Approved Code Of Practice For Safety in

EXCAVATION AND SHAFTS FOR FOUNDATIONS

OSH
occupational safety & health service
te ratonga oranga

DEPARTMENT OF LABOUR
TE TARI MAHI

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CONTENTS

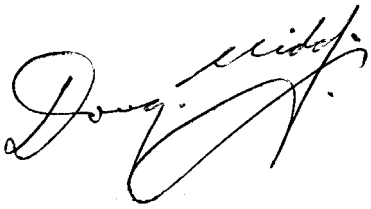
NOTICE OF ISSUE

I have issued this *Approved Code of Practice for Safety in Excavation and Shafts for Foundations*, being a statement of preferred work practices or arrangements for the purpose of ensuring the health and safety of persons to which this code applies and persons who may be affected by the activities covered by this code.

J. M. Chetwin
Secretary of Labour
September 1995

FOREWORD

I have approved this statement of preferred work practices, which is an *Approved Code of Practice for Safety in Excavation and Shafts for Foundations*, under section 20 of the Health and Safety in Employment Act 1992. When a code is approved, a Court may have regard to it in relation to compliance with the relevant sections of the Health and Safety in Employment Act. This means that if an employer in an industry or using a process to which an approved code applies can show compliance with that code in all matters it covers, a Court may consider this to be compliance with the provisions of the Act to which the code relates.



Hon. Doug Kidd
Minister of Labour
September 1995

SUMMARY OF THE HEALTH AND SAFETY IN EMPLOYMENT ACT AND REGULATIONS

The principal object of the Health and Safety in Employment Act 1992 is to prevent harm to employees at work. To do this, it imposes duties on employers, employees, principals and others, and promotes excellent health and safety management by employers. It also provides for the making of regulations and codes of practice.

REGULATIONS

Regulations are promulgated from time to time under the HSE Act. Regulations may impose duties on employers, employees, designers, manufacturers, and others relating to health and safety. These regulations may apply with respect to places of work, plant, processes or substances and may have been made to deal with particular problems that have arisen. Under the Health and Safety in Employment Regulations 1995, certain construction work is required to be notified to the Occupational Safety and Health Service of the Department of Labour.

APPROVED CODES OF PRACTICE

"Approved Codes of Practice" are provided for in section 20 of the HSE Act. They are statements of preferred work practice or arrangements, and may include procedures which could be taken into account when deciding on the practicable steps to be taken. Compliance with codes of practice is not mandatory. However, they may be used as evidence of good practice in court.

EMPLOYERS' DUTIES

Employers have the most duties to perform to ensure the health and safety of employees at work.

Employers have a general duty to take all practicable steps to ensure the safety of employees. In particular, they are required to take all practicable steps to:

- Provide and maintain a safe working environment;
- Provide and maintain facilities for the safety and health of employees at work;
- Ensure that machinery and equipment is safe for employees;

- Ensure that working arrangements are not hazardous to employees; and
- Provide procedures to deal with emergencies that may arise while employees are at work.

Taking "all practicable steps" means what is reasonably able to be done to achieve the result in the circumstances, taking into account:

- The severity of any injury or harm to health that may occur;
- The degree of risk or probability of that injury or harm occurring;
- How much is known about the hazard and the ways of eliminating, reducing or controlling it; and
- The availability, effectiveness and cost of the possible safeguards.

HAZARD MANAGEMENT

Employers must have an effective method to identify and regularly review hazards in the place of work (existing, new and potential). They must determine whether the identified hazards are *significant* hazards and require further action.

If an accident or harm occurs that requires particulars to be recorded, employers are required to investigate it to determine if it was caused by or arose from a significant hazard.

"Significant hazard" means a hazard that is an actual or potential cause or source of:

- Serious harm; or
- Harm (being more than trivial) where the severity of effects on a person depends (entirely or among other things) on the extent or frequency of the person's exposure to the hazard; or
- Harm that does not usually occur, or usually is not easily detectable, until a significant time after exposure to the hazard.

Where the hazard is significant, the HSE Act sets out the steps employers must take:

- Where practicable, the hazard must be *eliminated*.
- If elimination is not practicable, the hazard must be *isolated*.
- If it is impracticable to eliminate or isolate the hazard, the employer must *minimise* the likelihood that employees will be harmed by the hazard.

Where the hazard has not been eliminated or isolated, employers must, where appropriate:

- Ensure that protective equipment is provided, accessible and used;
- Monitor employees' exposure to the hazard;
- Seek the consent of employees to monitor their health; and
- With their informed consent, monitor employees' health.

INFORMATION FOR EMPLOYEES

Before employees begin work, they must be informed by their employer of:

- Hazards employees may be exposed to while at work;
- Hazards employees may create which could harm people;
- How to minimise the likelihood of these hazards becoming a source of harm to themselves and others;
- The location of safety equipment; and
- Emergency procedures.

Employees should be provided with the results of any health and safety monitoring. In doing so, the privacy of individual employees must be protected.

EMPLOYERS TO INVOLVE EMPLOYEES IN THE DEVELOPMENT OF HEALTH AND SAFETY PROCEDURES

Employers need to ensure that all employers have the opportunity to be fully involved in the development of procedures for the purpose of identifying and controlling significant hazards, or dealing with or reacting to emergencies and imminent dangers.

TRAINING OF EMPLOYEES

Employers must ensure employees are either sufficiently experienced to do their work safely or are supervised by an experienced person. In addition, employees must be adequately trained in the safe use of all plant, objects, substances and protective clothing and equipment that the employee may be required to use or handle.

SAFETY OF PEOPLE WHO ARE NOT EMPLOYEES

Employers also have a general duty towards persons who are not employees.

Employers must take all practicable steps to ensure that employees do not harm any other person while at work, including members of the public or visitors to the place of work.

EMPLOYEES' AND SELF-EMPLOYED PERSONS' DUTIES

Employees and self-employed persons have a responsibility for their own health and safety while at work. They must also ensure that their own actions do not harm anyone else.

However, these responsibilities do not detract from the employer's responsibilities.

ACCIDENTS AND SERIOUS HARM (RECORDING AND NOTIFICATION)

The HSE Act requires employers to keep a register of work-related accidents and serious harm. This includes every accident that harmed (or might have harmed):

- Any employee at work;
- Any person in a place of work under the employer's control.

Employers are also required to investigate all accidents and near-misses to determine whether they were caused by or arose from a significant hazard.

Employers are required to notify serious harm that occurs to employees while at work to the Secretary of Labour (in practice, the nearest OSH office), as soon as possible. In addition, the accident must also be notified in the form prescribed within 7 days. (Suitable forms for notification are available from OSH offices and selected stationers.)

If a person suffers serious harm, the scene of the accident must not be disturbed unless to:

- Save life or prevent suffering;
- Maintain public access for essential services, e.g. electricity, gas;
- Prevent serious damage or loss of property.

The OSH office will advise whether it wishes to investigate the accident and what action may be taken in the meantime.

NOTIFIABLE WORKS

The Health and Safety in Employment Regulations 1995 require an employer to notify the inspector of certain work, deemed to be more than usually dangerous, before it is started. A form for this purpose is available from all OSH offices.

Works that the inspector must be notified of include:

(a) Work where workers could fall 5 m or more, excluding work on a two-storied house, or work on a power or telephone line, or work carried out from a ladder only, or maintenance or repair work of a minor or routine nature.

(b) The erection and use of scaffolds 5 m or more above the ground.

(c) Every excavation which is more than 1.5 m deep and which is deeper than it is wide at the top.

(d) Any form of tunnel or drive where workers work underground, irrespective of timbering or support.

(e) Those excavations where the excavated face is more than 5 m deep and the batter of the face is steeper than 1 horizontal to 2 vertical.

(f) Any construction work where explosives are used or stored.

(g) Work such as diving, where construction workers breathe air or any other gas that has been compressed or is under pressure.

(h) Any construction work in connection with asbestos fibres.

(i) Lifts of half a tonne (500 kg) or more carried out by mechanical means other than by a mobile crane, excavator or forklift.

INTRODUCTION

This approved code of practice consists of two major parts.

Part One covers trenches and excavations. Fatal accident records relating to trench collapses highlight the need for employees to be protected against such failures. With proper precautions, accidents and injuries can be avoided. This section also includes recommendations intended to assist engineers who may be involved in the design of shoring.

Part Two covers shafts, drives and the construction of large-diameter shafts for piling, where persons enter for inspection or other work purposes.

This approved code of practice promotes good working practices, and sets out practicable steps that may be taken for compliance with the Health and Safety in Employment Act 1992 and the Health and Safety in Employment Regulations 1995 as they relate to excavation work and piling work. Other practices may be adopted where they are equivalent to or exceed those described. It should also be noted that the construction of some trenches, excavations and shafts, where these form part of the permanent work, is "Building Work" and the requirements of the Building Act, the Building Regulations, and the Building Code may apply. See the appendix for further information on these requirements.

2. GLOSSARY OF TERMS

Angle of Repose: The angle to the horizontal at which the material in the cut face is stable and does not fall away.

Batter: The inclination of a slope, expressed as (a) vertical units on (b) horizontal units.

Benching: Excavation of a sloping ground in horizontal steps.

Cleat: A small block of timber or other substantial material fixed across a member to provide strength and support and to prevent the movement of abutting timbers.

Face: An exposed sloping or vertical surface resulting from the excavation of material.

Filling: Any ground made up using imported material.

Frame: Of timber or steel, used in shafts in a horizontal plane to support the poling boards and resist any ground pressure from shaft walls.

HSE Act: Health and Safety in Employment Act 1992.

HSE Regulations: Health and Safety in Employment Regulations 1995.

Laths: Short lengths of material, usually about 1.25 to 1.5 m long, used to support the sides of walls and roof in a drive, and supported in turn by walings, props, sets, or caps as applicable.

Prop: A vertical timber member used to support a higher waling or strut from the one below.

Raker: An inclined strut.

