

Part 32 Excavating and Tunnelling

Highlights

- Section 441 defines the terms “buried facility” and “hand expose zone” which reflect current industry practices in Alberta and requirements under the *Pipeline Act*. Section 441 also describes what is meant when the “ground is disturbed”.
- Section 442 classifies soils into three categories: hard and compact; likely to crack or crumble; sandy or loose. The categories dictate how the walls of excavations and trenches are cut back or sloped.
- Section 447 requires that ground not be disturbed until buried facilities have been identified and their locations marked.
- Sections 447 and 448 clarify requirements that affect work involving buried facilities.
- Section 451 requires that if walls of an excavation in soft, sandy or loose soil are cut back, they must be sloped from the bottom of the excavation and the walls must be at an angle of not less than 45 degrees (measured from the vertical).
- Section 453 requires that loose materials be scaled and trimmed from spoil piles.
- Section 455 requires that a safe point of entry and exit be located within 8 metres of any worker in a trench that is more than 1.5 metres deep.

Requirements

Section 441 Disturbing the ground

Before excavating activities actually begin, the location of buried facilities that may be encountered during digging must first be located. Buried or underground facilities include anything below the ground that transports or stores products and services such as:

- water
- sewage
- oil
- natural gas
- chemicals
- cablevision services
- electric energy
- electric, telephonic and telegraphic communications.

These facilities may be contained in pipes, conduits, ducts, cables, wires, valves, manholes, catch basins, storage tanks and attachments associated with these items. Striking any of these facilities could result in personal injury and injury to other workers, electrocution, explosion or the release of a harmful substance(s). In addition to these health and safety consequences, vital services may be disrupted and repair costs may be incurred.

Disturbing the ground does not include

- (a) routine, minor road maintenance, such as patching, street sweeping and the grading of gravel roads,
- (b) agricultural cultivation to a depth of less than 450 millimetres (18 inches) below the ground surface over a pipeline, or
- (c) hand-digging to a depth of no more than 300 millimetres (12 inches) below the ground surface, so long as it does not permanently remove cover over a buried facility. Buried facilities tend to be more than 300 millimetres below the surface.

However, there are many activities that disturb the ground and have the potential to contact a buried facility. These include:

- (a) excavating, digging and trenching;
- (b) plowing, drilling, tunnelling, auguring and backfilling;
- (c) driving posts, bars, pins, etc., topsoil stripping, land leveling and quarrying; and
- (d) tree planting, rock picking, grading, blasting and clearing.

Section 442 Classification of soil type

The employer is responsible for classifying the soil being excavated into one of the three types described in this section and summarized in Table 32.1.

Table 32.1 Classification of soil types

Soil characteristics	Soil type		
	Hard and compact soil	Likely to crack and crumble soil	Soft, sandy or loose soil
Consistency	Hard, very dense in compactive condition	Stiff, compact in compactive condition	Firm to very soft, loose to very loose in compactive condition
Ability to penetrate	Only with difficulty by a small, sharp object	With moderate difficulty with a small, sharp object	With ease
Appearance	Dry	Damp after it is excavated, has low to medium natural moisture content	Appears solid but flows or becomes unstable when disturbed. Can be dry, running easily into a well-defined conical pile, or wet
Ability to excavate with hand tools	Extremely difficult	Moderately difficult	With ease
Water seepage	Shows no signs of water seepage	Shows signs of localized water seepage	
Other	Does not include previously excavated soil	Shows signs of surface cracking	<ul style="list-style-type: none"> ▪ Is granular soil below the water table, unless the soil has been dewatered ▪ Exerts substantial hydraulic pressure when a support system is used

The soil type helps to determine how stable the walls of an excavation will be. When the walls of an excavation are composed of layers — seams of gravel or debris may lie behind seemingly solid walls — the weakest layer is most likely to slump or slide. The total cross-section of soil must therefore be classified as the weakest soil type and the support system designed accordingly. Assume the worst and base precautions on the most unstable soil type that is likely to be present.

For example, a stronger layer overlain by a weaker layer could result in the uppermost, weaker layer slumping into the excavation, exposing workers to risk of injury. Similarly, if a stronger layer lies above a weaker layer, the slumping of the weaker layer could cause a large block of the upper layer to become unstable. Either case presents an unacceptable risk of injury or death to workers.

Because of the nature of classifying soil types, a competent person should be assigned to carry this out. A geotechnical engineer (a professional engineer) experienced in soil classification can assist with this.

Trench wall failure

Worker injuries and deaths resulting from trench wall collapse are common and completely preventable. The material removed from the ground to form a hole, trench or cavity is extremely heavy. It may weigh more than 1476 kilograms/cubic metre (100 pounds/cubic foot), the equivalent weight of a car in a space less than the size of the average office desk. Wet soil, rocky soil or rock is usually heavier.

Undisturbed soil is kept in place by the horizontal and vertical forces of adjacent soil. Once soil is removed to create a trench, it is no longer available to provide support for the soil left behind in the trench wall. Without support, soil from the trench wall eventually moves downward and inward into the excavation. This creates a serious life-threatening hazard for workers in the trench.

Figure 32.1 shows the three areas of failure in a trench wall. The first failure occurs in Zone 1 at the base of the trench wall. This movement creates an undercut area, allowing soil in Zone 2 to collapse. The failure of Zones 1 and 2 leaves the remaining trench wall, Zone 3, unsupported. Zone 3 will break away from the wall under its own weight and fall into the trench. How long it takes for Zones 2 and 3 to collapse is unpredictable. Many rescue attempts are unsuccessful because rescuers attempt to save victims before the second and third failures occur. The would-be rescuers are often trapped along with the first victim(s).

Figure 32.1 Mechanics of trench wall failure involving previously disturbed soil

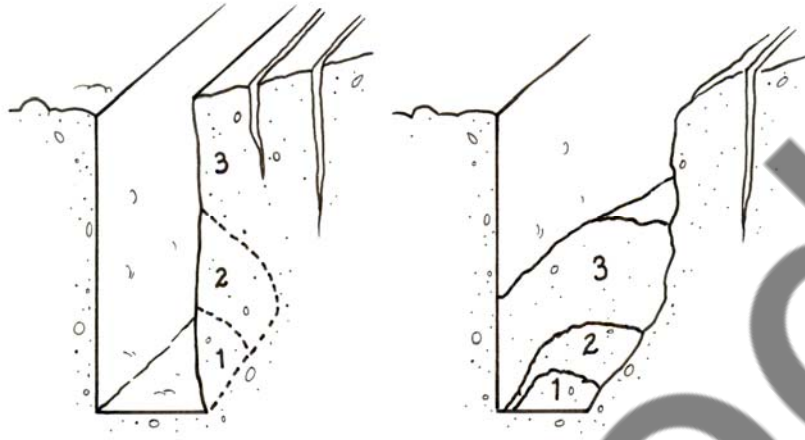
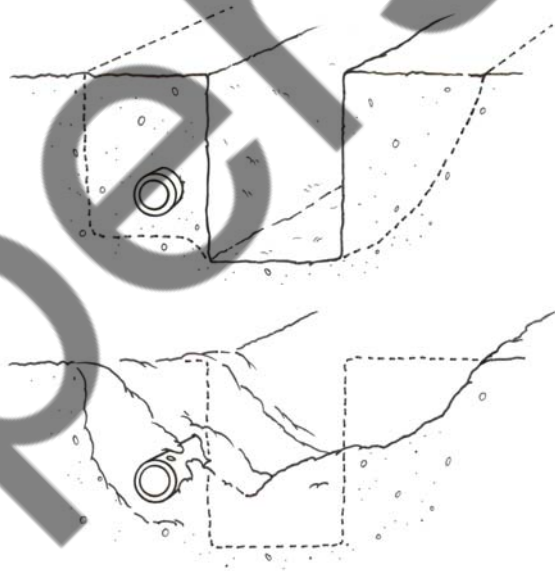


Figure 32.2 shows where soil that has already been excavated and backfilled is most likely to collapse. Previously disturbed soil takes a long time to return to its previous condition.

