

EXCAVATIONS

Excavation/Trench: Any man-made cavity or depression in the earth's surface, formed by earth removal and producing unsupported earth conditions by reason of the excavation.



The section of any excavation must always have an incline or be supported in such a way as to avoid collapse. When the depth of any excavation reaches the average height of a man, the danger of collapse increases especially if such excavation is narrow, e.g. for running piping, and there are no suitable means of exit or escape.

In these instances, it is compulsory to protect the slope of the excavations from sliding away etc.

Moreover, it is not acceptable to rely on visual check and/or experience alone: external factors, such as the weather or simply settlement of the surrounding area, could lead to the sudden collapse of excavations.

All excavations must be equipped with access stairs, which are fixed firmly to avoid accidental movement. Any large rocks and boulders should also be removed from the walls in case they become dislodged.

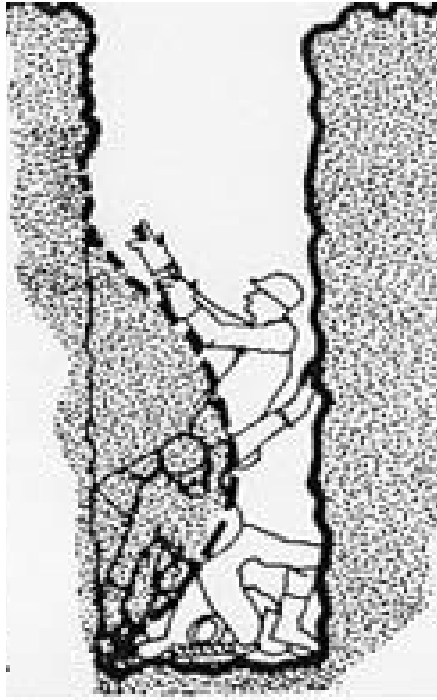
When it is suspected that any excavation may interfere with underground utilities (electrical cables and piping), the following procedure shall be adopted:

- make every possible effort to find “as built” drawings or information from historical data on the site;
- Proceed by making small test excavations manually, considering that cables and pipes are not generally located at any great depth;
- if the presence of live cables and/or pipes containing products is found, proceed with manual excavation or with a small mechanical excavator using the ‘reversed spoon’ method, i.e. use a smooth bucket (without teeth) and remove small quantities of material. The operation must be monitored and checked by a person equipped with a spade.
- In case underground utilities are discovered, the mechanical operation should cease and material scraped away manually in order to identify the lines.
- In any case follow the Work Permit (when issued by Client)

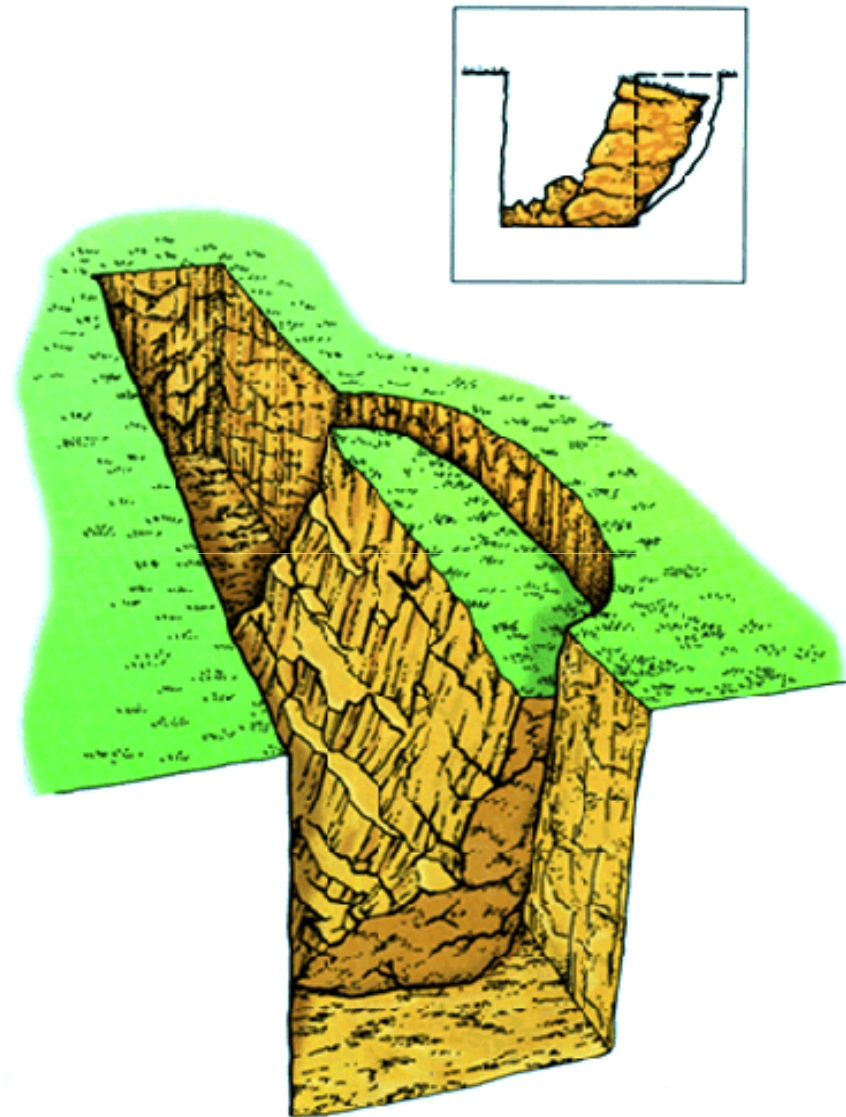
- Collapse of the sides of the excavation
- Contact with underground services
- Falls of people or vehicles into excavation
- Equipment or materials falling on to people within excavations
- Inert, Toxic or flammable vapours in excavation
- Water inside the excavation
- People being struck by machines
- Access and egress to excavation
- Vibration/Traffic close to the excavation
- Collapse of adjacent structures

