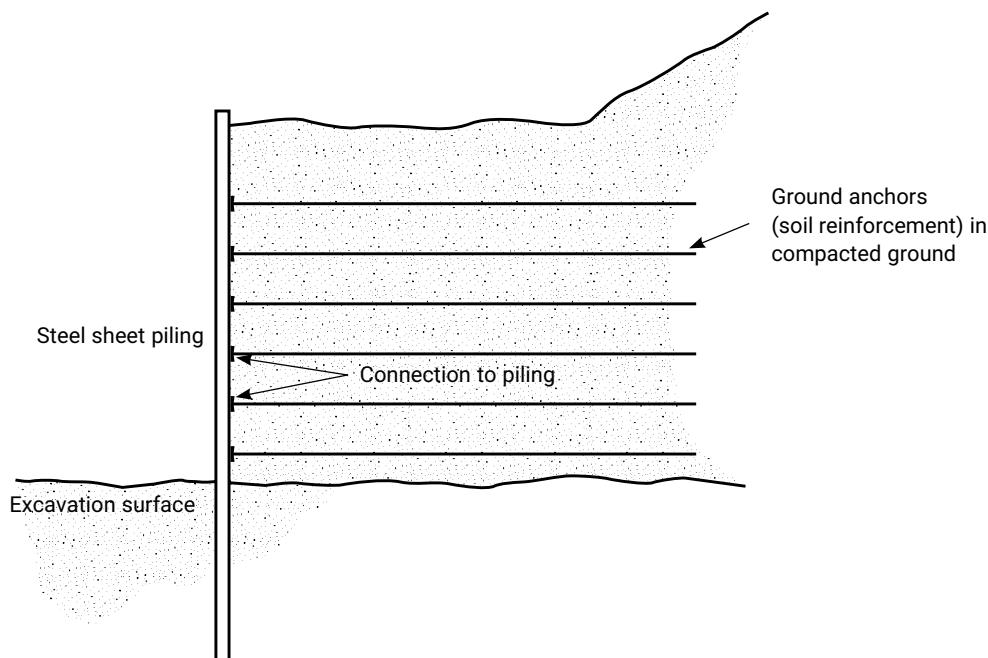


Figure 30 Ground anchors – for supporting steel sheet piling.

Ground anchors may be installed in either granular or clay soils. The design of ground anchors should be carried out by an engineer experienced in this type of work.

One or more horizontal rows of variously spaced ground anchors may be used. The spacing and sizes depend on the type of soil, the loads to be resisted and the physical limitations of the method used to install the anchors. These factors also determine the dip angle of the anchor.

Ground anchors can be installed using ground anchor rigs, modified drilling rigs or modified pile driving rigs.

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 are due, in part, to the overburden. Removal of soil above installed ground anchors should only be carried out after approval has been received from an engineer.

Removal of the soil between the retaining wall and the active soil limit line may cause the sheet piling to bend. This bending will release the load in the stressing cable, and hence render the ground anchor useless and dangerous to workers within the excavation. On replacement of the soil, the ground anchor may not develop its original load carrying capacity; also, the anchorage of the stressing cable at the face of the sheet piling may be 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.

14 Steel trench sheeting

Other methods of excavation may require the use of steel trench sheeting. Trench sheeting is simply a lighter section of sheet piling. It is positioned and pneumatically driven in to final depth. Toms and walings are placed into position as the soil is excavated. Timber can be used, but generally, it is found more efficient to use adjustable jacks or struts, as shown in Figure 31.