Figure 32.2 Areas of a trench in previously disturbed soil most likely to collapse



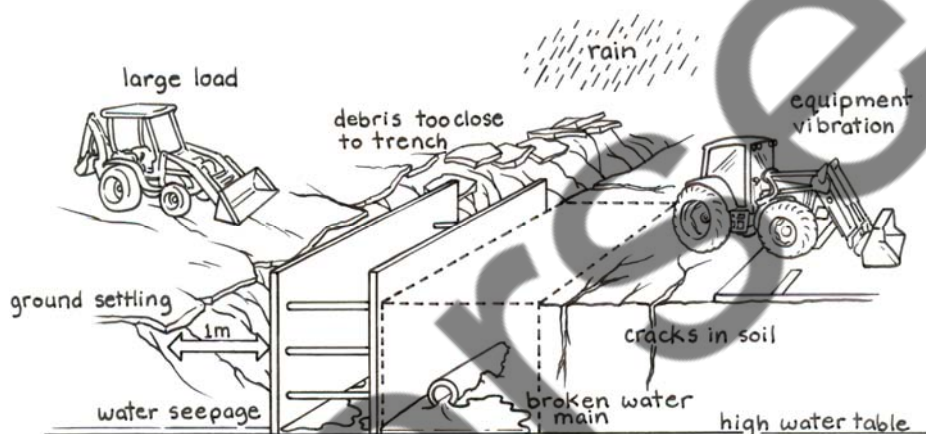
A trench wall collapse might involve 2.5 to 4 cubic metres of soil, weighing from 3700 to 7400 kilograms (8100 to 16,300 pounds). The human body cannot support such heavy loads without injury.

A worker buried to a depth of less than one metre of soil experiences enough pressure on the chest to prevent the lungs from expanding and drawing in a breath. Suffocation occurs within approximately three minutes. Even if the worker is quickly rescued, the heavy weight of the soil is likely to cause serious injuries, particularly if the worker's body comes to rest in an awkward position.

Factors that may cause wall collapse

Figure 32.3 shows examples of factors that may cause the wall of an excavation to collapse. Moisture in soil reduces its strength. Once an excavation is opened, the walls are exposed to the elements. Moisture content and soil stability can change rapidly.

Figure 32.3 Factors that may cause cave-in of an excavation or trench



Any large, heavy movement near an excavation causes vibration of the surrounding soils. This movement can result in soil failure. Moving machinery, nearby traffic, pile driving and blasting all cause vibration in surrounding soils.

Vibration-related soil failures can occur in all types of soil. However, certain types of soils are more susceptible to vibration failures than others. For example, sandy soils tolerate less vibration than clay soils. Since soil conditions may be a mixture of more than one soil type, it is better to play it safe when protecting an excavation from wall collapse.

Adjacent buildings and structures can reduce soil stability by placing extra pressure on the walls of an excavation. An excavation can cause nearby building walls to collapse because the soil that otherwise provided support to the walls has been removed.

Spoil piles and supplies placed near the excavation, and mobile equipment operating nearby, can put extra pressure on the walls of the excavation. These sources of pressure or loading should be kept as far away from the excavation as reasonably practicable.

For more information

 www.nclabor.com/osha/etta/indguide/ig14.pdf

A Guide to the OSHA Excavations Standard. North Carolina Department of Labor, 2002

Section 443 Soil stabilization

Subsection 443(1)

The OHS Code defines an excavation as a dug out area of ground that does not include a tunnel, underground shaft or open pit mine. As a result, a trench is considered to be a type of excavation having one special feature — it is deeper than its width at the bottom. Where the term “excavation” is used in this Part, it is meant to include trenches unless otherwise stated.

Subsection 443(2)

A number of artificial stabilization techniques are acceptable as alternatives to shoring an excavation, tunnel, underground shaft or open pit mine. Artificial methods such as freezing or grouting (injecting a chemical or cement grout into the voids of pervious soils, allowing the injected material to solidify and form an impervious barrier to groundwater), may require defined periods of time in which to “set”. Once “set”, the soil is stable.

Because of its critical importance to worker safety, this subsection makes it mandatory that a professional engineer design any artificial soil stabilization process. The employer is responsible for ensuring that the professional engineer’s specifications are followed.

Subsection 443(3)

Natural freezing is subject to changing temperature and weather conditions and cannot be controlled. Even if the soil is frozen to a specified depth, fluctuating temperatures could result in unexpected or unplanned thawing of surface layers. As such, the structural integrity of the excavation could be compromised and the risk to workers significantly increased. Natural freezing as a means of soil stabilization is therefore unacceptable under any circumstances.

Section 444 Marking an excavation

An open excavation can present a serious hazard to workers and equipment. Almost any device that clearly marks, blocks or safeguards the opening is acceptable. Examples include barricades formed by aligned concrete blocks, erected snow fencing, guardrails, piles of excavated material or total enclosure/hoarding. In all cases the solution must be effective and its purpose clearly understood by workers.

Section 445 Water hazard

Water creates a hazard since it can weaken excavation walls, increasing the potential of slope failure or complete collapse. The presence of water can also create poor under-foot conditions for workers, resulting in possible slips, trips and falls. In the worst case, accumulated water presents a drowning hazard. The employer must therefore control the accumulation of water and ensure that workers do not enter an excavation until hazardous accumulations are eliminated.

Section 446 Worker access

Subsection 446(1)

A safe means of entering or leaving an excavation could include a ladder, scaffold or a mechanical device such as a stairway. It could also include appropriate sloping of the ground or soil so that a worker can safely walk into or out of the excavation.

For a tunnel or underground shaft, a safe means of entry or exit could include separate entry and exit points. Each entry or exit point could be constructed as a ramp that allows workers to safely walk to and from the working location. A tunnel or underground shaft could include, or be combined with, a system of stairs, ladders, mechanical lifts or hoists that provide alternative routes of escape in case of an emergency.

Subsections 446(2) and 446(3)

An employer must not require a worker to enter, and a worker must not enter, a trench that is deeper than 1.5 metres (4 feet 10 inches) unless it is properly cut back, shored using the methods and materials specified in this Part, or protected by a trench box or cage designed by a professional engineer.

An employer must not require a worker to enter, and a worker must not enter, an excavation deeper than 1.5 metres (4 feet 10 inches) and work closer to the wall than the depth of the excavation unless the wall is properly cut back, shored or protected by a temporary protective structure.

These requirements do not apply to trenches cut in solid and stable rock (see subsection 450(2)), or excavations in a ground formation certified by a professional engineer as stable (see section 449).

Section 447 Locating buried facilities

Subsection 447(1)

Major hazards can be encountered when digging into or otherwise disturbing an underground pipeline or other buried facility. In the case of natural gas or oil, a major explosion and fire are possible if the pipeline is penetrated or damaged. In the least case an environmental spill may result. Digging into a buried electrical cable could result in an electrical flash, a fire or worker electrocution.

Sometimes buried facilities are embedded in concrete. These may include conduit or utility lines placed under a parking area, roadway or concrete sidewalk. To prevent damage to the facility, the owner may have encased the line(s) in concrete. The locating requirements of this section also apply in such cases.

If a buried facility might be affected by activities that disturb the ground, then the employer must advise the owner of the buried facility of the proposed activities and request that the buried facility be identified and its location marked. The owner or the owner's designate must be advised before the ground is disturbed.

Situations may arise in which the employer does not know the type of buried facility that may be present and therefore cannot contact the owner or the owner's designate. Despite this, the employer must not begin disturbing the ground until buried facilities have been identified and their locations marked. In this case, the employer should request the locate.