Many fatal accidents occur each year

- It must be recognised
- and controlled



- The risk increase if the excavation is tight, because the absence of escape ways





Bad example of collapsed excavation

- The likelihood of the sides of an excavation collapsing is dependent upon the characteristics of the soil or rock
- The following factors increase the risk of collapse of excavation sides:



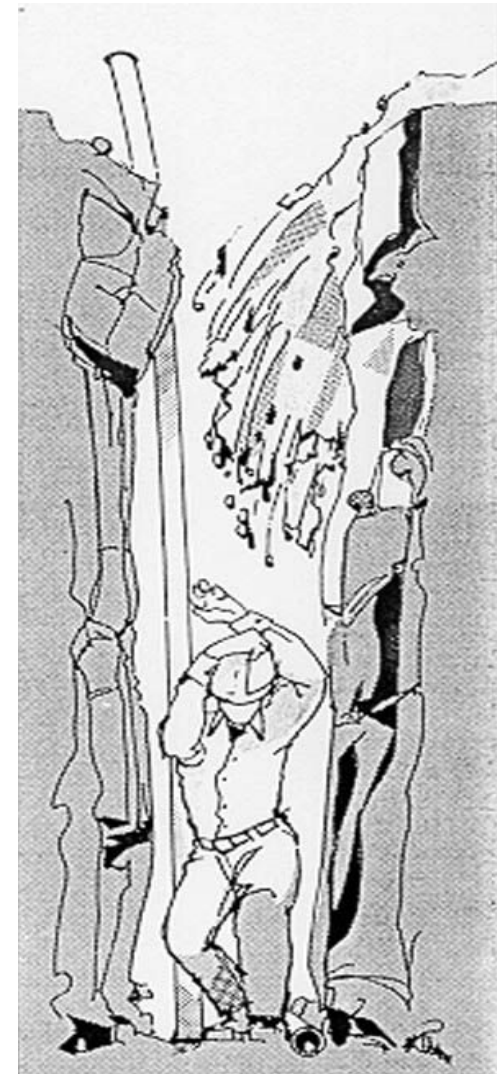
- (a) Loose, un-compacted, granular soils, i.e. sand or gravel, or mixtures containing them
- (b) Excavations through different strata
- (c) The presence of groundwater, and the effect on the excavation sides from surface water running into the ex.
- (d) Made-up ground
- (e) Proximity to earlier excavations
- (f) Loose blocks of fractured rock
- (g) Weathering
- (h) Vibration from plant, equipment, road or rail traffic
- (i) Surcharging by spoil, stored materials or plant including vehicles
- (j) Proximity of loaded foundations
- (k) Damage to the support system by personnel, or when materials are lowered into the excavation

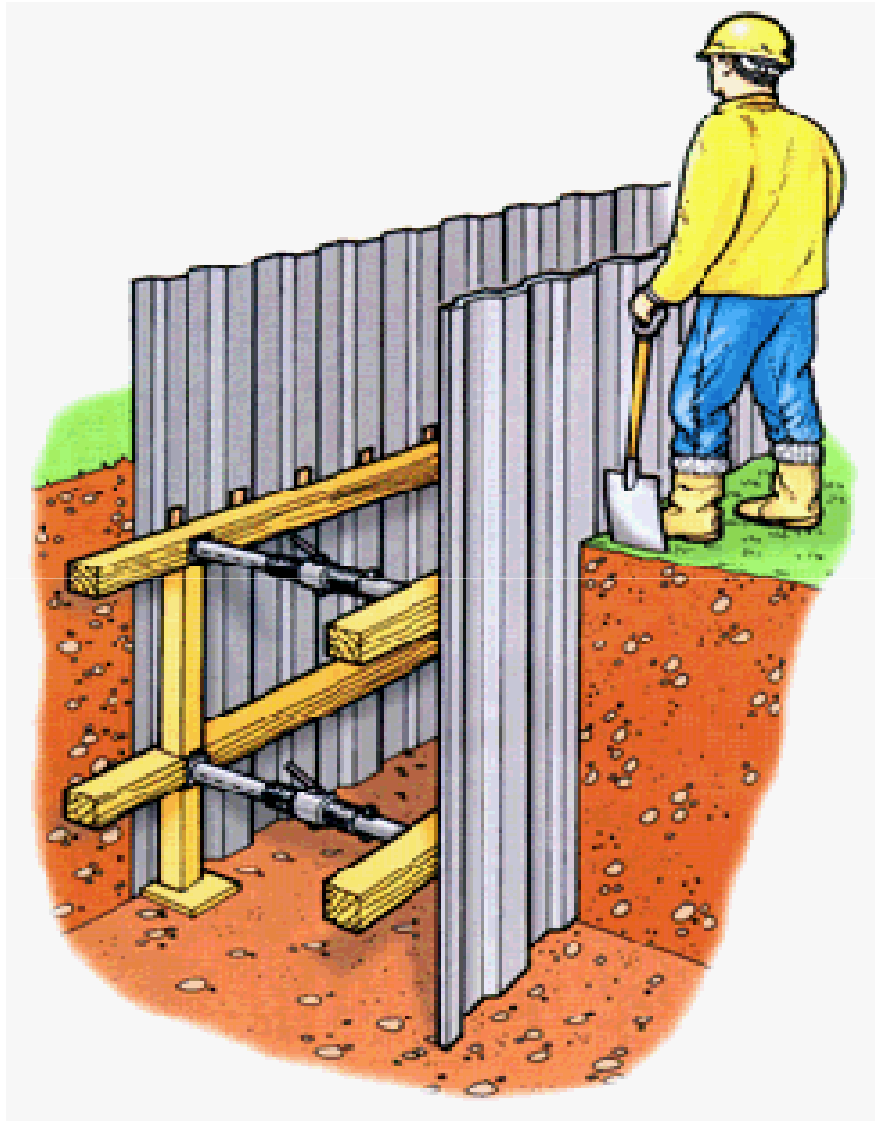
- Need to be removed or supported
- e.g. fencing, piping, structure, materials