Ramp: A sloping road to give construction plant access and egress at excavations.

Safe Slope: The steepest slope at which an excavated face is stable against slips and slides.

Sheeting: Vertical timber boards or steel trench sheets placed against the face of an excavation to give it support, and held in place by struts and walings as required.

Shoring: The use of timber, steel or other structural material for the purpose of providing effective and adequate temporary support for an exposed face of an excavation.

Soil: All materials encountered from the ground surface to the bedrock.

Soldier: A vertical timber or steel member taking the thrust from horizontal walings and supported by struts.

Strut: A timber or steel member usually horizontal in compression, resisting thrust or pressure from the face or faces of an excavation. Steel struts are

provided with end plates, corners of which are turned to form claws. They are adjustable.

Timbering: Has a similar meaning to shoring.

Trench: A long narrow excavation.

Trench Shield: A steel-framed box with two vertical side plates permanently braced apart by cross frames or struts, to provide a safe working place for employees while work in an excavation is being carried out.

Waling: A horizontal beam supporting vertical timbers, runners or sheeting.

Well Point System: A system of pipes, jetted or driven at close centres into the ground and connected to a suction main for the purpose of lowering ground water, particularly in granular soil.

3. SCOPE

Part One covers trench excavations and open excavations.

Trench excavations are those where the horizontal width at ground level is less than the vertical depth of the deeper side.

Open excavations are wider than trenches and include foundations, building sites and the like.

Part Two covers shafts, drives and large-diameter shafts.

Shafts are vertical excavations of variable depth and section: *drives* are small tunnels cut into the sides of trenches or shafts. In some cases, the Health and Safety (Mines, Quarries and Mining) Regulations may apply and employers, contractors and principals should establish which regulations relate to the particular shaft or drive. Advice can be obtained from the nearest OSH branch office.

Large-diameter shafts are those greater than or equal to 750 mm diameter where persons are required to enter for inspection or other work requirements. Persons should never enter shafts less than 750 mm diameter because of the difficulty of rescue in the event of an emergency.

PART ONE: TRENCHES AND OPEN EXCAVATIONS

4. GENERAL SAFETY PROVISIONS

4.1 LEGAL REQUIREMENTS

All work involving excavations must comply with the requirements in the HSE Act and the HSE Regulations. Notification must be given to the HSE inspector if the trench is deeper than 1.5 m (refer to the appendix for the particular requirements).

The provisions of the HSE Act and Regulations, and the Building Act and Regulations, which generally apply to excavation work are summarised in the introduction and appendix to this code.

4.2 MODES OF FAILURE

It should be noted that all excavations, no matter what depth, may be hazardous. Modes of failure will depend on the depth, the soil type or soil types if layered, bedding planes, vibration, the presence of moisture, rain, or a high water table level, any superimposed loading close to the edge of the excavation, the time the excavation is open, and any previous disturbance of the soil. While some types of soil often look stable and may stand for quite a long time, a false sense of security can build up. Indeed, experienced employees have been the victims in trench collapses.

Some common failure modes are shown in Fig. 1.

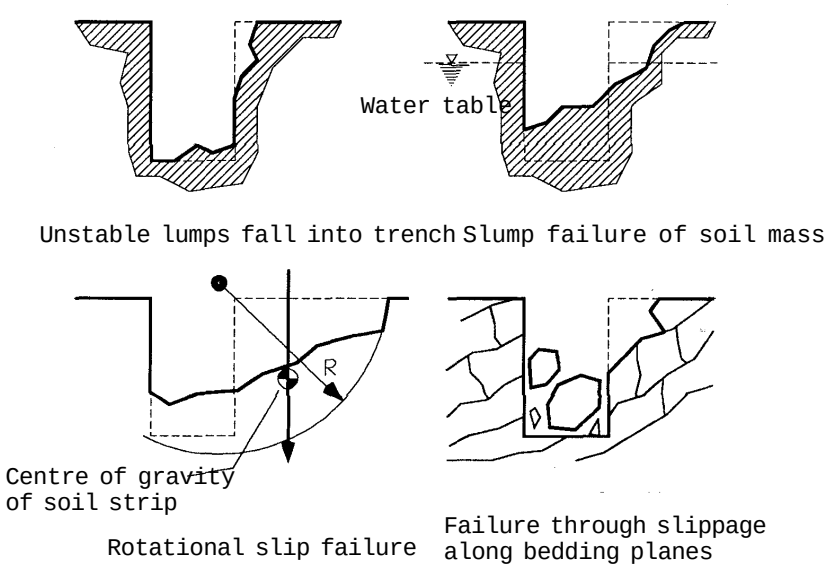


Fig.1 Soil failure modes.

Removal of soil from an excavation causes unbalanced soil stresses. The use of a shoring system, or the cutting of the sides of the excavation to a safe slope, will help compensate these soil stresses. A shoring system, or the design of safe side slopes, are engineering problems that involve both structural design and soil mechanics. While experience can guide operators in recognition of hazardous situations, it is only engineering practice that can provide known safe solutions. Just because a "solution" worked previously does not mean that solution is satisfactory for a current situation. There may be additional factors that need to be taken into account.

4.3 GENERAL REQUIREMENTS

The following requirements apply to all excavations in which employees are required to work.

4.3.1 EXCAVATIONS TO BE SHORED

4.3.1.1 Excavations Shallower than 1.5 metres

Excavations shallower than 1.5 m have been known to collapse. If an employee is in the trench and bending over at the time of the collapse, he or she may suffer serious injury. Employers are to consider such excavations and determine if special precautions or work methods are necessary.

4.3.1.2 Excavations 1.5 metres or Deeper

Excavations greater than or equal to 1.5 m deep are particularly hazardous and must be shored unless:

(a) The face is cut back to a safe slope and the material in the face will remain stable under all anticipated conditions of work and weather; or

(b) Shoring is impracticable or unreasonable, and safety precautions certified by a registered engineer to be adequate, have been taken.

4.3.2 SAFE SLOPES IN EXCAVATIONS

Unless the stability of the excavated face is determined by a registered engineer or a competent person (experienced in excavations), the safe slope should not exceed:

(a) 1V : 1H or the angle of repose, whichever is flatter, for soils above ground water table.

(b) 1V : 1.5H or the angle of repose, whichever is flatter, for saturated or submerged soils, or for excavations greater than 3 m in depth.

(c) Where the slope of an excavation is benched, the maximum height between benches should not exceed 1.5 m, excepting the bench adjacent to the work area, which should not exceed l m (Fig. 2). Overall, the total width of the benched excavation should not be less than required in (a) or (b) above.

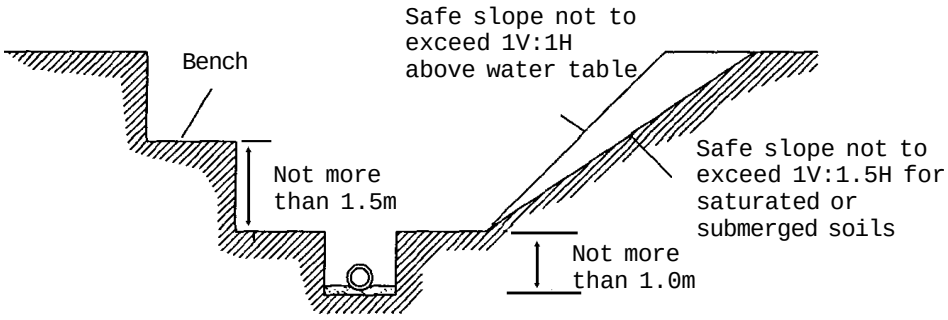


Fig.2 Excavation faces benched and battered to a safe slope.

4.3.3 SHORING

All shoring must be designed in accordance with sound engineering practice, and materials used must be suitable and of sound quality. On large and extensive excavations, the shoring should be designed by a registered engineer. Drawings of the temporary works must be available at the job site.

Shoring must be placed in a proper and workmanlike manner.

The shoring of a face must be carried along with the excavation with the least possible delay between the excavation of the face and the completion of the shoring.

Shoring must not be altered, dismantled, or interfered with except on the instructions of the employer or their representative.

4.3.4 MATERIALS AND LOADS ABOVE EXCAVATIONS

Excavated or other loose material must be effectively stored or retained not closer than 600 mm from the edge of the face unless the face is specially shored to allow for the increased load, and suitable toe boards or other safeguards are provided (Figs 3, 4a and 4b).

Mechanical plant, vehicles or any heavy loads must not approach closer than:

(a) 600mm from the edge of an excavation which is battered to a safe slope; or

(b) What would be the edge of the face if battered to a safe slope unless the actual face is specially shored to allow for the full effect of the additional load.

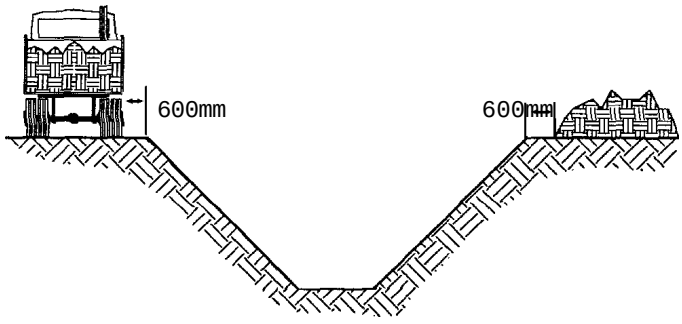


Fig.3 Excavation with battered faces.

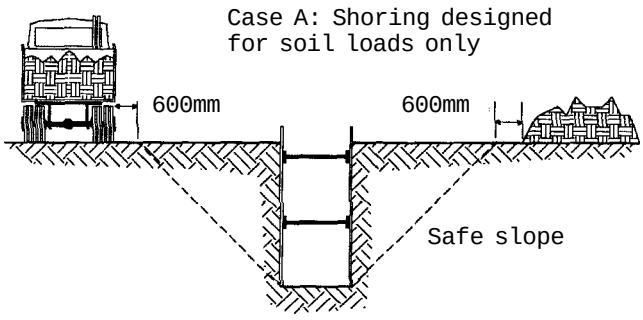


Fig.4a Excavation with shored faces.