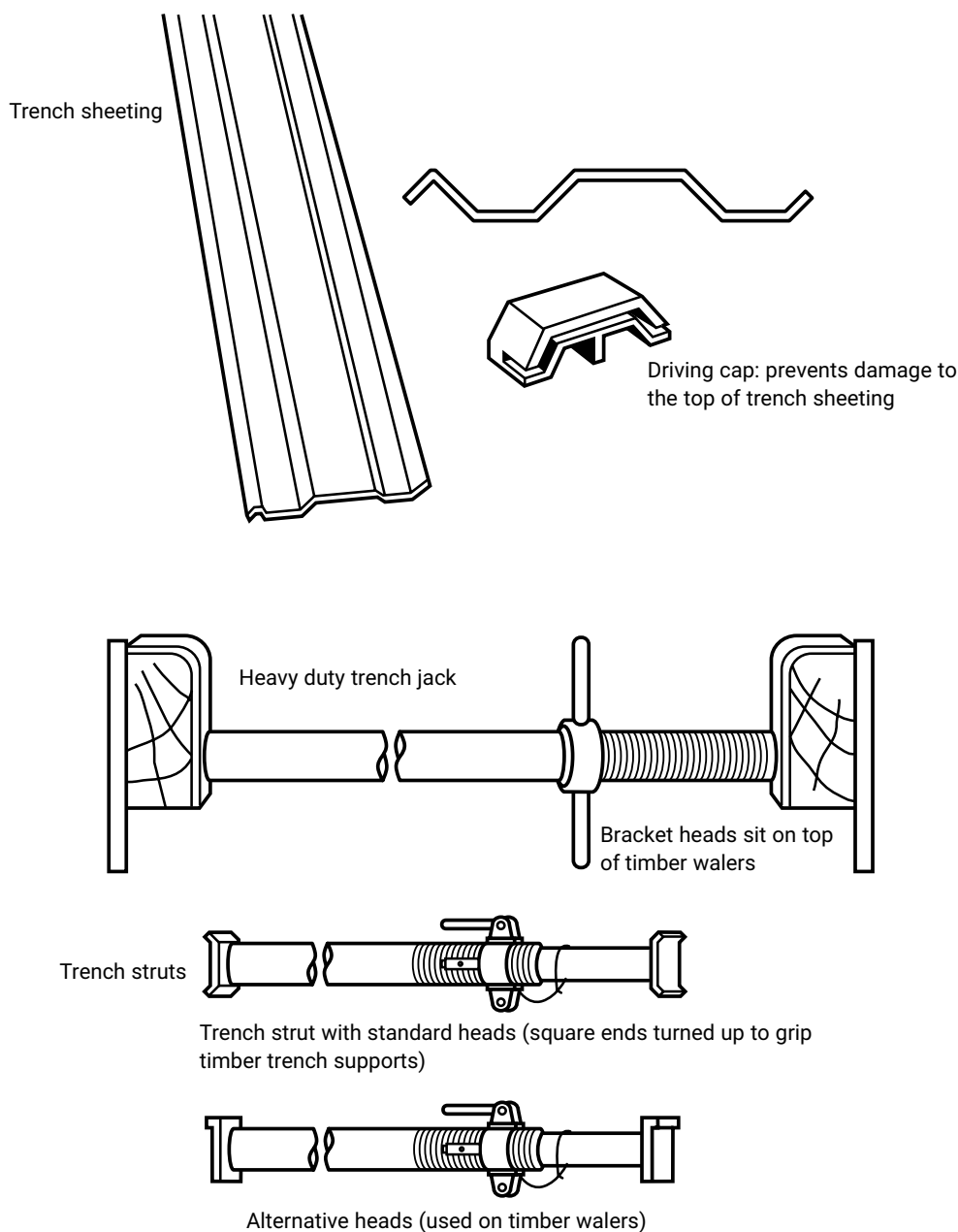


Figure 31 Steel trench sheeting.

14.1 Driving steel trench sheeting

Steel trench sheeting may be driven by any type of compressed air-operated jackhammer. In some cases, a sledgehammer or heavy maul may be used. The potential for manual handling injuries to occur in this operation is very high and should be addressed prior to commencement of driving the steel sheet. Any 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, workers may be exposed to noise levels in excess of the exposure standard, and require hearing protection in accordance with AS/NZS 1269.3 to be provided.

Whatever type of hammer is used, it is essential to protect the heads of the sheets with a special alloy cast steel cap, which is provided for that purpose. If the cap is omitted, the sheets will become damaged and the tops will need trimming before the sheets can be re-driven.

The cap can be handled and placed on top of the sheets without difficulty and can be seen at Figure 32.