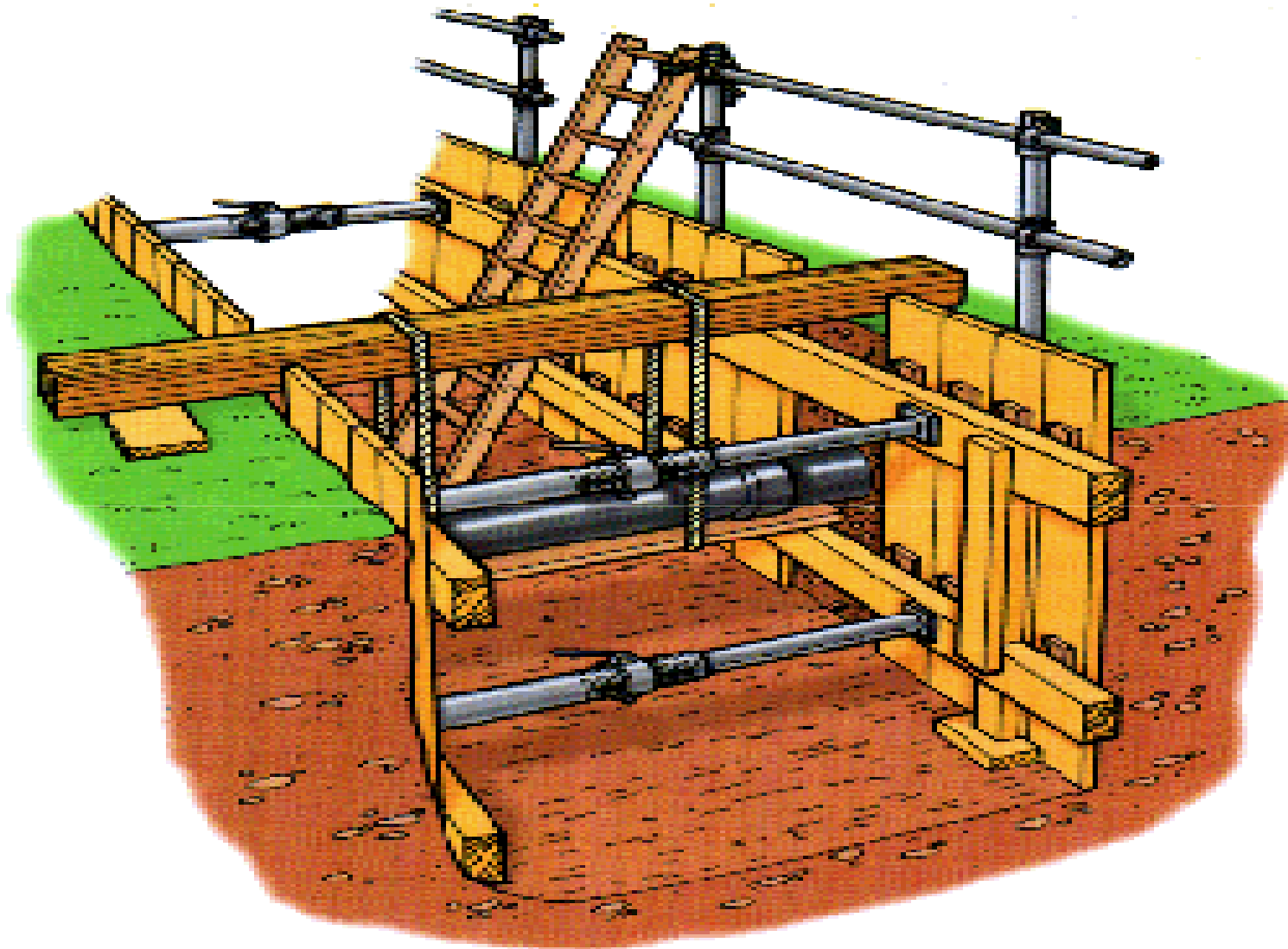
A well-planned excavation shall consider