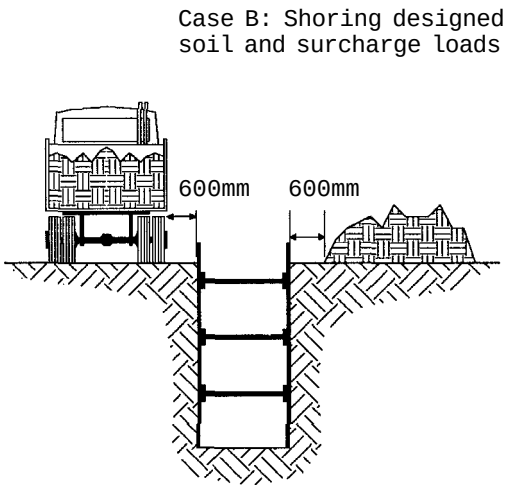


Fig.4b Excavation with shoring designed for surcharge loads.

4.3.5 EXCAVATIONS ADJACENT TO BUILDINGS OR STRUCTURES

Where it is intended to excavate alongside another structure, the following precautions must be observed:

(a) Never excavate below the level of the foundation of any adjacent structure, or within an area which would be inside the safe slope, unless adequate precautions have been taken to ensure that the stability of the excavation face and the building or structures above are not at risk either during or after excavating.

(b) If an excavation is likely to affect the stability of existing structures, advice from a registered engineer must be obtained before the excavation is started.

(c) Where pumping is being carried out to lower the ground water level, subsidence of adjacent structures may result. The characteristics of the supporting soil may be changed by pumping, causing a loss of fines and reducing the load-bearing capacity of the soil. If such works are to be undertaken, expert advice should be obtained.

4.3.6 PROTECTION OF THE PUBLIC AND EMPLOYEES

4.3.6.1 Fencing

(a) Excavations carried out at any place to which the public have or might gain access must be guarded to avoid danger to people. A fence l m high or a combination of signs, barriers, lights, markers, flags or sentries may be necessary to provide adequate protection for the public and employees. These safety devices must be properly maintained until the excavation is completed or when there is no longer any danger.

(b) Where during construction, an excavation is likely to collect or retain water of such a depth as will constitute a hazard to children, or persons in the vicinity, the excavation must be covered or fenced off during times when employees are not present.

4.3.6.2 Notices and Warning Signs

(a) Where construction vehicles or plant use public thoroughfares, notices must be placed at all exits and entrances to the work area to warn all persons in the vicinity.

(b) All work carried out on a road must have the approval of the road controlling authority before any work starts. Temporary warning signs must be erected and traffic control exercised in accordance with the requirements set out in the publication *Working on the Road,* available from Transit New Zealand.

4.3.6.3 Protection from Falling Objects

(a) Where excavation work is in or near public access ways and hazards exist, barricades, overhead protection, enclosed walkways, or other means of protection must be provided for the public.

(b) Where walkways or bridges are used, these must be designed in accordance with sound engineering practice. Guardrails and midrails must also be provided where there is a fall hazard.

4.3.6.4 Protective Helmets, Goggles, Hearing Protection

(a) Where employees could be injured by objects falling from above, adequate overhead protection must be provided. Hard hats must be worn both in the excavation and out of the excavation.

(b) Where there is a foreseeable risk of injury to the eyes, suitable eye protection must be worn. Windblown grit and dust are the most common sources of eye damage in excavation work.

(c) Where employees are exposed to excessive noise, they must use ear protectors.

4.3.7 EXAMINATION OF EXCAVATIONS

Excavations, including shoring and underpinning, must be examined by the employer or the employer's representative before work starts each day, and after rain or any occurrence that could affect the stability of an excavated face. Shoring

members should be checked for tightness against each other and against the soil face. A daily record should be kept of examinations made, conditions found and of precautions and actions taken.

4.4 OTHER SAFETY PRECAUTIONS

4.4.1 SURFACE WATER AND DRAINAGE

In all excavations, the safety of faces and fillings often depends on the effectiveness of the control of surface and ground water. To control surface water, cutoff drains constructed parallel and a safe distance back from the face, should collect water and discharge it clear of the working area. Drains may also be necessary in the trench itself. Subsurface drains, well pointing, or sump pumping should be installed to cut off, remove, or intercept groundwater and channel it away from the site if this is a hazard. Well pointing can lower the water table 4-6 m, and is most suitable in sands. (See Fig. 5.) The inflow from clay soils to well-pointing may be insufficient to be effective. During construction, checks should be made for inflow from springs or seepage. Any inflow should be collected in sumps and pumped clear of the excavation.

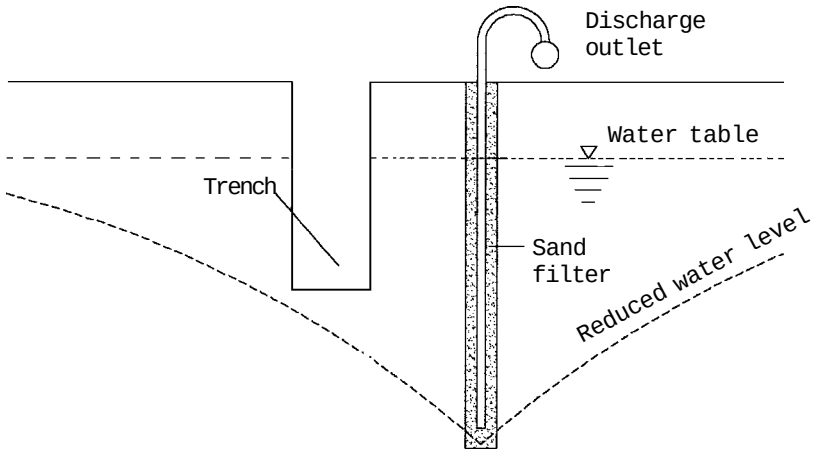


Fig.5 Well pointing.

Springs coming up through the floor of an excavation are another cause of unstable conditions. Sands and gravels are particularly vulnerable. This condition is usually called “quicksand” and barricading the area, pending the control of the water flow, is recommended. Leaching out of fine granular material by inflow may cause slumping or cave-ins. The presence of sediment in inflows may indicate the development of unstable conditions.

4.4.2 DUST NUISANCE

In dry conditions, frequent watering, oiling or chemical spraying of haul roads and working areas must be considered to reduce dust nuisance. Care must also be exercised to avoid the dust hazards being replaced by greasy over-watered surfaces.

4.4.3 HARMFUL GASES

Employees must be protected against the effects of toxic or explosive gases which may be encountered when carrying out work in trenches, open excavations, shafts and drives, by wearing approved equipment in relation to the type of hazard encountered.

Excavations being below ground are a natural receptacle for all gases heavier than air. Gas, of various kinds, from quite unknown sources, can seep through the ground particularly where other work is taking place in the vicinity. These gases may be natural like methane and sulphur dioxide, or they may arise from nearby internal combustion engines (carbon monoxide), leakage from liquefied petroleum gas equipment, leakage from underground storage or nearby oil piping, or from sewer gases, or from piped natural gas. One of the more commonly used and effective methods of prevention is to use special ventilation equipment to blow clean air into the excavation in sufficient quantities to dissipate the foul air.

Where there is any likelihood of air contamination, the works must be examined, using the correct type of detecting equipment. Tests must be carried out in advance of work starting and as a continuing exercise throughout the period of work. Respiratory protection should always be used in contaminated areas.

If combustible or explosive gases are suspected, all members of the public should be kept away from the area until there is no longer any danger.

The gases or fumes most likely to be found in various kinds of excavations are set out in Table 1. Note that some of these gases are both toxic and explosive.

TABLE 1: GASES COMMONLY FOUND IN EXCAVATIONS AND TRENCHES

TYPE OF GROUND	GASES OR FUMES FOUND
Peaty ground	methane, hydrogen sulphide
Filled and made ground	carbon dioxide, hydrogen sulphide
Reclaimed land and tip fills	carbon dioxide, methane
City streets	natural gas, carbon dioxide, steam
Thermal areas	carbon monoxide, carbon dioxide, hydrogen sulphide, sulphur dioxide, methane
Petroleum installations, service stations	petrol fumes, LPG, kerosene

4.4.4 UNDERGROUND SERVICES

Because of the many services such as electric power cables, telegraph cables, gas pipes, water pipes, oil pipes and sewer reticulation that are located underground, employers must, before starting work, ascertain the location of all services that are likely to be affected by the excavation. The owners of these services must be advised and their assistance sought.

When the existing services are uncovered during excavation, proper supports must be provided and all practicable steps must taken to prevent danger to employees or unnecessary interruption to these services. Suitable warning devices must be erected to warn employees and persons in the vicinity. For further information, reference should be made to the publication *Guide For Safety with Underground Services*, published by the Occupational Safety and Health Service.

4.5 BLASTING

Where blasting is to be carried out in connection with excavation work, a certificated construction blaster must be in charge of the actual blasting work. In addition, any work that involves blasting must be notified to the OSH inspector. Suitable precautions are to be taken before any blast is fired.

5. RECOMMENDED SAFE PRACTICES FOR EXCAVATIONS

5.1 BEFORE EXCAVATION

5.1.1 GENERAL

Excavation work involves the removal of rock, weathered rock, gravels and/or soil. Amounts can be small as in shallow trenches for foundations, or many tonnes as in extensive civil engineering work. Since soil varies in its nature, and water is nearly always present either as a free liquid or as moisture within the soil itself, it cannot be relied upon to support its own weight. The sides of any excavation have to potential to collapse; a fall of even a small amount of earth, or the plant used in the rescue attempt, can maim or kill. Excavation work should therefore be carefully planned.