Alberta One-Call Corporation (Alberta 1-Call) is a good starting point because its mandate is to prevent damage to buried electrical, gas and communication facilities. There is no charge to the owner or employer for using this service. Alberta One-Call can be reached toll free at 1-800-242-3447.

However, other facilities such as underground storage tanks and sewer lines may also be present. Finding these may require the assistance of a different locator service. For a listing of companies offering locator services, readers should check their local telephone book under the heading "Utilities – Underground Location Service", as well as the following contractor listing prepared by Alberta One-Call






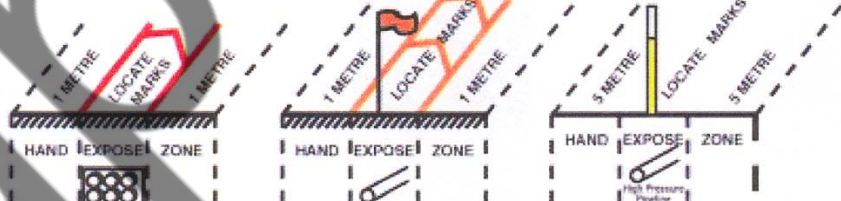
 <http://www.alberta1call.com/>
Pipeline and Utility Locators in Alberta

Figure 32.4 shows the international colour code used for marking buried facilities.

Figure 32.4 International colour code used for marking buried facilities
(www.alberta1call.com)

INTERNATIONAL COLOUR CODE FOR MARKING BURIED FACILITIES

	WHITE - Proposed Excavation
	PINK - Temporary Survey Markings
	RED - Electric Power Lines, Cable Conduit and Lighting Cables
	YELLOW - Gas, Oil, Petroleum and Gaseous Materials
	ORANGE - Telephone, Cable TV, Communication, Alarm and Signal Lines
	BLUE - Potable Water
	GREEN - Sanitary Sewers, Storm Sewers and Drain Lines
	PURPLE - Reclaimed Water, Irrigation and Slurry Lines




FACILITIES MUST BE HAND EXPOSED AND VISIBLE BEFORE MECHANICAL EQUIPMENT IS USED WITHIN THE HAND EXPOSE ZONE.



1-800-242-3447

PLEASE PROVIDE AT LEAST
2 FULL WORKING DAY'S NOTICE



ALBERTA 1 CALL

Subsection 447(2)

Once a survey has been completed and all appropriate buried or concrete-embedded facilities marked, the employer must ensure that workers have been informed accordingly.

Subsection 447 (3)

Since the original locate marks can be disturbed or destroyed by activities at the site or with progressive excavation, the marks must be re-established as often as necessary to ensure the safety of workers.

Subsections 447(4) and 447(5)

If the planned activity does not involve excavation or removal of overlying material and overall penetration of the ground is 1 metre or less – placement of survey stakes, pin flags, etc. – the employer may use as-built drawings of the facilities for locating purposes rather than contacting Alberta 1-Call for a locate. The use of as-built drawings to locate the facilities, in combination with the shallow depth of ground penetration, protects workers from potential injury. Although the employer is not required to notify the facility owner of the planned activity, doing so should be done as a matter of good practice.

As-built drawings change to reflect modifications to, or maintenance of, installed buried facilities. The as-built drawings used by the employer must therefore be certified by the owner as being the most current drawings of record available.

Section 448 Exposing buried facilities

Subsection 448(1)

The “hand expose zone” is the zone lying within 1 metre of each side of the locate marks that identify the location of the buried facility. Before allowing mechanical excavation equipment to be used within this zone, the employer must ensure that the buried facility is exposed to sight by hand digging, a non-destructive technique acceptable to the owner of the buried facility, or an equivalent method. New water-jet or hydrovac excavation systems for example, can quickly remove soil and under the right operating conditions, do so without damaging buried facilities.

Because of the potential for damage, particularly in the case of water jets cutting through or damaging electrical cables, any non-destructive technique used as an alternative to hand digging must be acceptable to the owner of the buried facility. The employer is responsible for checking with the owner.

Manitoba Hydro has determined that water-jet excavation systems are capable of damaging almost any type of electrical cable, especially 5 kilovolt to 15 kilovolt cables installed prior to 1974. The most susceptible cables cannot be exposed while energized and can be damaged at extremely low water pressures. If the water stream is applied directly to these types of cables, damage can be expected.

Some water-jet excavation systems can reach temperatures approaching 66° C (150° F) and pressures approaching 20.6 megapascals (3000 pounds/square inch). As good practice, it is recommended that when excavating within 1 metre of any energized or de-energized cable, the water temperature should be limited to 38° C (100° F) and the pressure limited to 10.3 megapascals (1500 pounds/square inch). The water-jet excavation system should allow workers using it to monitor both temperature and pressure to ensure that the limits are not exceeded.

Wand tips should be of the oscillating type to prevent the release of a concentrated water stream. This type of tip can be identified by the circular pattern created by the water leaving the wand when pressure is first applied to the wand. Tests performed by Manitoba Hydro showed that cables could be damaged when a single stream nozzle end was directed toward a specific location on the cable. Damage was also observed when the single stream nozzle end was used in a sweeping motion.

The damage to a cable created by excessive water pressure appears as a slice of unknown depth, or the outer surface looks as though it has been torn and pulled outward. Cable damaged by excessive water pressure can fail immediately or at a later time as moisture penetrates broken sheathing. Before backfilling, all cables exposed by water-jet excavation should be inspected for damage.

Hand digging requires the use of hand tools. Hand tools are defined in the OHS Code as hand held equipment that depends on the energy of the worker for its direct effect and it does not have a pneumatic, hydraulic, electrical or chemical energy source for its operation.

Subsection 448(2)

Hand digging to expose buried facilities is an important safe work practice that protects workers from potential injury and reduces the likelihood of facilities being damaged. However, hand digging to expose buried facilities that are no longer in use can be avoided if the employer ensures that the planned work does not present a

hazard to workers and the employer has notified and receive the written approval of the facility owner to remove the facility.

An electrical cable or conduit can be mechanically excavated only if it is grounded and isolated so that its disconnection is visible.

Written approval is necessary because the owner may have important knowledge about the facility. For example, a hydrocarbon or gas pipeline could still contain explosive hydrocarbon residue or quantities of a chemical. “Dead” gas mains may contain residual natural gas concentrations in the 5-15 percent range – this is the explosive range for natural gas – making it potentially more hazardous than a live or operating line. Hand digging is still required in such instances.

Subsection 448(3)

If a high-pressure pipeline (operating pressure of 700 kilopascals or more) falls within the scope of the *Pipeline Act*, then a mandatory 5 metre hand expose zone must be maintained. If the *Pipeline Act* does not apply to the high-pressure pipeline, then the pipeline may be treated like any other buried facility and the 1 metre on each side of the buried facility hand expose zone requirements apply. If the employer plans to reduce the hand expose zone to the 1 metre limit, the employer must get the written approval of the owner of the high-pressure pipeline to do so.

Subsection 448(4)

Even if the planned disturbance lies more than 30 metres away from a buried facility, the operator or licensee of a pipeline right-of-way must be contacted if the disturbance is to take place within that pipeline right-of-way. The owner or licensee’s approval must be obtained before any ground disturbance begins.

Subsection 448(5)

Where the use of mechanical equipment is required to excavate within 600 millimetres (24 inches) of a buried pipeline, the activity can only be undertaken under the direct supervision of an owner’s representative. The owner’s representative is the person most knowledgeable about the characteristics of the buried pipeline. This knowledge will help to ensure that workers and the pipeline are protected from injury or damage. Whenever possible, powered excavation equipment should be operated to dig parallel to the direction of the buried pipeline.