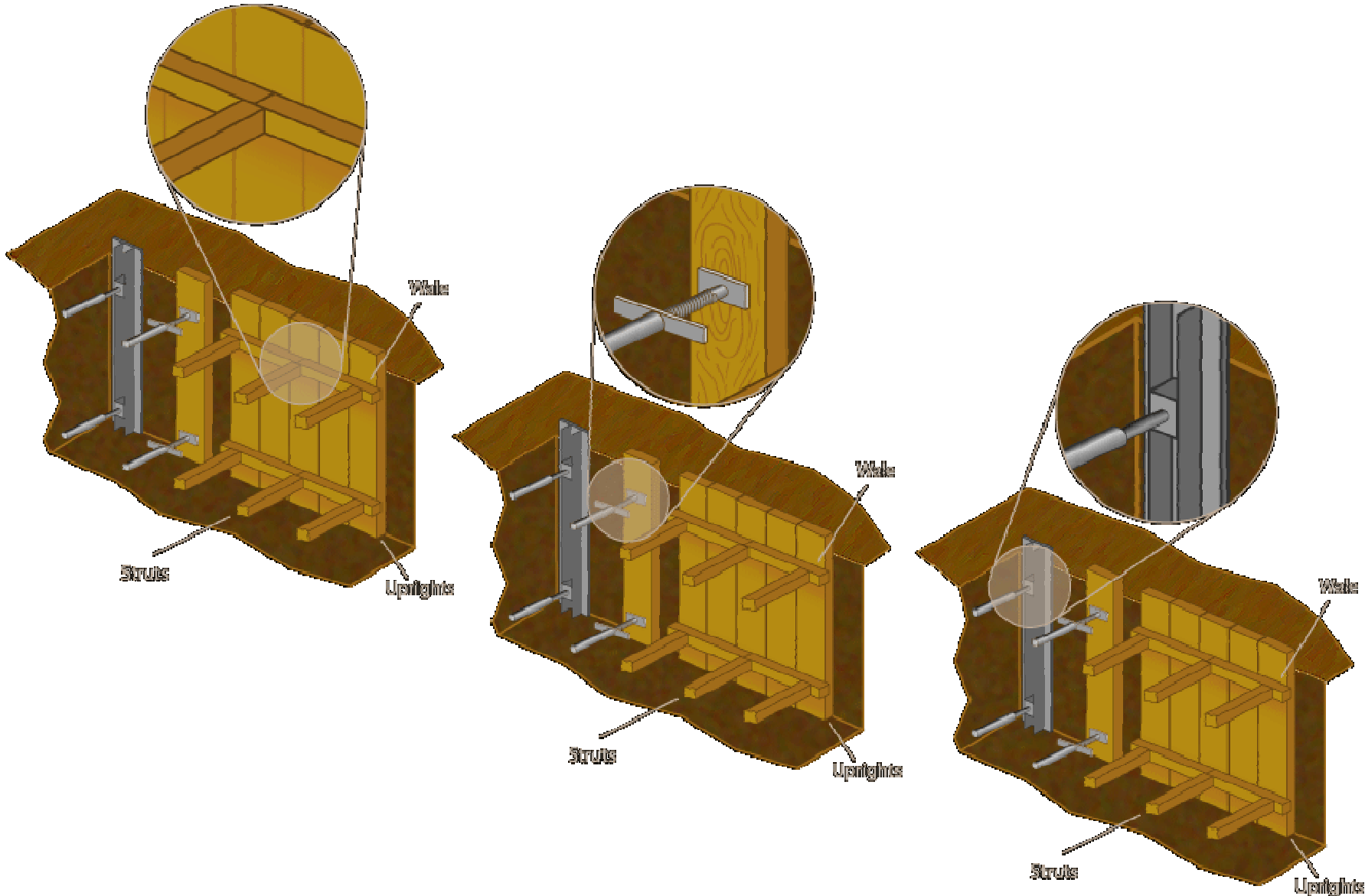
- Type of Soil
- Underground/Above ground utilities
- Any protections needed
- Correct design of protections (sloping, benching, etc.)
- Attention to correct installation and removal
- Entrance/Egress
- Appropriate handling of materials and equipment
- Control of interferences with machine/vehicles/people/ adjacent structures





The most common form or support for excavations is the use of timber or metal sheeting braced by timber or steel struts





A trench box was built around this work area

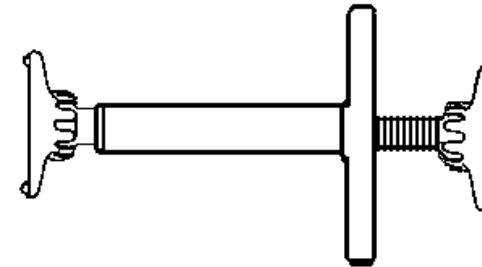


Figure 3. Trench Jacks (Screw Jacks)