5.1.2 PLANNING

In planning a safe, sound and efficient work system, the following questions should be considered:

(a) What underground/overhead services are in the vicinity?

(b) What is the best method of excavation?

(c) What is the best plant for the job, bearing in mind the limitations of access, right of ways, headroom, overhead cables, bearing capacity of ground and noise restrictions?

(d) What is the best type of support for the sides of the excavation, or can the sides be cut back to a safe batter?

(e) How can the side support system be installed safely?

(f) What is the best method, if occasion demands, of keeping water out of the excavation and reasonably dry, so that work can proceed without interruption?

5.1.3 INVESTIGATIONS

After studying the layout and detailed drawings of the permanent works, the site and ground conditions should be investigated. Check:

(a) The effect excavation may have on adjoining occupiers, adjacent structures, roading and underground services such as electricity, gas or water reticulation, and on the safety of persons in the vicinity.

(b) The nature of the soil to be excavated and its method of disposal, the length and nature of the haul route, the conditions of tipping or spreading and possible compaction.

(c) The water table level, presence of standing or running water, possibility of flooding by surface runoff, and suitable means of disposing of discharged water.

(d) The measures for controlling traffic and pedestrians; the effect of explosives if they are used (especially in regard to excessive particle velocity) on adjacent buildings or structures.

5.1.4 MATERIALS

Adequate supplies of suitable support material should be arranged before work starts, unless other safety precautions have been taken.

5.2 DURING EXCAVATION

5.2.1 ACCESS FOR EMPLOYEES

(a) Safe access and egress must be provided for all employees at all times. The floor of the excavation must be kept clear of loose spoil, debris, tools, timber or anything that would impede employees' safe egress in an emergency.

(b) Access to surfaces more than l m above or below ground level may be provided by means of ladders, stairways or ramps.

(c) In every trench of 1.5 m or more in depth, ladders or stairways must always be provided where work is being carried out.

(d) Where an excavation, trench or shaft is of such small dimensions that it is not practicable to use ladders as a means of access or egress, other means must be provided to allow employees safe access and egress.

(e) Ladders used in an excavation must be constructed of suitable materials, conform to the appropriate New Zealand Standard, and be maintained in good order or condition. Ladder runs of more than 6 m high should be broken up with intermediate landings. Where ladders meet a landing, the ladder below is to be offset from the ladder above by at least 600 mm. A ladder should extend l m above the landing which it serves, unless alternative handholds are provided. Landing platforms should be fitted with guardrails, midrails and / or toe boards.

(f) In deep excavations, temporary stairways should be used as they provide a safer means of access than ladders. Each flight of stairs should have uniform risers; and landings of the same width as the stairs should be provided for every vertical rise of 6 m.

(g) Where ramps in lieu of steps are provided as access, the maximum slope should not be greater than 1 in 6, unless traction cleats are provided at 0.5 m spacing for 1 in 5 slopes, or at 0.4 m spacing for 1 in 4 slopes. Ramps should not be steeper than 1 in 4.

5.2.2 SEPARATION OF TRAFFIC

Where practicable, the route used for hauling spoil should be separated from the one used by employees. In small shafts or drives, where it is not possible to provide separate routes for the two kinds of traffic, the movement of personnel must be forbidden while spoil or plant is being moved, and vice versa. Unless the excavation is so shallow that those outside can see and talk readily to those at the face, an effective signalling system and interlocks that prevent the operation of winding gear, while personnel are moving, must be provided.

Where mechanical haulage is used in small drives or manholes, refuges should be excavated into the side of the drive to provide shelter from passing traffic. Such refuges should be a least 1.2 m deep by l m wide by 2 m high (or the height of the drive if it is less than 2 m) and spaced not more that 18 m apart and all should be on the same side of the drive.

5.2.3 WORKING SPACE

Employees should be kept sufficiently far apart in working areas to avoid injury from hand tools, such as picks or shovels. Generally, a clearance distance of 2 m should be observed to allow employees to safely carry out the work.

5.2.4 ADEQUATE LIGHTING

Shafts, drives, trenches, and open excavations where there is insufficient natural lighting should be provided with adequate artificial lighting. Glare from artificial lighting greatly increases the risk of falls from slipping or tripping, therefore suitable shades may be necessary to eliminate this problem.

5.2.5 HANDLING LARGE-DIAMETER PIPES

Because of the dangers involved in handling and positioning heavy pipes in and about excavations, the following general safety guidelines should be observed:

(a) Always ensure that the load to be lifted does not exceed the safe working load capacity at the various radii of the lifting machine.

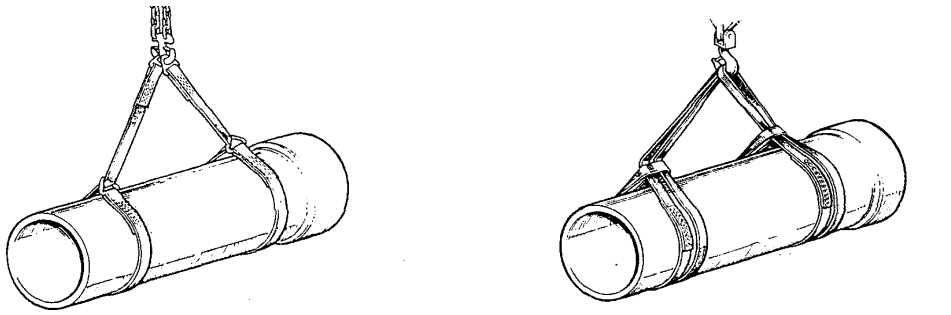
(b) Position the lifting machine on a firm, stable, level surface. Out-of-level surfaces induce a torsional overload into the machine, and when lifting on the low side overloading occurs.

(c) Throughout the entire operation, no part of the machine or its load should come within the minimum approach distances (see Table 2) from overhead power lines unless written permission has been obtained from the controlling electricity supply authority.

TABLE 2: MINIMUM APPROACH DISTANCES FROM ELECTRICAL CONDUCTORS FOR THE USE OF ELEVATING WORK PLATFORMS

LINE VOLTAGE (AND SPAN)	MINIMUM DISTANCE (M)
Not exceeding 66 kV (maximum span 125 m)	4.0 m
Exceeding 66 kV (maximum span 125 m)	5.0 m
Any voltage (span greater than 125 m but less than 250 m)	6.0 m
Any voltage (span greater than 250 m but less than 500 m)	8.0 m
Any voltage (span exceeding 500 m)	As agreed with the owner of the line but not less than 8.0 m

(d) Use lifting tackle that either grips or is attached to the pipe. Lifting tackle must have a minimum factor for safety of not less than 5. Where possible use either two slings with "D" rings or two endless slings, as illustrated in Fig 5. Eye bolts or hairpin fittings may also be used for lifting. Purpose-made lifting equipment should be used in accordance with the manufacturer's instructions. The angle created by the two legs of the sling should not exceed 60 degrees.



Using slings with "D" rings Using endless slings

Fig.5 Method of lifting pipes.

(e) Never permit anyone to walk or work underneath the machine-lifted pipe.

(f) When positioning the pipe, do so from a position of safety, preferably after the pipe has been lowered on to or nearly on to its supporting bed.

5.2.6 REMOVAL OF SHORING

Removal of shoring consists essentially of removing material in reverse order to its setting, i.e. struts, walings and final sheeting. It is of special importance during these operations that employees involved remain within the protection of still-supported areas, as sudden falls of earth at this stage are not uncommon.

5.2.7 BACKFILLING AND COMPACTING

Particular care needs to be taken while backfilling and compacting trenches. The vibration from the compactors can loosen soil from the trench sides and cause collapse. In addition, the fumes from the exhaust can fill the excavation. Precautions may be necessary.

6. METHODS OF SHORING

6.1 PROTECTION AND SUPPORT SYSTEMS

6.1.1 TRENCHES WITH BATTERED SIDES

Trench sides which are battered to stable slopes should not exceed the safe slope limits prescribed in 4.3.2.

6.1.2 SHORING

Where shoring is used as a means of supporting trench walls, the sizes of struts, walings and sheeting material must not be less than the minimum sizes prescribed in Table 3. A registered engineer's design will be required for shoring that does not conform with the requirements set out, or is outside the scope of the table.

Where the trench is in saturated or running ground, the sheeting material used must be such as to prevent the movement of fine material out of the bank. Shoring arrangements are illustrated in Figs 6, 7 and 8.

TABLE 3: SHORING REQUIREMENTS FOR TRENCH EXCAVATIONS

SOIL CONDITIONS	TRENCH DEPTH (m)	TIMBER SHEETING		TIMBER WALINGS		TIMBER STRUTS (mm)					STEEL TRENCH STRUTS (SIZE No.)				
		Min. Dims (mm)	Horizontal Spacing (mm)	Min Dims (mm)	Vertical Spacing C to C (mm)	Trench width up to 1.0 (m)	2.0 (m)	2.5 (m)	Spacing C to C Vertical (mm)	Horizontal (mm)	Trench width up to 1.0 (m)	1.5 (m)	2.0 (m)	Spacing C to C Vertical (mm)	Horizontal (mm)
TYPE A Unsaturated ground; soils above ground water table or level	up to 3.0	150 x 50	1200-300 (a)	150 x 100	1200	100 x 100	150 x 100	150 x 150	1200	1800	No.2	No.3	No.3	1200	1600
	3.0 - 4.5	150 x 50	600 - close (b)	150 x 100	1200	150 x 100	150 x 150	150 x 150	1200	1800	No.2	No.3	No.3	1200	1000
	4.5 - 6.0	200 x 50	300 close (c)	250 x 100	1200	150 x 100	150 x 150	200 x 150	1200	1800	2/No.2	2/No.3	2/No.3	1200	1600
TYPE B Saturated ground, soils below ground water table or level	Up to 3.0	150 x 50	close	225 x 150	1200	150 x 100	150 x 150	150 x 150	1200	1800	2/No.2	2/No.3	2/No.3	1200	1600
	3.0 - 4.5	200 x 50	close	250 x 150	1200	150 x 150	200 x 150	200 x 150	1200	1800	2/No.2	2/No.3	2/No.3	1200	1000