Subsection 448(5.1)

This subsection establishes an acceptable option for situations involving emergency work.

Subsection 448(6)

Once a buried facility is exposed, the employer is responsible for making sure the facility is protected and supported so that workers are not injured.

Subsection 448(7)

Once a pipeline is exposed, the operator or licensee must be notified before the excavation is backfilled. This notification provides the operator or licensee with an opportunity to examine the exposed pipeline and to ensure that appropriate protective measures are taken before backfilling proceeds. The operator or licensee also has the opportunity to oversee the backfilling operation.

Section 449 Exemption

If a professional engineer has analyzed the ground formation and certified that it is stable and the workings safe, and will remain so throughout the work period, sections 450 to 459 and sections 461 to 464 do not apply.

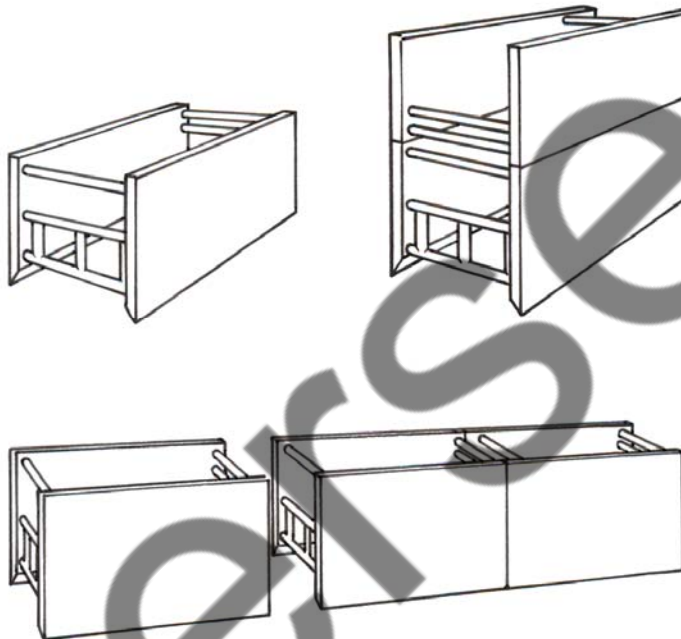
Section 450 Methods of protection

Subsection 450(1)

The history of fatalities associated with work in excavations is such that protective measures must be taken unless the excavation is constructed in solid rock or the ground stability is certified by a professional engineer.

Workers must be protected from cave ins or sliding materials that could cause personal injury. The listed alternatives reflect industry practice and provide an employer with some measure of flexibility in selecting the most appropriate method for the job. Cutting back or sloping the upper walls so that the remaining vertical height is no more than 1.5 metres above the floor of the excavation, installing temporary protective structures such as the trench shields shown in Figure 32.5, or a combination of these methods is acceptable under this section. The objective of the requirement is to ensure that any worker entering an excavation is protected. Figure 32.6 summarizes the options available.

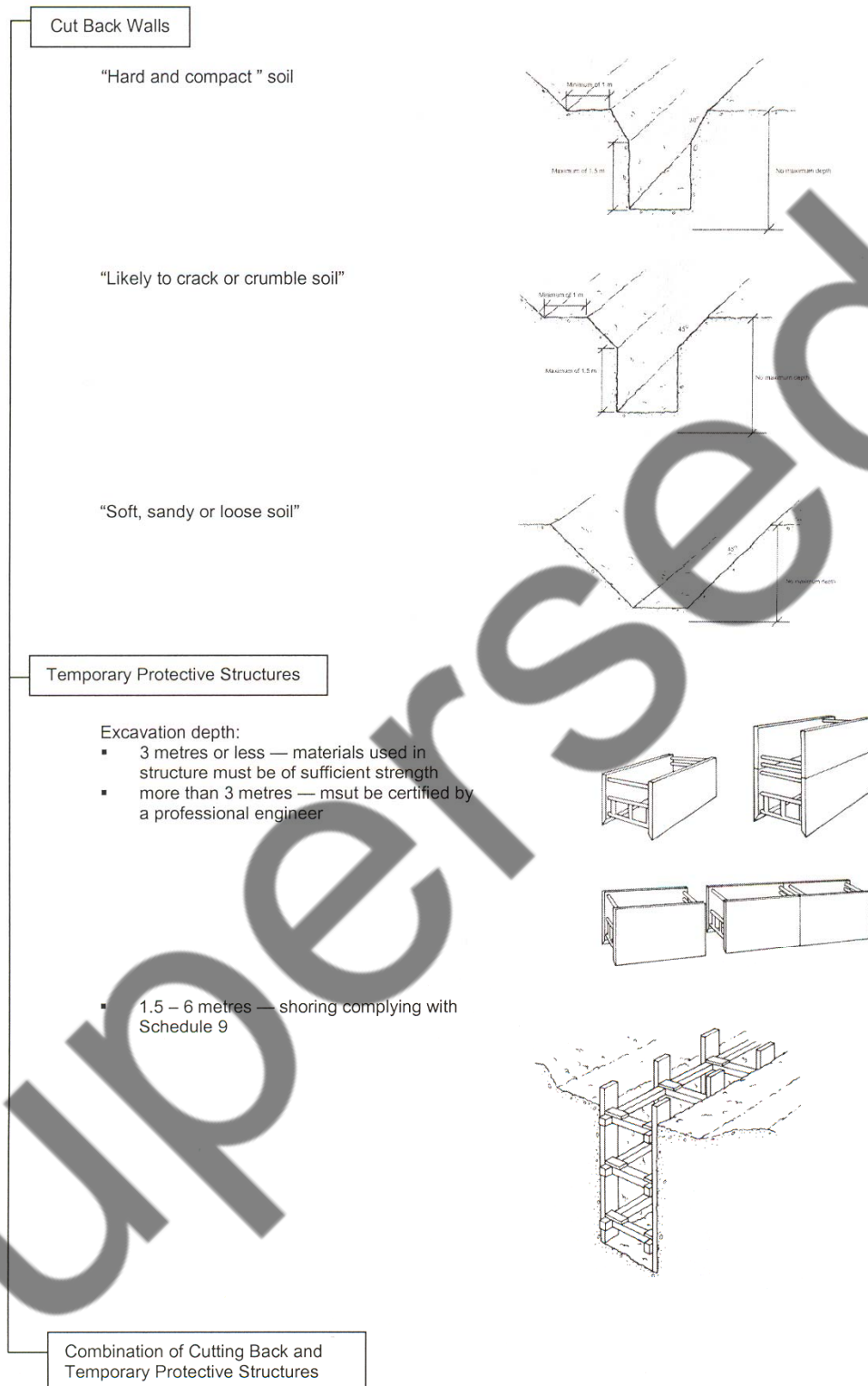
Figure 32.5 Examples of trench shields



Subsection 450(2)

Subsection (1) does not apply if a trench is constructed in solid rock throughout its entire length. Since the interpretation of “solid rock” is somewhat subjective – due to fractures, formation dips, etc. – it is recommended that, where at all in question, the services of a professional engineer be engaged. This decision is at the discretion of the employer unless ordered by an officer.