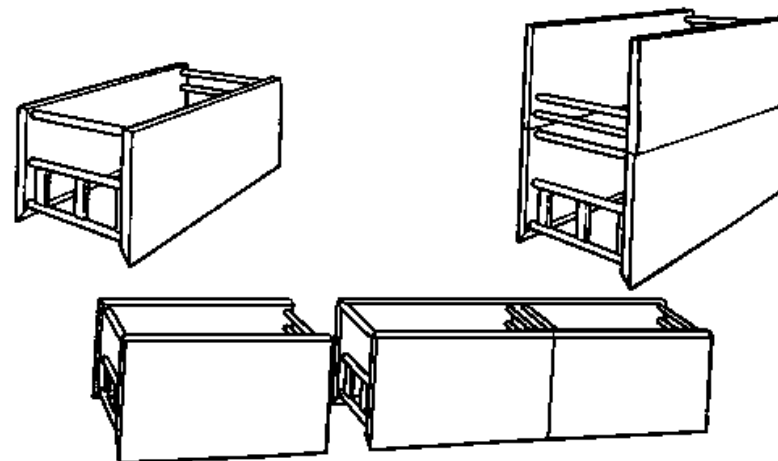
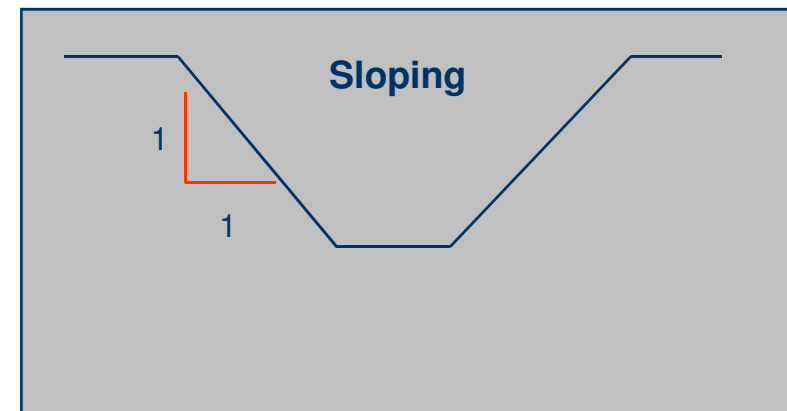
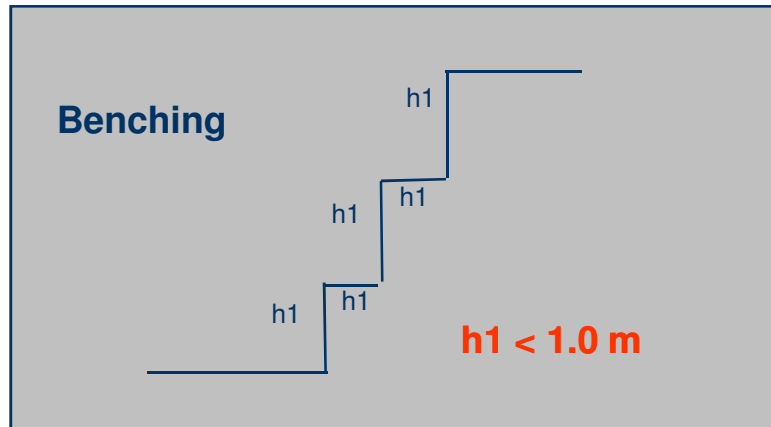


Figure 4. Trench Shields



- Using hydraulic jacks the operator can easily drop the system into the hole
- Once in place, hydraulic pressure is increased to keep the forms in place
- Trench pins are installed in case of hydraulic failure

- An alternative to supporting the sides of an excavation is the sloping or stepping of the sides of the excavation. It depends from several factors, as the depth and the dimension of the excavation



Material	Dry Ground	Wet Ground
Gravel	30-40 degrees	10-30 degrees
Sand	30-35 degrees	10-30 degrees
Silt	20-40 degrees	5-20 degrees
Clay	20-45 degrees	10-35 degrees
Peat	10-45 degrees	5-35 degrees

Type C soil, sandy & loose: width versus height angled at 1.5 to 1 slope, or 34°

Type B soil, mix of sand, rocks and clay: angled at a 1 to 1 slope, or 45°

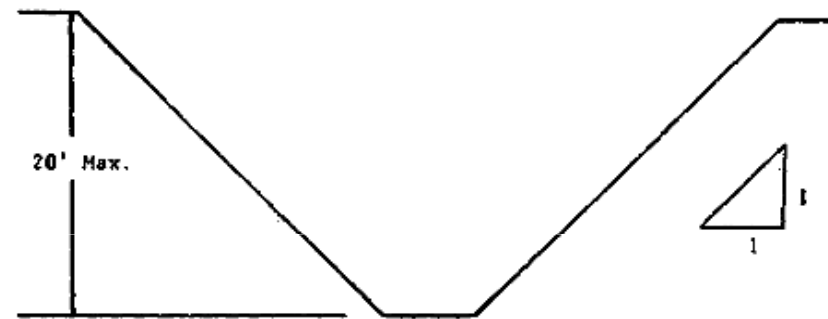
Type A soil, clay, rocks, and cohesive: angled at a 3/4 to 1 slope, or 53° .

Stable rock is 90% or vertical.