NOTES
1. All timber used for shoring shall be of sound quality No.1 framing grade or better and shall conform to the requirements of NZS 3603: 1981
2. Steel trench struts shall conform to BS 4074: 1982 or an equivalent standard. Metal props such as Acrow, Rapid Metal, etc. should not be used in place of trench struts.
3. Timber walings and sheeting made of steel or other material may be used in lieu of timber provided they are equivalent in strength to the sizes prescribed.
4. Shoring systems outside the scope of this table or not conforming with the requirements set out in it, shall be designed by a registered engineer.
5. (a) = 1/8 to 1/2 sheeting
   (b) = 1/4 to full sheeting
   (c) = 1/2 to full sheeting

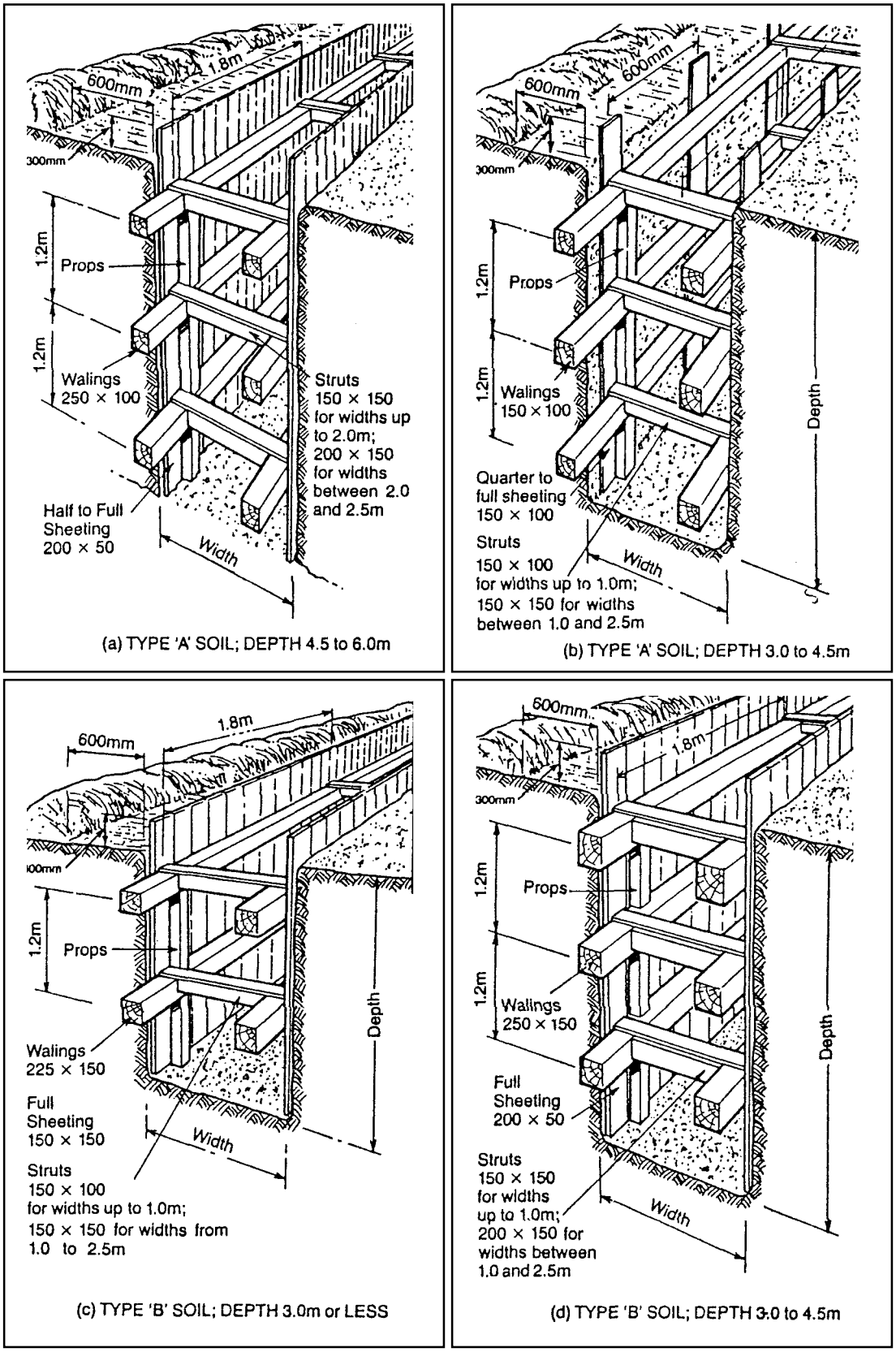


Fig.6 Shoring requirements.

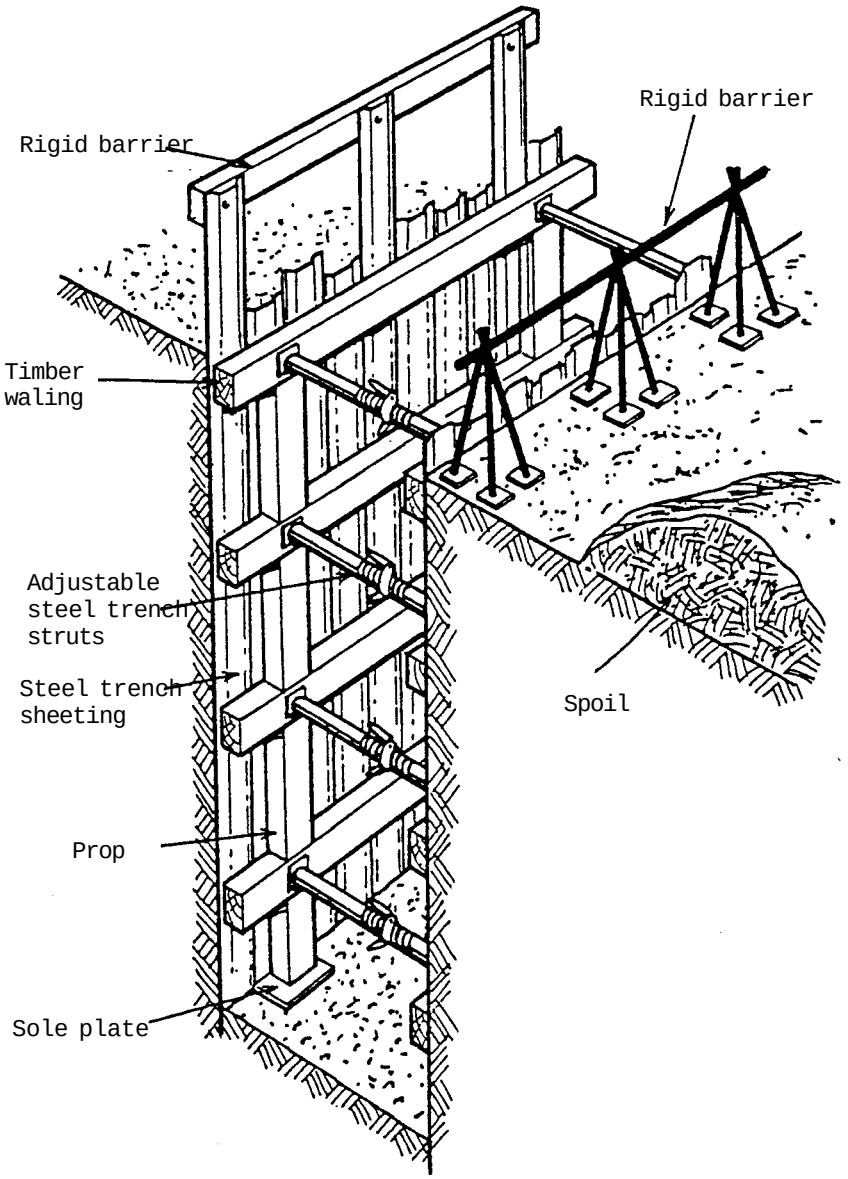


Fig.7 Typical close sheet trench support method.

6.1.3 SHIELDS OR BOXES AND OTHER PROPRIETARY SYSTEMS

These protective systems must be designed in accordance with sound engineering practice. A design certificate from a registered engineer may be required by an OSH Inspector.

Shields are frequently used in wide excavations for the installation of large-diameter pipes where greater disturbance of ground occurs. Whilst they do not in effect provide support to the trench walls, they are a very effective means of preventing the collapse of ground on employees within the excavation. It is essential to ensure that the shield is of sufficient length and that there is no danger of ground spilling over the top of the shield. The basic form of a shield is two vertical plates permanently braced apart to provide a safe working place between them. See Fig. 9 for trench shield illustrations.