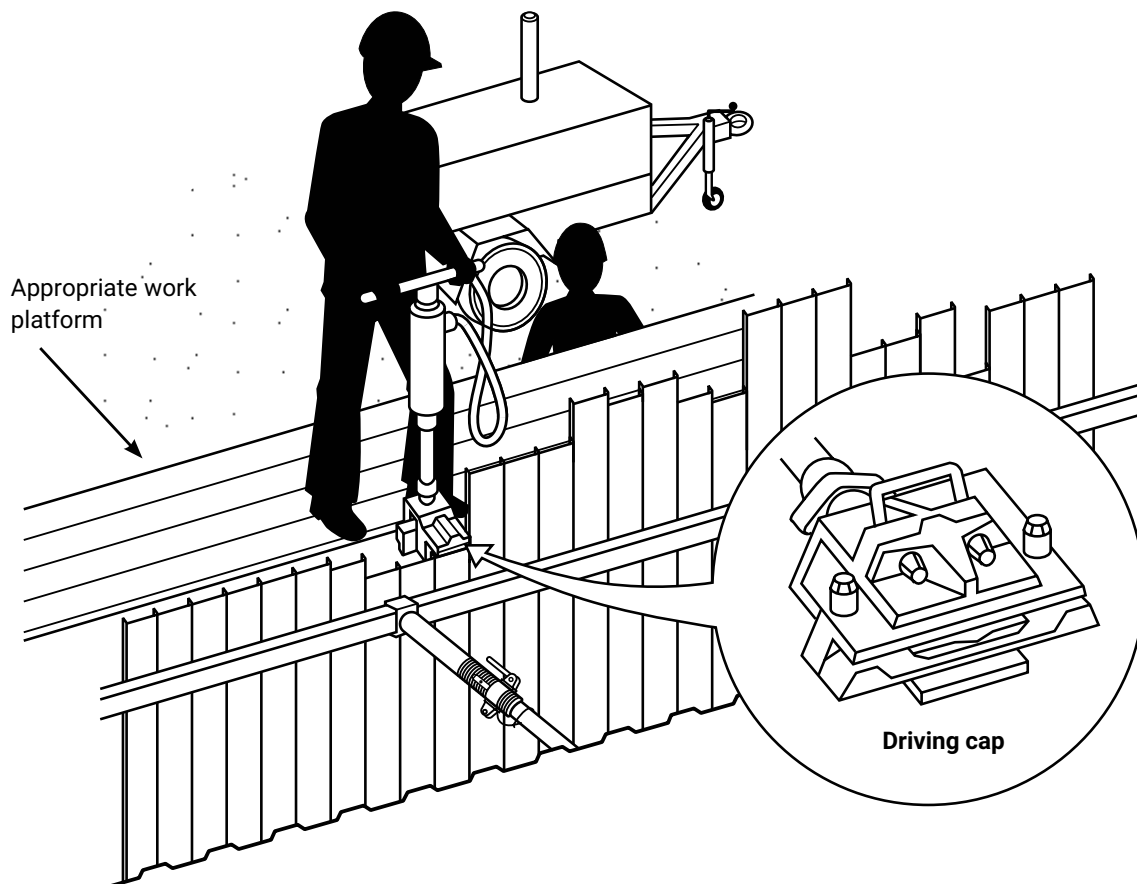


Figure 32 Showing trench sheeting, driving cap and trench struts.

Appendix 1 Definition of terms

Batter	The stable, formed slope of an excavation or earth bank, cut to an angle usually less than the natural angle of repose to prevent earth slippage.
Bearer	A structural member, supported on foundation walls, piers, piles or pressure boards on the sides of a trench.
Bench	An excavation cut in steps to provide horizontal bearing and sliding resistance.
Boning	The operation of setting out levels by sighting over boning rods whereby, from two given points, other points at the same level, or on the same gradient, may be established.
Capping	A member attached to the top face of toms to help position the tom between the walers.
Cleat	A block attached to soldiers to locate and support toms.
Close sheeting	Vertical metal or hardwood timber members used to fully cover and support a trench wall which are in turn supported by other members of a support system.
Drive	An excavation made below the surface of the ground, its longer axis being horizontal or less than 45 degrees from horizontal.
Excavation	Means a hole in the earth, or a face of earth, formed after rock, sand, soil or other material is removed (e.g. a trench, ditch, shaft, well, tunnel, pier hole, cutting or caisson or a hole drilled in the earth).
Excavation work	Means work to make, fill or partly fill an excavation.
Face	A sloping exposed surface resulting from the excavation of material.
Filling	Any ground (usually compacted to some degree) made from excavated material.
Lacing	A structural member used to position and suspend walers.
Laths	Short lengths of metal or hardwood timber about 1.25 to 1.5 metres long used to support the side walls and supported in turn by walings and toms.
May	Used to indicate an optional course of action.
Must	Indicates that legal requirement exists, which must be complied with.
Requires	Indicates that legal requirements exist, which must be complied with.
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. A safe 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.
Set	A term used in trenching to define an assembly of toms and soldiers at a cross section supporting the sides of a trench. Steel sets are now replacing the use of timber sets for trench work.