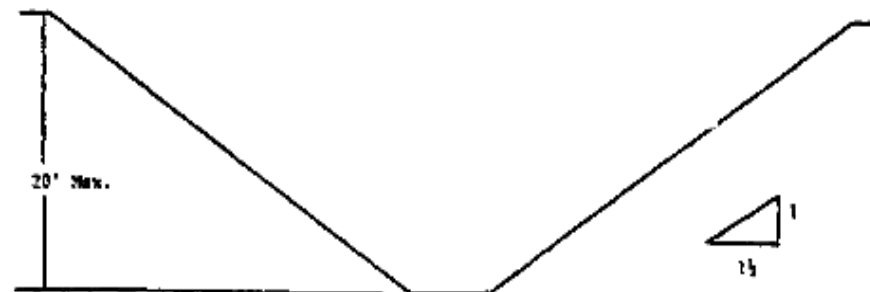
- Type A - 3/4:1



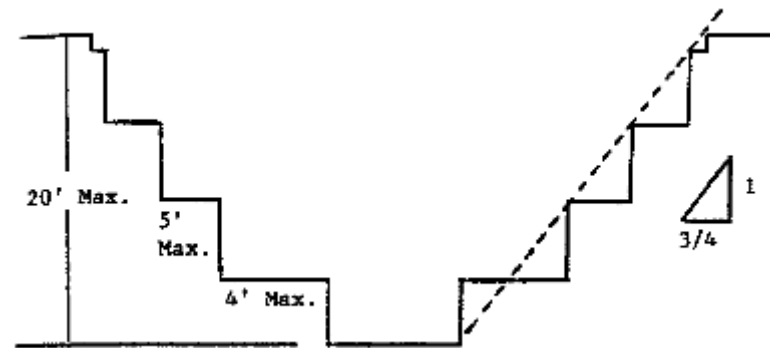
- Type B - 1:1



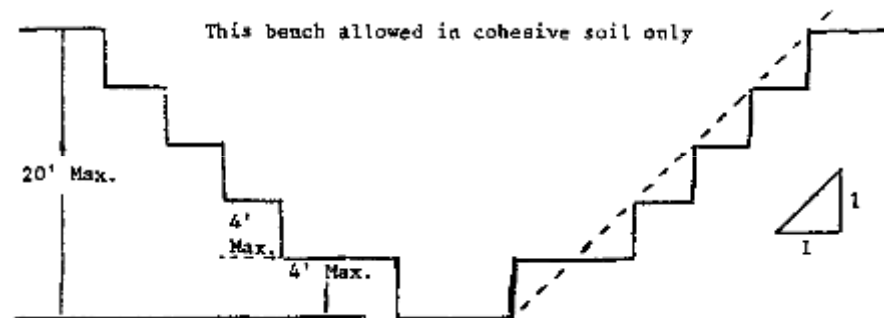
- Type C - 1½ :1



- Type A



- Type B
(cohesive soil)



- Type C

n.a.

Underground services include

- buried pipeline,
- sewers, drains
- cables (electrical and/or communications).










Before starting an excavation all steps must be taken:

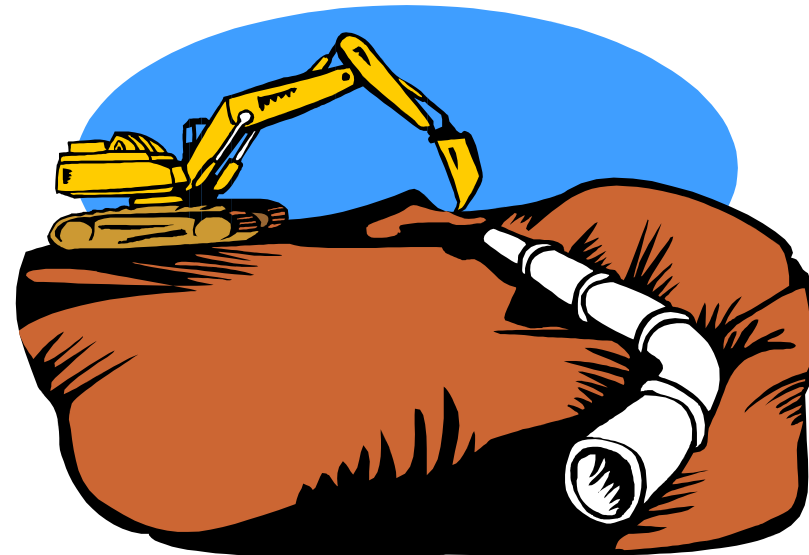
- Must determine location of utilities underground. (gas lines, electric lines, etc.) from drawings
- Exact location must be made by safe and acceptable means. Service-locating devices should be used by competent people to determine the exact location of services
- Exploration trenching
- While excavation is open, underground utilities shall be protected, supported or removed to safeguard employees.

Underground

- Locate prior to digging
- Certify deactivation
- Protect, support or remove



	ELECTRIC
	GAS-OIL-STEAM
	COMMUNICATION CATV
	WATER
	SEWER



- **Red concrete or bricks coverage:**

Stop mechanical excavations and proceed manually. Normally under the concrete there is sand. **Caution** Services are below.

- **Sand coverage:**

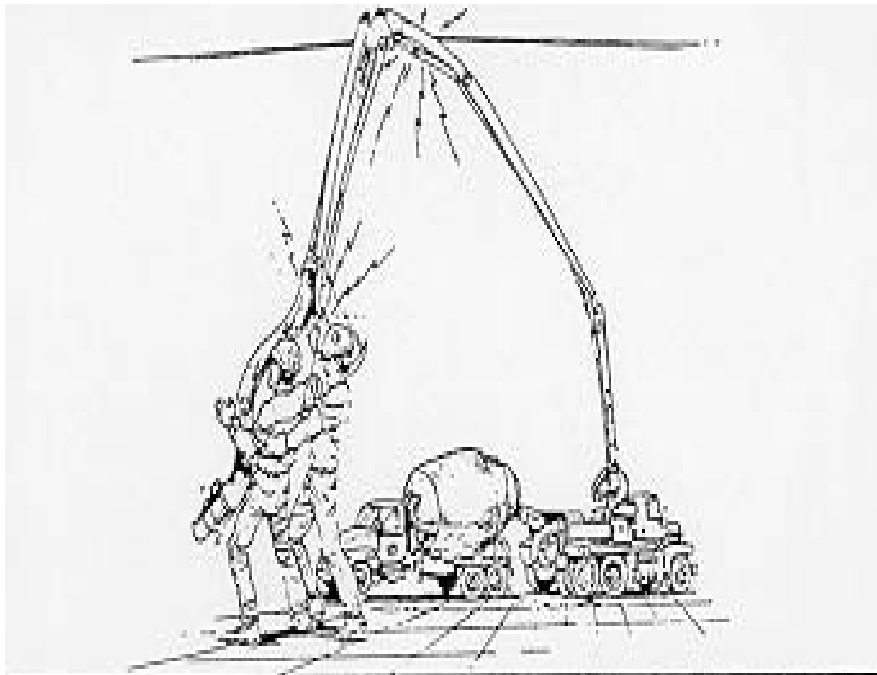
Stop mechanical excavations and proceed manually. **Caution.** Normally the services are below.