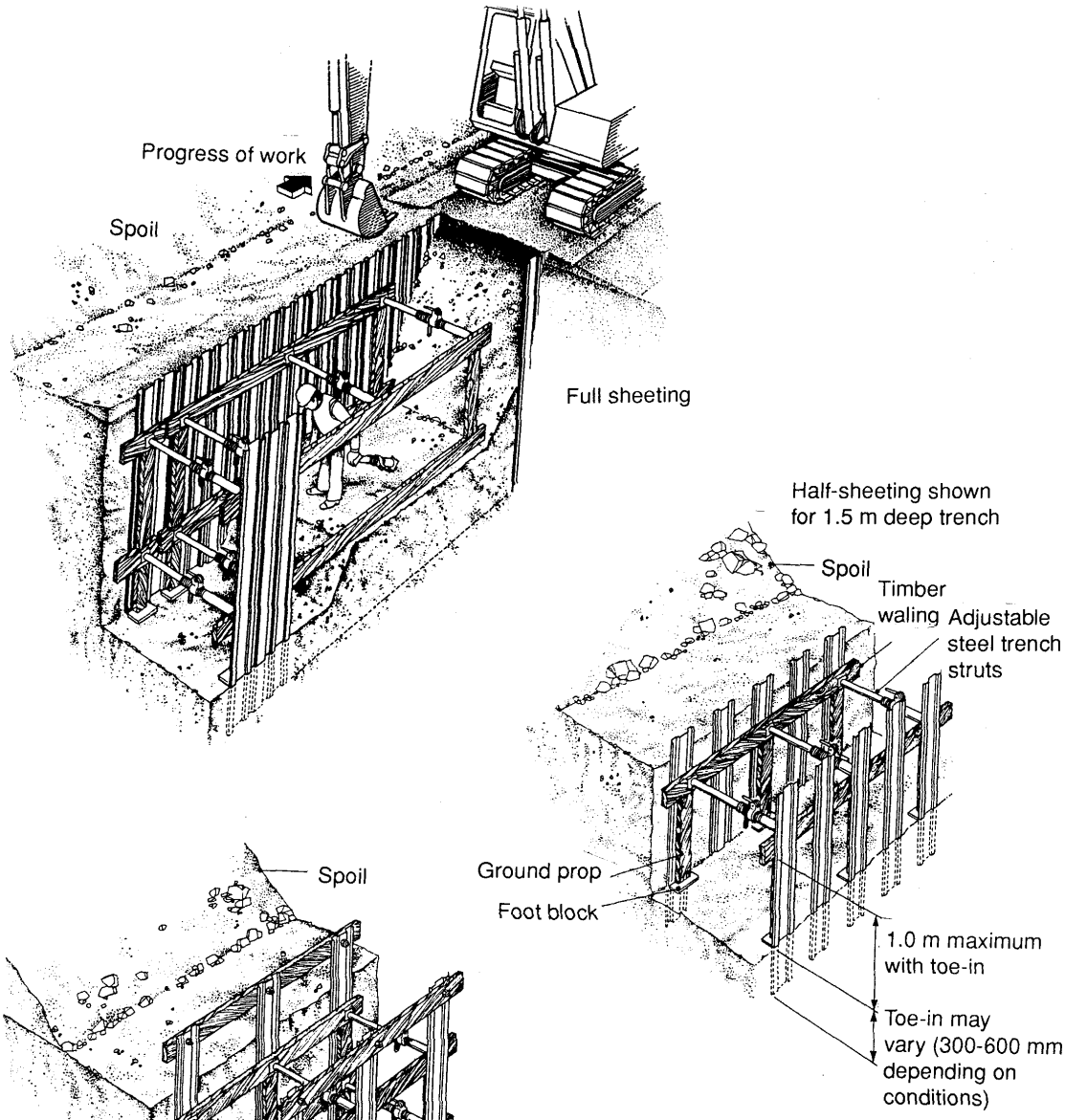


Fig. 8 Sheeting requirements.

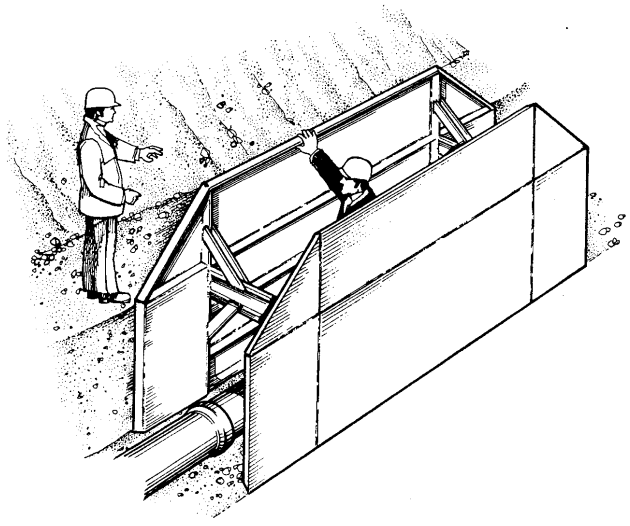


Fig. 9 Trench shield.

6.2 SAFETY CONSIDERATIONS: DO'S AND DON'TS

DO:

(a) Erect and maintain good warning signs.

(b) Protect public and employees from falling objects.

(c) Keep all plant and gear in good working order.

(d) Be aware of all electric lines both overhead and underground.

(e) Compact all fillings.

(f) Seek professional advice if unsure.

DON'T:

(a) Leave signs up when not required.

(b) Fire a blast before clearing everyone from the danger area.

(c) Forget to wear a protective helmet.

(d) Start digging before checking on all underground services.

(e) Cause a dust nuisance.

(f) Let drains block.

(g) Allow hazards to develop.

(h) Take chances on the weather.

(i) Take shortcuts or risks.

6.3 TRENCHING: SAFETY CHECK LIST

This is a basic check list. Other items should be added as appropriate to a particular scheme.

1. Is the surface clear of plant, spoil heaps, materials, etc. for at least 600 mm from the edge of the excavation?
2. Are spoil heaps being properly controlled and will they stay like this in wet weather?
3. Is the trench clear of employees while the spoil heap is being worked on?
4. Is the space between the trench and the spoil heap clear of pipes, bricks, stones, tools, etc.?
5. Is the work properly fenced off and 'signed' during the day. Is the work properly fenced off, 'signed', guarded and lit during the night?
6. Is access adequate without anyone having to jump across? Are footbridges with guard rails available and being used?
7. Are ladders available and being used?
8. Is the supervisor ensuring that no one climbs on the timbering?
9. Is the trench safe from exhaust gases from machines working in the trench or nearby?

10. Does everyone know where the buried services are and are they clearly marked?
11. Are the employees who are excavating and shoring the trench experienced in this sort of work?
12. Are they working at safe distances from each other?
13. Is the ground as the design assumed?
14. Is there any movement or deterioration of the ground that may put adjacent services, roads or structures at risk?
15. Is the area affected by any blasting or other heavy vibrations?
16. Is the ground water level as used in the design (i.e not higher)?
17. Have proper sumps been provided?
18. Does the pumping arrangement avoid drawing material from behind the sheeting?
19. Is the work being done in accordance with the drawings or sketches? If not, is the variation permissible?
20. Are unsheeted faces safe, with no sign of peeling away, etc?
21. Are materials used of the correct design size and quality?
22. Are wedges tight?
23. Is timbering free of damage by skips?
24. Are waling and strut spacing within +/-100 mm?
25. Are deflections excessive?
26. Are all struts horizontal and positioned squarely to the walings (within 1 in 40)?
27. Are frames supported against downward movement (by hangers or lip blocks, puncheons and sole plates)?
28. Have correct pins been used in steel trench struts?
29. Is the method of withdrawing sheeting and support for the trench during backfill safe?
30. Is the work area tidy?
31. Are stops provided for mobile plant?
32. Is visibility adequate in trench?
33. Are safety helmets, goggles, etc. available and being used?

7. OPEN EXCAVATIONS

7.1 GENERAL

Open excavations vary in plan from an extra wide trench in open ground to an irregular shape defined by adjacent buildings as in city centre developments. It is difficult to provide standard solutions for the support of these wide excavations as so many site factors have to be taken into account. It is therefore recommended that open excavations are designed by suitably qualified and experienced persons.

The hazards to employees in open excavations are not quite so immediate as in confined trench work. However, it is necessary to safeguard against failures of excavated faces to prevent loss of life and property.

7.2 PROTECTION AND SUPPORT SYSTEMS

Where space is available, the sides of the excavation should be battered to a point where they become stable and do not exceed the safe slope requirements prescribed in 4.3.2.

Where the sides have to be supported, typical methods are illustrated in Figs 10 and 11. For a given depth, a wide excavation when supported by walings and struts will require heavier struts to the frames than a trench supported in a similar manner. For very wide excavations, ground anchors, tie rods or raking struts should be considered. Other methods may also be used such as bored piles, diaphragm walls.

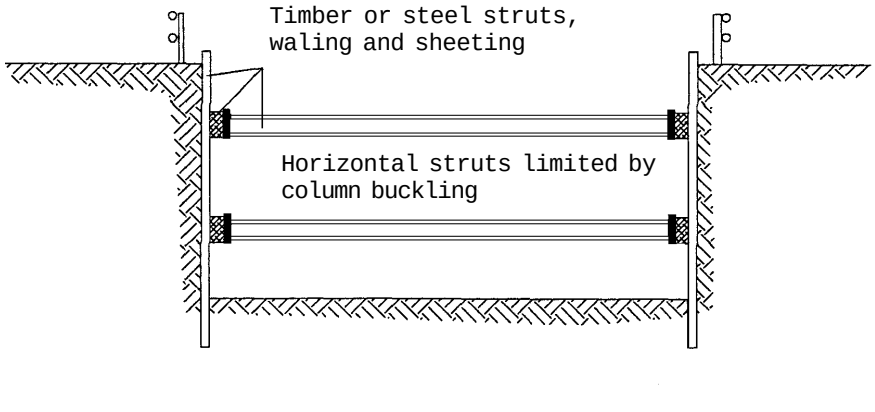


Fig. 10 Horizontal struts and walings.

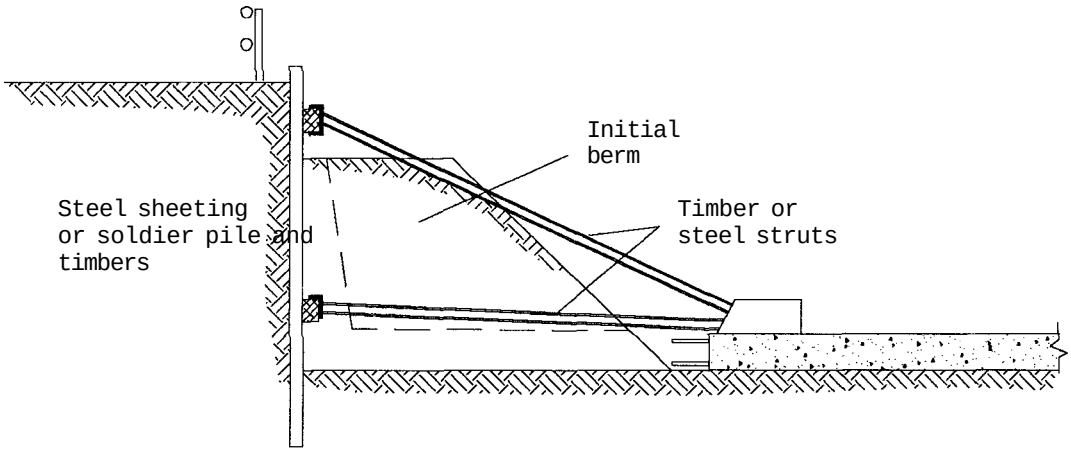


Fig.11 Raking struts.