Figure 32.6 Protecting workers in excavations



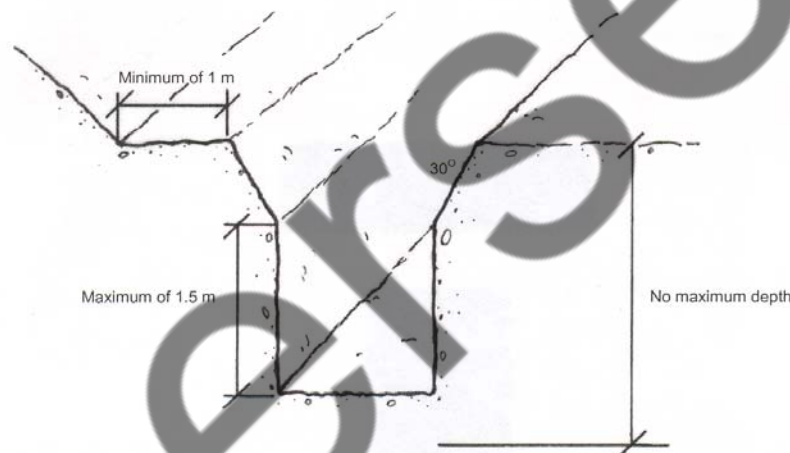
Section 451 Cutting back walls

If the walls of an excavation are cut back, the design specifications of this section must be followed. Since the specifications are based on a subjective interpretation of soil type, a professional engineer should be consulted whenever there is a question of doubt related to the soil type and potential risk to workers. The regulatory responsibility for compliance rests with the employer, who must make the related decision.

Hard and compact soil

As shown in Figure 32.7, the walls must be sloped to within 1.5 metres of the bottom of the excavation at an angle of not less than 30° measured from the vertical.

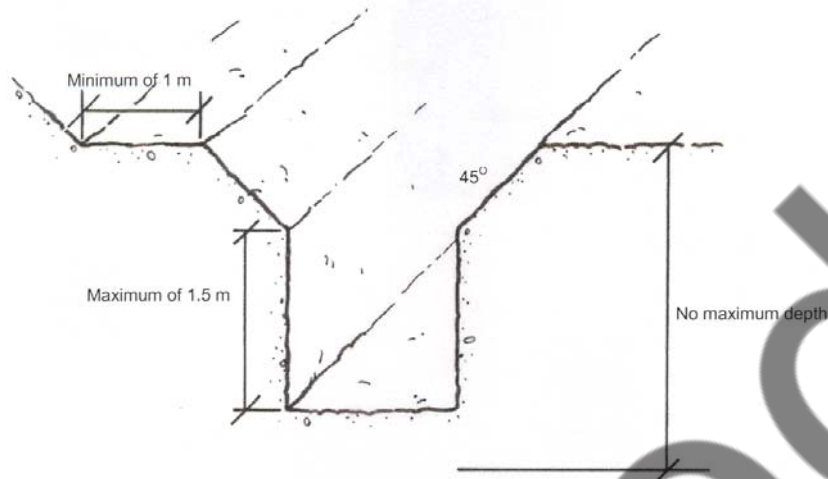
Figure 32.7 Cut back of excavation walls in “hard and compact soil”



Likely to crack or crumble soil

As shown in Figure 32.8, the walls must be sloped to within 1.5 metres of the bottom of the excavation at an angle of not less than 45° measured from the vertical.

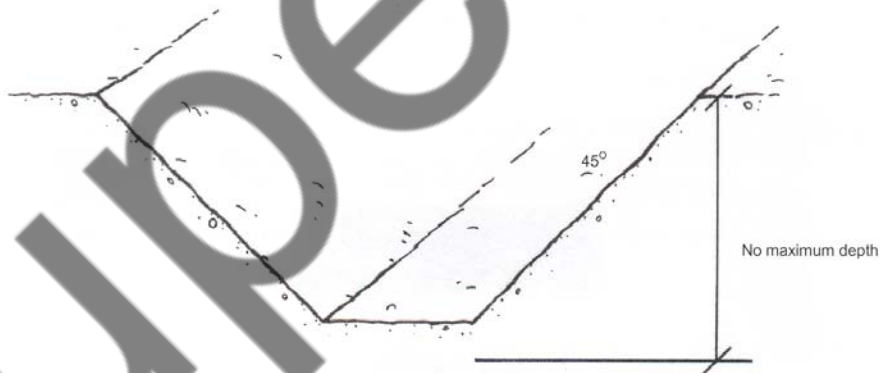
Figure 32.8 Cut back of excavation walls in “likely to crack or crumble soil”



Soft, sandy or loose soil

As shown in Figure 32.9, the walls must be sloped from the bottom of the excavation at an angle of not less than 45° measured from the vertical.

Figure 32.9 Cut back of excavation walls in “soft, sandy or loose soil”



Benching as a safe alternative to cutting back

Based on the results of a report prepared for Workplace Health and Safety by a geotechnical engineer (March 2009), benching is an acceptable alternative to the practice of cutting back the walls of an excavation as required by section 451. If benching is used by an employer, the following practices need to be followed:

- (1) benching can be a safe alternative to the straight cutting back of excavation walls in hard and compact, and likely to crack or crumble soils. Benching is not acceptable for soft, sandy or loose soil;
- (2) the rise and run for hard and compact soil should be at least 1 Vertical: $\frac{3}{4}$ Horizontal (or flatter) with a maximum rise of 1.2 metres. The maximum unsupported vertical cut at the base is 1.2 metres rather than the 1.5 metres allowed by section 451 if the walls are sloped. The run of the first bench must be twice that of the succeeding benches. This wide first bench provides a more stable slope base. See Figure 32.10;
- (3) the rise and run for likely to crack or crumble soil should be at least 1 Vertical: 1 Horizontal (or flatter) with a maximum rise of 1.0 m. The maximum unsupported vertical cut at the base is 1.0 metre rather than the 1.5 metres allowed by section 451 if the walls are sloped. The run of the first bench must be twice that of the succeeding benches. This wide first bench provides a more stable slope base. See Figure 32.11;
- (4) the maximum depth of a benched excavation is limited to 6 metres. Increasing the depth of the excavation or increasing the height of the slope and benches increases the risk of slope failure, compromising the safety of workers within the excavation. Benched excavations deeper than 6 metres need to be certified by a professional engineer;
- (5) heavy equipment and spoil piles of soil should not be allowed within 1.2 metres of the edge of the uppermost bench. Vibration caused by construction equipment may cause instability of the bench;
- (6) although benching may result in an overall more stable slope, it may have some adverse effects on the sidewalls. Benching exposes more surface area which allows more evaporation and drying of the soil. This can lead to cracking and fissures in some soils. Also, water can pool on the horizontal bench surfaces and then infiltrate the slopes and benches. The employer should provide surface drainage such as drainage ditches on benches, minimize the infiltration of water and try to minimize any rise in the ground water table. Horizontal bench surfaces should not be sloped away from the wall to drain water collecting on the bench. Doing so will cause water to cascade over each bench and run down the slope, causing erosion of the soil; and

- (7) benches need to be formed during the excavation process and not by cutting the slope from the bottom. Cutting a slope at its base can momentarily destabilize the slope until the soil at the top is removed. Therefore top down construction of the benches is required.