- **Concrete burrows:**

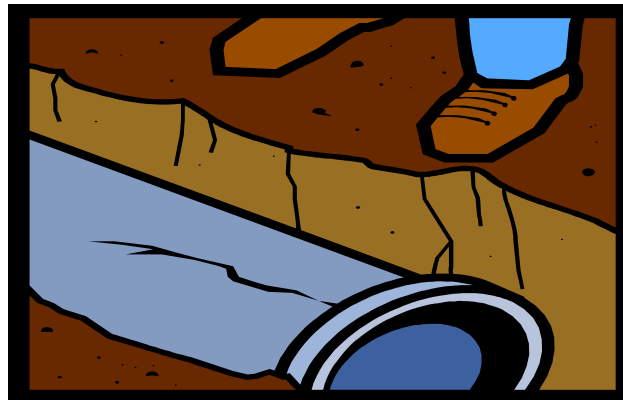
Services are inside. Verify the source of utilities by the perimeter check before starts excavation works and decide how to proceed the kind of excavation.

Aboveground

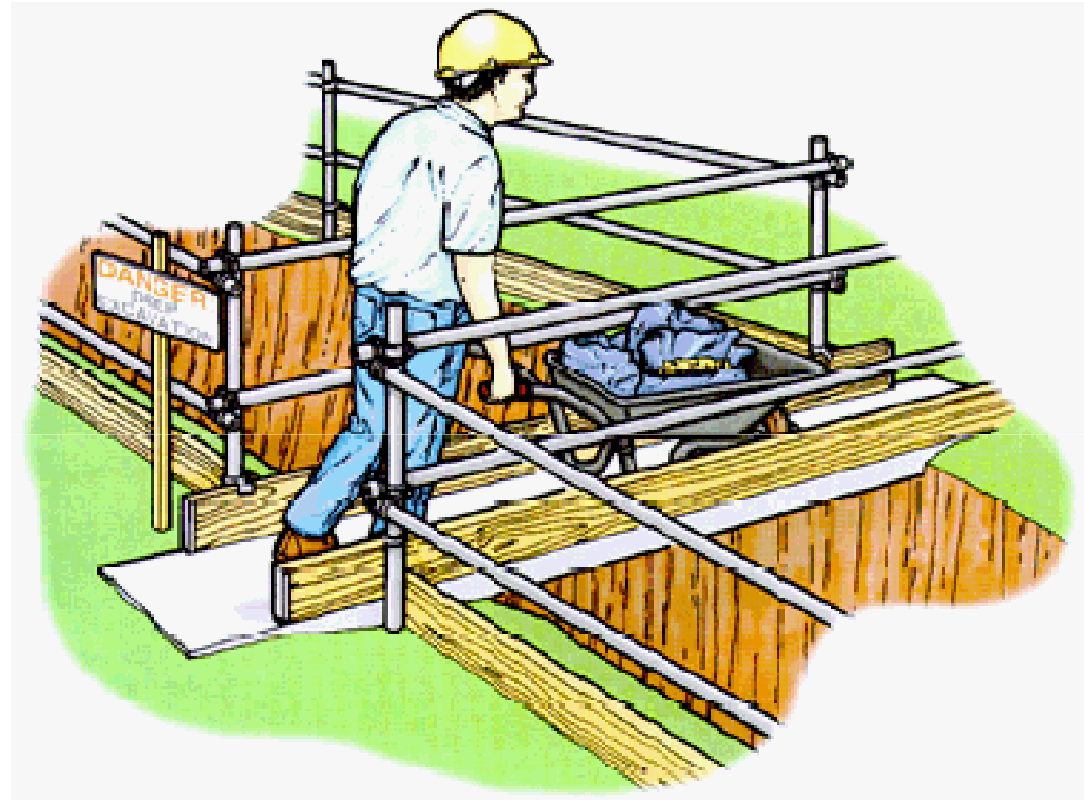
- De-energize
- Isolation from Power Lines



- People falling into excavations are the cause of many injuries. All excavations shall be securely fenced with a guard, intermediate rails and toe boards.



- Crossing over a trench can be dangerous. Where necessary access-ways of at least 80 cm width, with edge protection, should be provided.



- Heavy plant or other equipment toppling into an excavation can cause serious injury to those working within it and to the plant operator. **The routes for vehicles and plant such as excavators shall be carefully planned to avoid approaching the edge of excavations and these routes must be clearly marked and preferably barriered / fenced.**
- Where vehicles, such as dumper trucks, **have to approach the excavation to tip material physical barriers such as stop blocks (see below) must be place in such a position to prevent driver error allowing the vehicle to fall into the excavation.**

- Traffic Control
- Barricades
- Hand/mechanical signals/Flags
- Stop logs
- Grade soil away from excavation
- Fence/lights overnight





The weight and vibrations of the vehicles can seriously affect the excavation stability.

Very High Risk !!!



- If shallow excavations have not been shored, plant positioned close to the edge may destabilise the excavation causing the plant to fall into the excavation. The use of plant in this way should either be avoided or trench support provided, however shallow the excavation.
- Spoil from excavations should be stored at least 1m away from the edge of the excavation both to minimise surcharging forces (see above) and also to reduce the risk of the material falling into the excavation. The storage of other materials near the edge of an excavation should be prohibited.

- Where people have to enter excavations to carry out work consideration should be given to **the potential presence, within excavations, of fumes, which can cause asphyxiation and/or poisoning.**
- As appropriate, Work in excavations should be treated as work in a **confined space** and the precautions defined in confined space Safety Practice should be complied with.