7.3 SAFETY CONSIDERATIONS

(a) Investigate and plan each phase of the job and choose the most suitable plant.

(b) Provide for emergency access and egress at all times.

(c) Provide protection for the public and employees.

(d) Guard against face failures.

(e) Remember that high faces need proper shoring. No raker is stronger than its end support, so always ensure that its top is securely housed and it is foot blocked.

(f) Ensure that foot blocks cannot lose grip if the ground becomes wet. Keep drains clear.

(g) Guard against displacement of struts and rakers by accidental knocks from plant, gear, boulders or earth falls.

(h) Maintain all timbering and shoring materials in good order and condition.

(i) Look out for change in ground or water conditions.

(j) Ensure that protective helmets are worn at all times.

(k) Record the results of daily examinations.

PART TWO: SHAFTS AND DRIVES FOR FOUNDATIONS

9. SCOPE

Sections 10 to 12 deal with the safety precautions that should be taken in the construction of shafts, of greater than or 0.75 m diameter, into which a person may descend for inspection or other work purposes. Persons should never enter shafts less than 0.75 m diameter, because of the difficulty of rescue. This part also deals with specific safety requirements for the equipment which is to be used and the gas hazards which might be encountered in deep shafts. Large-diameter drilled shafts can be thought of as a "confined space" and information contained in standards such as AS 2865:1995 *Safe working in a confined space* may be useful in planning and executing the work.

10. GENERAL

10.1 SAFETY IN SHAFTS AND DRIVES

Shafts and drives are sunk for investigation purposes, for constructing bridge or structural foundations, for removing crush zone material or for dewatering deep foundations, and like other excavations, are affected by soil conditions.

Shafts are vertical excavations of variable depth and section which are normally square, rectangular or circular. The restricted working area and the single avenue of escape means that particular attention must paid to safety precautions and standards of workmanship. Gas accumulation at the base, or the inrush of water into the shaft, are some of the hazards that must be guarded against.

Drives are small tunnels cut into the sides of trenches or shafts or elsewhere, e.g. under roads. The cutting of a drive is particularly hazardous, as in addition to the dangers associated with a trench or a shaft, the risk of a collapse, trapping employees with no alternative escape route, is introduced.

10.2 SHAFTS AND DRIVES ASSOCIATED WITH MINES, QUARRIES OR TUNNELS

Shafts and drives associated with mines, quarries or tunnels are not covered by this code of practice. Reference should be made to information published by the Mining Inspection Group of the Ministry of Commerce.

10.3 METHODS OF SUPPORT

The support of the sides of a shaft or drive generally consists of sets of frames of timber or steel with poling boards (sometimes called lagging or laths) placed between the sets and the ground and then wedged tight. In special cases, support may be provided by precast concrete or steel caissons, steel liner plates, steel piling or some other method.

The temporary works associated with shafts and drives must be designed, constructed and supervised by competent persons having relevant knowledge and experience of this kind of work.

A registered engineer's certificate for the temporary works may be required by a health and safety inspector.

10.4 SITE INVESTIGATION

Proper site investigations should be made before the permanent construction works commence. The results, together with any records of any underground installations and services, should be made available to the employer who will carry out the work. The employer must assess the general hazards which may arise during construction. Such hazards could include the nature of the ground, the existence of high water pressures in strata immediately beneath the bottom of the shaft, underground installations and services, the nature of any industry on adjoining property, and vibration from traffic or other sources.

On sites where adequate information on ground conditions is not available, investigations are necessary to determine the nature of the ground in relation to possible hazards during construction. These investigations should be made before commencement of the shaft construction work on site.

The location of small-diameter holes made during site investigations should be accurately recorded and the holes backfilled or cased, and sealed at the top of impervious strata. It is hazardous to excavate a large-diameter shaft immediately adjacent to an unsealed small shaft. This may cause partial collapse of the wall and influx of water into the shaft or under-ream.

11. PRECAUTIONS DURING CONSTRUCTION OF DRILLED LARGE-DIAMETER SHAFTS FOR PILING AND OTHER PURPOSES

11.1. GENERAL PRECAUTIONS

11.1.1. SUPERVISION

Employers should ensure that the daily operations are supervised by a competent person, experienced in the construction of large-diameter shafts. They should have the experience and ability to recognize potential dangers as they arise. Unusual smells or extraordinary ground conditions are signals of danger which require further investigation, especially on sites affected by previous occupation. Overhead transmission lines, buried electrical cables, sewers and other drains and pipes may pose additional hazards.

Persons new to the work should be accompanied on their first descent by an experienced person, unless the size of the shaft prevents this. In this case, an experienced person should always make a preliminary descent to ensure no hazards exist.

11.1.2 PRECAUTIONS AGAINST PERSONS FALLING INTO UNATTENDED SHAFTS

All shafts which are left unattended should be adequately and securely covered or have an effective barrier placed as close as is reasonably practicable to the edge.

11.1.3 PRECAUTIONS AGAINST FALL-IN OF OBJECTS FROM THE SURFACE

Before anyone enters a shaft, the ground surface next to the shaft should be cleared for a distance of at least 1 m and all loose soil, materials and equipment removed. A starter casing protruding a minimum of 300 mm above ground level helps to provide a barrier against objects falling in the shaft.

A person working near or descending the shaft should on no account carry any loose tools, nor should tools and equipment be thrown into the shaft.

All component parts of surface equipment should be secured, i.e. there should not be any detachable handles or any sections of winches, etc., which may come loose and fall into the shaft.

11.1.4 SMOKING

Smoking should be strictly prohibited in shafts and appropriate notices should be displayed. Matches should not be taken down into shafts and personnel should be made aware of the risk in disposing of matches and cigarette ends down shafts.

11.1.5 INTERNAL COMBUSTION ENGINES

Internal combustion engines should not be used in shafts where there is a possibility that anyone may be lowered into the shaft. Where the engines are on the surface, care should be taken that their exhaust gases are not drawn into compressors ventilating the shaft or into the shaft itself.

11.1.6 STATIC ELECTRICITY

Nylon lines and nylon clothing should not be used where there may be a presence of explosive gases, owing to the danger of generating static electricity.

11.2 SURFACE EQUIPMENT AND ATTENDANCE

Persons entering shafts should be lowered and raised in suitable skips, cages, or platforms, using properly constructed appliances for the purpose. While persons are below ground, this equipment should be continuously attended by competent operators. In addition, there should always be one or more persons within easy calling distance to render assistance if it becomes necessary to lift anyone out of a shaft. The power source of the appliance must be kept running when any person is below ground.

A person should be in attendance at ground level at all times unless the operator of the lifting appliance is always in a position to observe and hear persons working at the bottom of the shaft. While persons are working in a shaft, the attendant at the surface should ensure that they are aware of the movement of skips or cages. A code of signals should be arranged between the person working in the shaft and the attendant at the surface.

Before any person descends into a shaft, it should be lined to a depth necessary to maintain the stability of the shaft and the ground adjacent. It must be adequately supported to prevent it slipping from the set position.

The plant used to extract lining tubes must not be overloaded.

11.3 LINING THROUGH WATER-BEARING AND UNSTABLE OVERBURDEN

Where persons are to descend into shafts in unstable strata, linings must be used. The lining must be strong enough so that it is not distorted by ground or water pressures.

Water entering the shaft from overburden or underlying strata should be sealed off by driving the lining tubes sufficiently into impervious material to provide a secure seal. Where this is not possible or practicable, other precautions, such as pumping, should be taken if persons are required to enter a shaft. Persons must not enter the shaft if there is any possibility of flooding.

11.4 COLLAPSE OF SHAFT

The employer must pay particular attention to the general stability of the ground and safety of the persons in the vicinity of the shaft. No one should descend a shaft where there is a danger of collapse of the wall. Such dangers can only be assessed by persons with responsible judgement and experience.

Factors are:

(a) The length of time that the shaft has been opened;

(b) The presence of water in the shaft or seepage into the shaft, particularly at the bottom edge of tight linings;

(c) Equipment causing ground vibrations.

Cracks in the wall of the shaft, the presence of extensive fissures or joints, are warnings, but are often difficult to detect. Loose boulders and stones in the wall of the shaft should be removed. It is in the interests of safety that the shafts are not left for long periods awaiting inspection.

No one should be allowed to descend into shafts immediately adjacent to other shafts containing drilling mud, water, or concrete that has not set.

11.5 DESCENT INTO UNLINED SHAFTS

In cases where shafts are bored in material considered by the employer to be stable over a sufficient length of time, no lining other than the lining tube at the top of the shaft need be used provided the following conditions are observed:

(a) The employer should ensure that a physical examination is made by a competent person of each shaft on the site with particular reference to the wall and the roof of the under-ream, to ensure that descent into the unlined shaft is safe. Examinations are required thereafter at a frequency determined appropriate for the ground conditions found.

(b) Wherever practicable, a descent should not be made into an unlined shaft more than 12 hours after completion of excavation. Where entry into the shaft is necessary more than 12 hours after excavation, it must be re-examined by a competent person before any further descent takes place.

(c) Wherever practicable, hand excavation work should be limited to the clearance of loose spoil, softened zones in the base and limited excavation within the time limit given in (b).