Figure 32.10 Benching profile for hard and compact soil

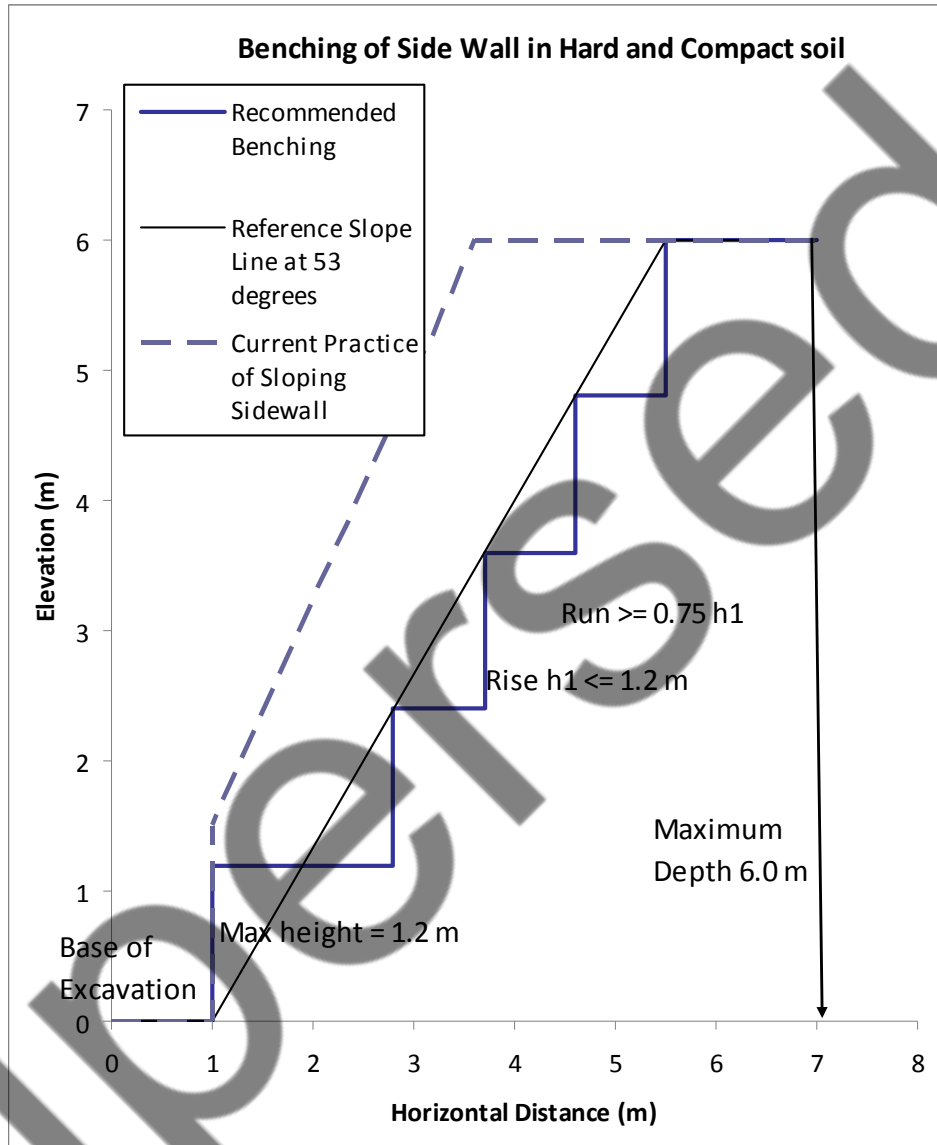
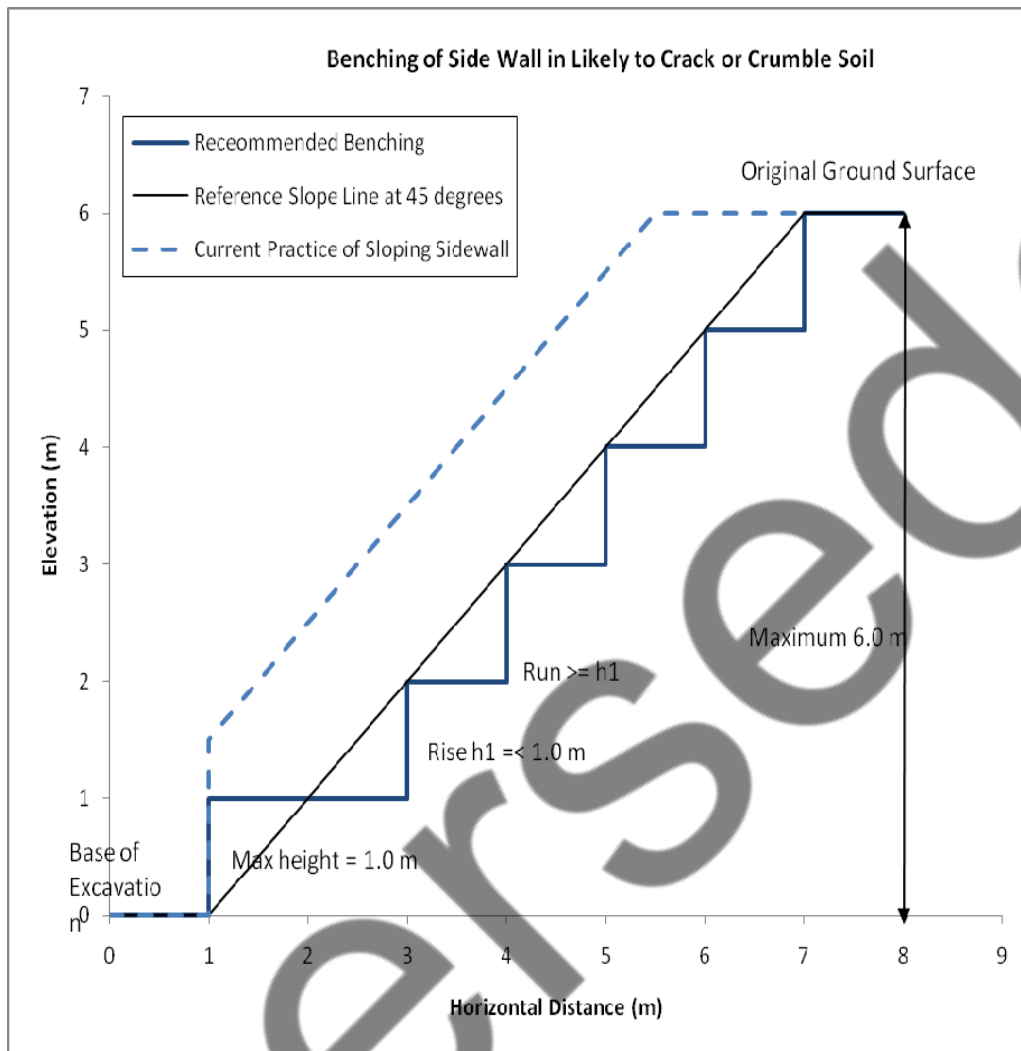


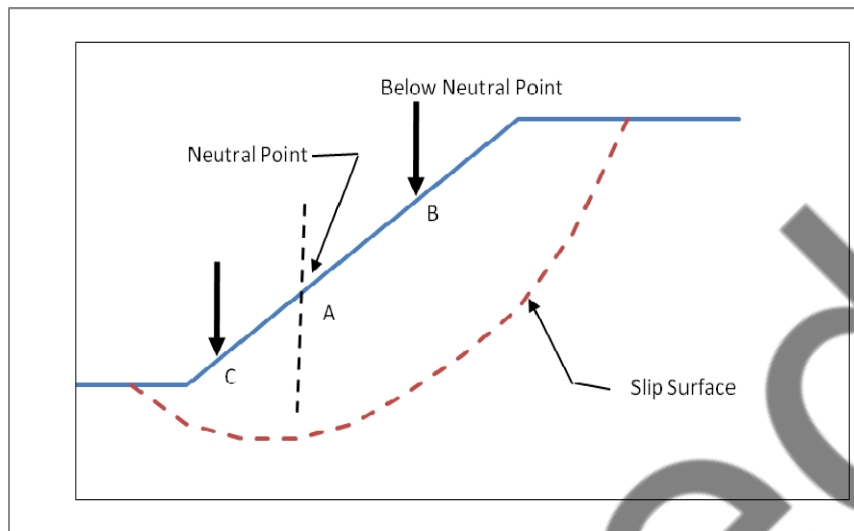
Figure 32.11 Benching profile for likely to crack or crumble soil



The effect of benching on overall slope stability

To see the effect of benching on the overall stability of a slope, it is necessary to understand the effects of applying a force on the surface of the slope. A force applied on the surface of a slope has a stabilizing effect if it is applied above the neutral point. The neutral point is defined as a point on the surface of a slope where a force has neither a stabilizing nor destabilizing effect (see point A in Figure 32.12). A downward force applied above a neutral point will have a destabilizing effect.