A **confined space** is any space:

- 1) that has limited or restricted means of entry or exit;
- 2) is large enough for a person to enter to perform tasks and is not designed or configured for continuous occupancy

The exact definition of a **confined space** varies depending on the type of industry. That is, **confined spaces** on a construction site are defined differently than confined spaces in a paper mill.

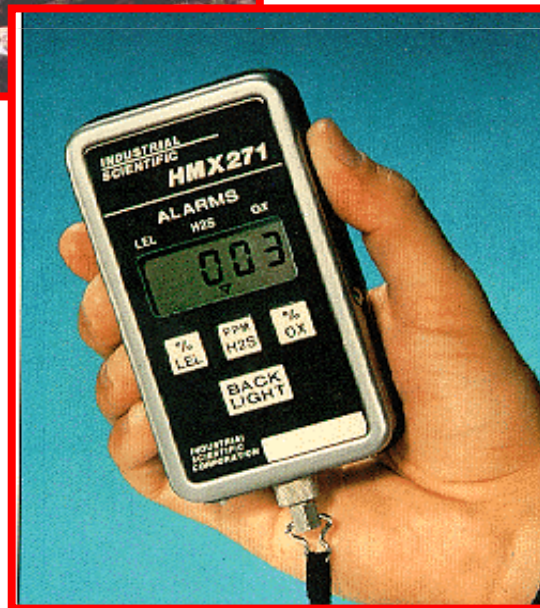
Confined spaces that present special hazards to workers, including risks of toxic or asphyxiant gas accumulation, fires, falls, flooding, and entrapment may be classified as permit-required confined spaces depending on the nature and severity of the hazard.

- The Work Permit for Excavation should be transformed in a Work Permit for Confined space, as per conditions below. Involve the Electrical Dept and use the “as built” documentation in this case.
 - Depth progressively close to 1,50 meters;
 - Potentially less than 19.5% or more than 23.5% oxygen;
 - A combustible gas concentration greater than 20% of the lower flammable limit;
 - Concentrations of hazardous substances that exceed those specified in the Threshold Limit Values established by the ACGIH (American Conference of Governmental Industrial Hygienists).



Test excavations more than 1,50* m before an employee enters the excavation for:

- Oxygen deficiency
- High combustible gas concentration (i.e. HC, etc.)
- High levels of other hazardous substances (i.e. H₂S, CO, etc.)



* See local laws/regulations

Displace hazardous gases and vapors

- Heavier than air or lighter than air contaminant
- Exhausting or blowing in
- Volume/time required to lower concentrations to acceptable levels



- In a previous section the hazards of plant and materials falling into excavations were discussed, however there are occasions when excavation plant (e.g. diggers /backhoes) and lifting equipment has to be used. Such equipment creates additional risks from surcharging (see above), damage to the supporting structure and also to people within the excavation being struck by the equipment or the load being lifted. **The planning of such work should identify where the plant is to be located to minimise the risk of surcharging or falling into the excavation especially if the sides of the excavation collapse under the weight of the plant.**

- When excavators are being used to remove material from an excavation, the bucket can easily strike people working within the excavation. **As a general principle people should not be allowed into the excavation when such equipment is being used.** Where it is unavoidable work control must ensure that the minimum number of people are allowed into the excavation, the driver must have a clear view of people in the excavation and the workers must stay clear of the area in which the bucket is being used.

- A safe means to enter an exit from excavations should be provided as many serious injuries have occurred when people have entered excavations using the supporting structure. There is also a risk that using the supports in this way will disturb them and weaken the supporting structure.

The normal form of access and egress:

- ladder
- height to base ratio of 4:1
- be securely lashed
- maintain three-point contact
- means of getting tools and equipment into and out of the excavation should be provided

Egress provided

- Ladders
- Ramps
- Stairs



- Provision must be made to allow rapid egress in the event of water ingress or other emergency. Consideration must also be given to how an injured person who is unable to use the ladder will be removed from the excavation in an emergency.
- Housekeeping

Water = Cave-in Hazard

DO NOT ENTER !!!



These workers must be protected from cave-in. Note the water in the bottom of the trench. This is an hazardous condition!

- Whenever an excavation is to be carried out close to services or existing buildings or structures, including scaffolding, care should be taken to ensure that the services or foundations of such buildings or structures are not disturbed.



- In all types of soil, some inward movement of the sides of an excavation will occur. Any lateral movement will produce settlement of the surrounding ground, the amount depending on the type of ground and the care taken with the installation of the support. For excavations in rock, movement along bedding planes may have to be considered.
- Building foundations that are at a distance of less than two times the excavation depth from the face of the excavation are more likely to be affected by ground movement; underpinning of such structures may be necessary to prevent structural damage.

- **Notify close out of road**
- **Do not work underneath, or very close to an excavation machine**
- **Possibility of touching overhead power cables by the excavation machine**
- **At an excavation site, watch out hazard of electrical shock when welding inside**
- **Unprotected sharp steel bar ends**

- Hazard assessment of the work site completed by competent person
- All underground hazards... eg. pipelines, electric cables ...must be identified, isolated and protected
- A confined space Permit must be issued if the entry meets the definition
- Ground movement must be controlled and collapse prevented by systematically shoring, sloping, benching etc. as appropriate
- Interference between workers and machines shall be minimised, as well the presence of workers inside the excavation
- Excavation shall be barricaded, materials shall be stocked away from the edge, proper access/egress to be ensured
- Ground and environment conditions must be continuously monitored for change

RESTRICTED AREAS – DANGER, DO NOT ENTER !!!

FENCED