11.6 PROVISION OF LOOSE SAFETY LINING AND OTHER PROTECTION

Safety lining tubes of suitable type and diameter should be available, to be used before entry into shafts which do not satisfy the conditions described in 11.5 (a), (b) and (c). Where it is necessary to line an under-reamed shaft, a lining tube should be inserted to the level of the top of the under-ream and must be adequately supported to prevent it slipping from its set position.

Joints in the lining should be avoided if possible as jointing causes delays which increase the possibility of ground deterioration before anyone can descend.

In most cases where ground shows potential weakness which would lead to the collapse of under-reams, the practice of under-reaming should not be carried out except under water or bentonite.

11.7 EMERGENCY PROCEDURES

Prior to work commencing, emergency procedures must be developed and discussed with site personnel. These procedures should include a list of contact names and telephone numbers to use in the event of an emergency.

Specialised equipment to rescue a person from the bottom of a shaft must be kept ready on stand-by. Employees must be trained in the safe use of such equipment.

Each supervisor and at least one other person should be trained in gas detection, first aid, respiratory resuscitation and the use of breathing apparatus. They should be familiar with all the equipment provided for descent and rescue purposes. It is preferable that as many people as possible be trained. Periodic retraining is essential.

11.8 SAFETY HARNESSES

A safety harness, capable of being used to lift an unconscious person in an upright position should always be worn in the shaft. Suitable means should be provided for attaching the harness quickly to the hoist rope. In smaller diameter shafts, where the rescue of an unconscious or injured employee would be difficult, their safety harness should always be attached to the hoist rope or a safety rope.

11.9 FIRST AID KIT

A first aid kit should be provided which complies with the requirements of the HSE Regulations.

12. VENTILATION, GAS HAZARDS, SYMPTOMS AND EFFECTS

12.1 CHECKING AIR QUALITY

Before any person works underground, the air quality needs to be checked to ensure no oxygen deficiency exists, nor any toxic or hazardous gases, fumes, or dusts are present. Gas detection equipment should be regularly checked, calibrations tested and a record of servicing maintained.

Detector tubes are available which can detect the majority of gases likely to be encountered and also to indicate oxygen deficiency. A quantitative assessment is obtained by this method and enables comparison to be made with published threshold limit values. (Refer to OSH publication *Workplace Exposure Standards.*)

12.1.1 VENTILATION

Clean respirable air must be available at the bottom of the shaft if work is to be carried out there.

Equipment used for ventilation should be in good condition, suitable for its purpose, (industrial compressors may require filtration equipment) and supply at least 25 litres/sec (1.5 m^3/min) of air per person to the bottom of the shaft. Oxygen should not be used for air freshening or ventilation. The purpose of any ventilation is to:

(a) Maintain a breathable atmosphere; and

(b) Render harmless, so far as is reasonably practicable, fumes, dust or other impurities which may be hazardous to health and which may be found in the shaft.

Where airborne dust is likely to be present in shafts, increased ventilation may be necessary to reduce any dusts to safe limits. If increased ventilation does not provide a satisfactory atmosphere, appropriate respirators must be worn by the persons in the shaft.

12.1.2 BREATHING APPARATUS FOR EMERGENCY PURPOSES

Self-contained compressed air breathing apparatus should be available at ground level in close proximity to the shaft, so that a person can enter it for rescue or emergency purposes. In planning the emergency procedures (well before work commences), consideration must be given to the shaft dimension and the required

duration of the air supply. Spare fully charged air cylinders should be stored near to the breathing apparatus. Empty cylinders should be kept separate.

12.2 PRESENCE OF GAS IN SHAFTS

12.2.1 GENERAL

It is essential that employers take all practicable steps to investigate the presence of gases in the subsoils of the site.

12.2.2 RECOGNITION

It is important to be able to recognize any hazardous gas condition, and all involved need to be on the alert for unusual smells or conditions in the soil which might lead to danger. Care must be taken in fissured or fractured ground. Sites near or previously occupied by petrol service stations or chemical works, or traversed by gas mains or sewers, may have contaminated soils. Similarly, sites close to old mine workings or rubbish dumps may be affected. Deposits such as coal, peat or other organic matter may contain methane gas. Hydrogen sulphide is found in thermal regions. Dry or partially saturated permeable deposits may contain "locked up" bad air which may be released. Other natural strata may contain noxious gases, e.g. limestone can contain carbon dioxide. Alternatively, petrol or other fumes can result from careless cleaning of equipment near the exposed shafts.

The odour of certain noxious gases may help detection but the sense of smell varies appreciably from person to person. Many common dangerous gases have no smell.

Explosive gas/air mixtures are a potential hazard to all persons working in or near the shaft. If there is a possibility of an explosive gas being present, the shaft must be frequently and thoroughly ventilated, to remove any explosive gas which could be ignited from a tool or from welding equipment.

12.2.3 OXYGEN DEFICIENCY

The effects of oxygen deficiency are insidious and the person may collapse without any warning symptoms. Although the classical symptoms are described as "deep and rapid breathing, headache, buzzing in the ears and rapid heart action", in some cases these symptoms never arise. Often, the tendency is to feel extremely confident and well, up to the moment of sudden unconsciousness.

12.2.4 CARBON DIOXIDE

The effects of moderately high concentrations of carbon dioxide are excessive panting and laboured breathing. Greater concentrations may produce a narcotic effect or sudden collapse, and death may result in a short time.

12.2.5 METHANE

Methane is not normally toxic to humans but in moderate concentrations in air it is explosive. In high concentrations, it dilutes the oxygen so much as to result in oxygen deficiency.

12.2.6 CARBON MONOXIDE

In very low concentrations carbon monoxide may cause headache but if the concentrations are higher, rapid unconsciousness may occur without any obvious warning.

Carbon monoxide is not a common gas in natural soils but it could find its way into shafts from the exhausts of machines or from damaged gas pipes in the vicinity of the top of the shaft. Plant with internal combustion engines should be kept away from shafts and where this is not possible, as in the case of the drilling machine itself, the exhaust pipe should be arranged to point well away from the shaft. The covering of a shaft, when unattended, will reduce this danger.

12.2.7 HYDROGEN SULPHIDE

Hydrogen sulphide is a dangerous gas and is common in thermal regions. In low concentrations it has a characteristic smell of rotten eggs but the sense of smell is lost in high concentrations, such that it cannot be detected. Traces of this gas are therefore to be regarded with great suspicion.

12.2.8 NITROUS FUMES

It is reasonable to suspect the presence of nitrous fumes in shafts if blasting has taken place during the excavation work, or if a diesel or petrol engine exhaust discharges near ventilation air intakes. The effects of nitrous fumes may not become apparent for several hours after inhalation. It is therefore essential that any case of exposure to nitrous fumes, however mild, should be referred for medical opinion.

12.2.9 AMMONIA AND PETROL FUMES

Ammonia, petrol fumes and other fumes and gases resulting from previous occupancy or unusual soil conditions should always be regarded with great caution. Where boring in the vicinity of sewers, attention should be paid to the possibility of contamination of the shaft by trade effluent.

12.2.10 ALDEHYDES

Aldehydes have an irritant effect on the eyes and lungs and will cause narcosis at higher concentrations. They can also be explosive.

APPENDIX: THE BUILDING ACT AND REGULATIONS

BUILDING CONSENT REQUIREMENTS

Where the site work contains permanent work associated with a building, then that site work could be part of the building consent, and those works must comply with the Building Code.

BUILDING ACT 1991

The Building Act 1991 has several purposes (see section 6 of that Act), including:

(a) The necessary controls relating to building work and the use of buildings.

(b) To safeguard people from possible injury, illness, or loss of amenity in the use of any building.

(c) To provide for the protection of other property from physical damage resulting from the construction, use, and demolition of any building.

In addition, regulations have been promulgated describing procedures for regulating and controlling construction and demolition of buildings. (Refer to sections 48 to 50.)

The application for a Building Consent must contain provisions for the protection of the public, including suppression of dust, disposal of debris, disconnection from public utilities, suppression of noise and protective structures and fencing.

BUILDING REGULATIONS

The Building Code is the First Schedule to the Building Regulations 1992. Clause F5.2 of the Building Code requires that building and demolition work be performed in a manner that avoids the likelihood of:

(a) Objects falling onto people on or off the site;

(b) Objects falling on property off the site;

(c) Other hazards arising on the site affecting people off the site and other property,

(d) Unauthorised entry of children to hazards on the site.

Clause F5.3.1 requires that suitable construction methods be used to avoid the likelihood of tools or materials falling onto places where people may be present.

Clause F5.3.2 requires clearly marked barriers of appropriate height and construction, that are difficult to climb and that only have openings as approved by the Territorial Authority, be provided where construction or demolition work presents a hazard in places where the public has access.

Clause F5.3.3 requires that where a site contains hazards that might attract children, that the hazard be enclosed to restrict access by children.

Clause F5.3.4 requires suitable barriers to provide a safe route for public access where lifting equipment creates a risk from objects falling or where a similar risk results occurs. (Note: Users of this code should consult the actual Building Act, Regulations or Building Code for the most current requirements.)

ACCEPTABLE SOLUTIONS

The Territorial Authority may require the employers to put in place various precautions to ensure compliance with the Building Regulations. The document F5/AS1 (of the Building Code) provides solutions that employers may adopt, including fencing, gantries, and hoardings, depending on the hazards that may arise. (Note: Even though a Territorial Authority may not initially require protection on the work, an Occupational Safety and Health inspector may issue a prohibition notice to stop the work until the inspector is satisfied that the hazard has been eliminated. The inspector may also notify the Territorial Authority of hazards arising due to inadequate protection for the public from the demolition works.)

OTHER CONDITIONS IMPOSED BY TERRITORIAL AUTHORITIES

Territorial authorities may also impose conditions to control other hazards. Such conditions may include traffic management systems, hours of work, lighting, dust and noise control. Such controls may be placed under legislation such as the Resource Management Act.

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