Figure 32.12 Neutral point on a slope



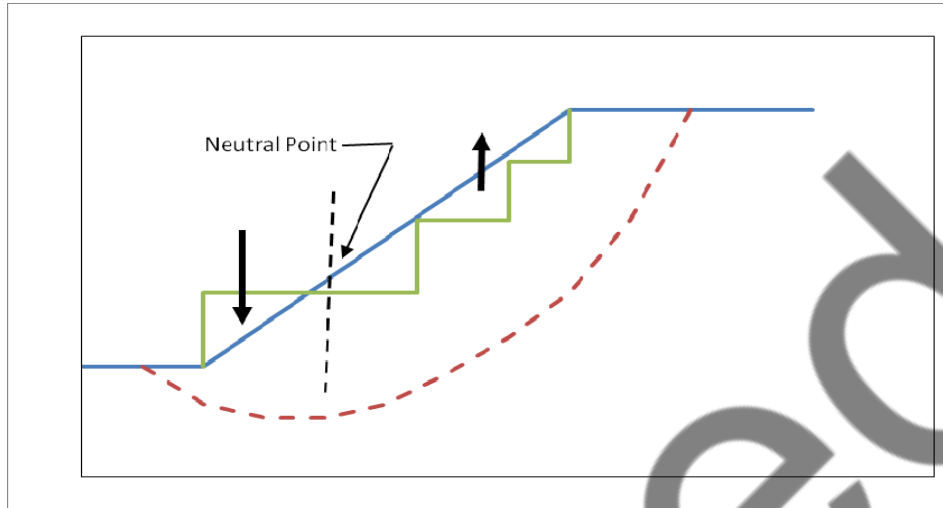
On the other hand, if a downward force is applied below the neutral point, it will have a stabilizing effect. The reverse is true if upward forces are applied. It should be noted that the neutral point is not a fixed point on the slope. In slope stability analysis, it is the critical slip surface that is the most important slip surface in considering stability.

A slip surface is a potential failure surface on a slope which separates the slide soil mass from the unmoving ground. The critical slip surface is the one that has the lowest factor of safety i.e. the most likely to fail. The critical slip surface not only depends on the geometry of the slope and properties of the soil, it also depends on the forces applied on the boundary of the sliding mass. If the location of the applied force is moved along the surface, the critical slip surface changes, which also changes the location of the neutral point.

Benching can be viewed as adding and removing soil masses from the surface of a slope. As shown in Figure 32.13, adding a bench at the bottom of the slope has a stabilizing effect since a force is applied below the neutral point due to the weight of the bench. Creating a bench by removing soil at the top of the slope also has a stabilizing effect since it is the equivalent of applying an upward force above the neutral point.

Therefore benching, if carried out properly, should enhance the overall stability of the slope.

Figure 32.13 Loading which enhances the stability of a slope



Although benching has an overall stabilizing effect on a slope if it is carried out properly, it does have adverse effects on a slope. As stated earlier, benching creates a larger surface area than a plane cut, exposing more soil to evaporation which promotes drying. This may lead to cracking and fissures in cohesive soil.

Benching creates a flat surface on top of each bench which can potentially promote infiltration of water and pooling of water in localized areas. Increased water content in the soil and a rise in the ground water table have destabilizing effects on a slope and bench. Therefore, infiltration of water needs to be minimized.

Section 452 Loose materials

Loose material that can be dislodged through natural settling and routine worker activities must be scaled or trimmed from the sides of an excavation where workers are, or will be present. Even a moderately-sized rock or clump of soil can cause a serious injury if it falls from a height. Fallen debris in the bottom of an excavation can create a slip, trip or fall hazard. All scaled or trimmed materials should be removed to a location where they have no potential to cause injury.

Section 453 Spoil piles

The distance between the edge of the excavation and the leading edge of any spoil pile must be at least 1 m. The slope of the spoil pile cannot exceed 45° from the horizontal. These measures are intended to reduce the possibility of the spoil pile slumping into the excavation and loose materials rolling down the pile into the excavation. Spoil pile materials have rolled into excavations as a result of natural settling and daytime warming of frozen excavated material.

Spoil piles should also be located away from the edge of an excavation because the weight of excavated materials can exert unnecessary pressure on the walls of the excavation. Such pressure can cause excavation walls to collapse.

Section 454 Power pole support

The collapse of a power pole could expose workers to both a falling pole structure and to one or more energized power line conductors. The employer must therefore ensure that when disturbing the ground in the vicinity of an overhead power line, doing so does not reduce the original pole support provided.

When the impact of the planned activity is uncertain, it is suggested that the owner of the power pole or utility be contacted before any work begins. Readers are reminded that the requirements of Part 17 of the OHS Code must be met when working in the vicinity of overhead power lines.

Section 455 Safe entry and exit

The employer must ensure that workers required to enter a trench have a safe means of entering and leaving the trench. This could include a ladder, scaffold or a mechanical device such as a stairway. It could also include appropriate sloping of the ground or soil so that a worker can safely walk into or out of the excavation.

When a trench is more than 1.5 metres deep, a safe point of entering and leaving must be located no more than 8 metres from the worker. The trench walls located between the worker and the safe point of entering and leaving must be supported or sloped as required by this Part.

Section 456 Temporary protective structures

Subsection 456(1) and 456(2)

In an excavation 3 metres or less deep, the type of temporary protective structure used is left to the discretion of the employer, as long as the structure is of sufficient strength to protect workers. In common practice, protective structures are often pre-fabricated from steel, or built in place from wood materials for shoring, stringers and bracing.

If an excavation is more than 3 metres deep, the risk of injury to workers increases dramatically. It is therefore mandatory that any temporary supporting structure be designed and certified by a professional engineer. The engineer's specifications must indicate all details related to the design, including the type and grade of materials to be used and the calculated loads the structure is designed to support.

Subsection 456(3)

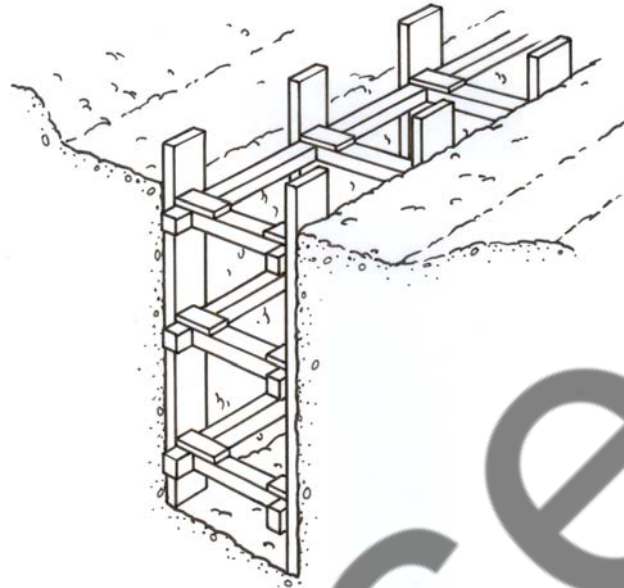
Where an excavation could affect an existing foundation, the foundation must be supported by a temporary protective structure. The structure must be designed, constructed and installed in accordance with the specifications of a professional engineer. This extra precautionary measure reduces the risk of injury to workers working near the foundation, as well as the risk to persons in or near the structure supported by the foundation.

Section 457 Alternative to temporary protective structures

Subsection 457(1)

Instead of complying with section 456, this section permits an employer to use shoring, stringers and bracing constructed of lumber (see Figure 32.14) that complies with Schedule 9, or alternate materials, in trenches 1.5 metres to 6 metres deep. If alternate materials are used, they must possess equal or greater properties than those of lumber. For ease of reference, Schedule 9 is shown as Table 32.2.