Shaft	An excavation made below the surface of the ground, its longer axis being vertical or less than 45 degrees from vertical.
Should	Indicates a recommended course of action.
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, or by progressive strutting (with walings as needed) from within the excavation as the work proceeds.
Shield	A steel or metal structure able to withstand the forces imposed on it by a cave-in and thereby protect workers within it. Shields used in trenches are usually referred to as trench shields or boxes.
Shore	A substantial prop of steel or hardwood timber or other material used in direct compression to give temporary support. It may be a horizontal shore between two walls without direct support from the ground or inclined as a raking shore, with the top end supporting a wall or similar and the bottom end supported by the ground in the floor of the excavation usually with the addition of a foot block.
Shoring	Providing support by means of a shore or a system of shores.
Soil	All materials encountered from the ground surface down to bedrock.
Soldier	Vertical upright steel or hardwood timber used for supporting a trench wall, taking the thrust from horizontal walings and supported by toms.
Spoil pile	A heap of excavated material.
Strut	Structural member (usually horizontal) in compression resisting thrust or pressure from the face or faces of an excavation.
The Act	Refers to the <i>Occupational Safety and Health Act 1984</i> .
The Regulations	Refers to the Occupational Safety and Health Regulations 1996 and regulation refers to individual regulations in the Regulations.
Tom	Structural member used to hold soldiers against a trench wall or to press walers apart in a close sheeted trench.
Trench	A long, narrow, open excavation in which the horizontal width across the top is less than twice the vertical depth of the deeper side.
Virgin ground	Ground that is undisturbed and in situ, as distinct from transported, made-up or backfill material.
Waler	Horizontal member used to hold close sheeting in position.

Appendix 2 Referenced documents

Legislation

Dangerous Goods Safety (Explosives) Regulations 2007

Mines Safety and Inspection Act 1994

Occupational Safety and Health Act 1984

Occupational Safety and Health Regulations 1996

Commission for Occupational Safety and Health

Codes of practice: *First aid facilities and services; Workplace amenities and facilities; Personal protective clothing and equipment*

Code of practice: *Managing noise at workplaces*

Code of practice: *Prevention of falls from height at workplaces*

Guidance note: *The general duty of care in Western Australian workplaces*

Department of Mines, Industry Regulation and Safety

Guidelines for work in the vicinity of overhead power lines

Australian Standards

AS/NZS 1269 *Occupational noise management, Part 3: Hearing protector program*

AS 1319 *Safety signs for the occupational environment*

AS/NZS 1337 *Eye protectors for industrial applications*

AS/NZS 1576 *Scaffolding*

AS/NZS 1715 *Selection, use and maintenance of respiratory protective devices*

AS/NZS 1716 *Respiratory protective devices*

AS/NZS 1801 *Occupational protective helmets*

AS/NZS 1892 *Portable ladders, Part 1: Portable ladders – metal*
Part 2: Portable ladders – timber

AS/NZS 2211 *Safety of laser products*

AS 2397 *Safe use of lasers in the building and construction industry*

AS/NZS 4501 *Occupational protective clothing*

AS/NZS 4576 *Guidelines for scaffolding*

Other documents

Dial Before You Dig WA, *Best practice guide*

Main Roads Western Australia, *Traffic management for works on roads: Code of practice*

Utility Providers Services Committee, *Utility providers code of practice for Western Australia*

The State of Western Australia supports and encourages the dissemination and exchange of its information. The copyright in this publication is licensed under a Creative Commons Attribution 4.0 International (CC BY) licence.



Under this licence, with the exception of the Government of Western Australia Coat of Arms, the Department's logo, any material protected by a trade mark or licence and where otherwise noted, you are free, without having to seek our permission, to use this publication in accordance with the licence terms.

We also request that you observe and retain any copyright or related notices that may accompany this material as part of the attribution. This is also a requirement of the Creative Commons Licences.

For more information on this licence, visit creativecommons.org/licenses/by/4.0/legalcode



Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

Department of Mines, Industry Regulation and Safety
303 Sevenoaks Street
CANNINGTON WA 6107

Telephone: 1300 307 877

NRS: 13 36 77

Email: Safety@dmirs.wa.gov.au

Website: www.dmirs.wa.gov.au