Figure 32.14 Trench protected by shoring



Exterior grade plywood can be installed as a substitute for 38 millimetre shoring elements if the plywood meets the requirements of either of the two referenced CSA Standards.

Subsection 457(2)

Mechanical devices such as screw jacks and hydraulic equipment can be used in place of the shoring, stringers or bracing described in Schedule 9. The devices must be at least equivalent in strength and reliability to the shoring, stringers or bracing.

Subsection 457(3)

The use of stringers in trenches less than 2.4 metres deep in “hard and compact soil” is optional.

Table 32.2 Shoring component used in excavations, trenches, tunnels and underground shafts (appears in the OHS Code as Schedule 9)

Soil type	Depth of excavation (metres)	Uprights		Stringers		Cross-braces			
		Minimum dimensions (millimetres)	Maximum horizontal spacing (millimetres)	Minimum dimensions (millimetres)	Maximum vertical spacing (millimetres)	Minimum dimensions (millimetres)		Maximum spacing (millimetres)	
						Width of trench		Vertical	Horizontal
Less than 1.8 metres	1.8 to 3.7 metres								
Hard and compact	1.5 to 3.0	38 x 235	1800	89 x 140	1200	89 x 89	140 x 140	1200	1800
	More than 3.0 to 4.5	38 x 235	1200	89 x 140	1200	89 x 140	140 x 140	1200	1800
	More than 4.5 to 6.0	38 x 235	10	140 x 140	1200	140 x 184	140 x 184	1200	1800
Likely to crack or crumble	1.5 to 3.0	38 x 235	1200	89 x 140	1200	89 x 140	140 x 140	1200	1800
	More than 3.0 to 4.5	38 x 235	900	140 x 140	1200	140 x 140	140 x 184	1200	1800
	More than 4.5 to 6.0	38 x 235	10	140 x 184	1200	140 x 184	140 x 184	1200	1800
Soft, sandy or loose	1.5 to 3.0	38 x 235	10	140 x 140	1200	140 x 140	140 x 184	1200	1800
	More than 3.0 to 4.5	38 x 235	10	140 x 184	1200	140 x 184	184 x 184	1200	1800
	More than 4.5 to 6.0	38 x 235	10	184 x 184	1200	140 x 184	184 x 235	1200	1800

Subsection 457(4) and 457(5)

Where there is a risk of additional stress, vibration or weight being placed on the walls of a trench (see Figure 32.3), additional protection certified by a professional engineer must be used. In assessing the risk to workers, the employer must consider any of the following being placed, passing by, or working within a distance equal to the depth of the trench:

- (a) vehicular traffic;
- (b) machinery, which may include road compaction equipment or compaction equipment used during backfill activities close to the excavation; and
- (c) heavy object(s).

Additional protection is also required to compensate for the stress, vibration or weight resulting from the trench being adjacent to, or abutting, a building or other structure.

Section 458 Installation of shoring, stringers or bracing

Subsection 458(1)

The greatest potential for worker injury exists at the bottom of a trench having unsupported walls. To reduce the likelihood of being injured by a trench wall collapse, workers must use a ladder and install shoring, stringers or bracing downward from the top of the trench, installing each brace in descending order.

Following this sequence, workers are always working in the protected zone. As the protection is installed, workers progress downward until the bottom of the trench is reached.

Subsection 458(2)

When removing shoring, stringers or bracing, workers must work in a sequence that is the reverse of the installation sequence. Specifically, the removal sequence must proceed upwards from the bottom of the trench so that workers are located above the zone of greatest potential for injury. Again, a ladder must be used to keep workers above any possible trench wall collapse.

Subsection 458(3)

Workers must install and remove shoring, stringers or braces as required by subsections (1) and (2). This means that workers must receive training in the employer's safe work procedures for performing the work, be made aware of the requirements of subsections (1) and (2), and may require supervision by the employer.

Subsection 458(4)

If ground conditions deteriorate to the point that it is unsafe to remove shoring, stringers or bracing using the method described in subsection (2), the employer must develop a removal method that does not require a worker to be in the trench. Removal methods could involve use of equipment such as a crane, backhoe or other lifting/excavating equipment rigged or equipped, as necessary, to complete the job safely.

Section 459 Access for powered mobile equipment

Section 444 requires all excavations to be flagged and marked to prevent workers or equipment from falling into the opening. This section deals with the access route that is used by powered mobile equipment to enter and leave the excavation. In this case the barrier can be of any construction that is suitable for the purpose intended, although common practice is to use concrete blocks, a large piece of timber or even a pile of excavated material as a berm.

Section 460 Dumping block

Dumping blocks are required where equipment may back into or over a dump location. The dumping point may include hoppers, stock piles or waste dumps. Dumps of this type can be very high and a flip-over or rollover could cause serious injury. To reduce the risk to workers and their equipment, physical barriers are required to assist in stopping.

Section 461 Underground shafts

Subsection 461(1)

No explanation required.

Subsection 461(2)

No explanation required.

Subsection 461(3)

A variety of workers and equipment is likely to be present around a location where an underground shaft is being excavated. A means of protection must be provided to prevent workers, materials and equipment from falling into the shaft opening. This could involve the use of a solidly built fence, a barricade of concrete blocks, a retaining wall, or other equally effective means.

To provide a means of worker access to each underground shaft entrance, gates not less than 1 metre in height must be installed. The employer must ensure that the gate design, gate operating procedures and worker practices are such that the gates are kept closed except when being used.

Subsection 461(4)

In addition to the employer having to ensure that the gates required by subsection (3)(b) are kept closed when not in use, each worker is also responsible for keeping the gates closed when not in use. Section 2(2) of the *OHS Act* requires each worker to take reasonable care to protect the health and safety of himself or herself, and other workers present while that worker is working.

Subsection 461(5)

Water can introduce an unacceptable hazard since it can cause the walls or supporting structures of an underground shaft to deteriorate. The accumulation of water must therefore be controlled. The employer must ensure that suitable, efficient machinery or devices are available for this purpose.

Section 462 Drilled or bored underground shaft

Subsections 462(1) and 462(2)

Large-sized mechanical drilling or boring devices are sometimes used to excavate underground shafts. Before a worker is required to enter the shaft, the employer must ensure that protective structures have been installed. Such structures can be an installed casing or a temporary protective structure certified by a professional engineer. The professional engineer must certify that the installed protective structure is of sufficient strength to resist shifting of the surrounding materials.

To prevent materials at the surface from falling into the shaft and onto workers, the casing or temporary protective structure must be designed and constructed to extend at least 300 millimetres (12 inches) above surface level.

Subsection 462(3) and 462(4)

During the removal of excavated material, a worker in the belled area of an underground shaft can be exposed to falling material unless it is possible to stand clear. If the worker is unable to stand clear of falling material, then the worker must return to the surface ahead of (precede) each load going to the surface.

If it is not possible to precede each load to the surface, then the worker must accompany the load to the surface using equipment designed to do so, following written safe work procedures prepared by the employer. Section 8 of the *OHS Regulation* requires the procedures to be in writing and available to workers.

Section 463 Prohibition

The area at the bottom of a shaft can become belled – enlarged to a greater diameter than the designed shaft – as a result of excessive excavation, slumping or unplanned ground failure. Such a belled area presents a major hazard to workers and additional temporary structures must be installed before workers are allowed to enter the belled area.

Section 464 Tunnel

Subsection 464(1)

Temporary protective structures used to retain the walls of a tunnel while it is being excavated must be certified by a professional engineer. This ensures that the structures are designed and installed to prevent the walls from collapsing or caving in.

Subsection 464(2)

Water can introduce an unacceptable hazard since it can cause the walls or supporting structures of a tunnel to deteriorate. The accumulation of water must therefore be controlled. The employer must ensure that suitable, efficient machinery or devices are available for this purpose.